

JOURNAL OF INFORMATION SYSTEMS & OPERATIONS MANAGEMENT



JISOM
Vol.16 No.2
DECEMBER 2022

ANALYZE, CREATE, SHARE KNOWLEDGE

JOURNAL OF INFORMATION SYSTEMS & OPERATIONS MANAGEMENT

VOL. 16 No. 2
DECEMBER 2022



ROMANIAN-AMERICAN UNIVERSITY PUBLISHING HOUSE
BUCHAREST

EDITOR-IN-CHIEF NOTE

JISOM is a journal which enables researchers, academia, and professionals to make their voices heard, to share their findings with their peers and the public at large. Being an open-access journal, JISOM aims to increase the all-around level of knowledge in the fields of computer science and economics, to further the society's capabilities to understand new concepts, to see how things are done by cutting-edge technologies implementations, to understand what is in store for us not only at the present time but also in the near, and so near, future.

The published articles focus mainly on IT&C but we also provide a favorable exposure medium for correlated topics, such as economics, management, applied sciences, mathematics, statistics, etc. JISOM encourages cross-disciplinary research of national and international researchers and welcomes the contributions which give new and fresh perspectives to the above-mentioned fields of study.

National and international researchers, professionals, recognized experts, professors who want to share their research results and new ideas, and Ph.D. students who want to improve their knowledge or present their emerging doctoral research are all welcome to join our knowledge-eager community.

We have a history that started back in 2007 and we are permanently striving to bring our community to a higher level of knowledge in the fields we cover. With the constant support of our authors, reviewers, readers, and editorial staff I am sure we are and will live up to the mission we have taken on.

Many thanks to our JISOM community and good luck with your research!

Respectfully,

Alexandru TĂBUȘCĂ, PhD

JISOM Editor-in-Chief

JOURNAL OF INFORMATION SYSTEMS & OPERATIONS MANAGEMENT

EDITOR-IN-CHIEF

Alexandru TĂBUȘCĂ, PhD Associate Professor

MANAGING EDITOR

Daniela Alexandra CRIȘAN, PhD Associate Professor

EDITORIAL BOARD

Academician Gheorghe Păun	Romanian Academy, Romania
Professor Alexandru Pîrjan	Romanian-American University, Romania
Professor Allan Berg	University of Dallas, USA
Professor Cornelia Botezatu	Romanian-American University, Romania
Professor Costin Boiangiu	Politehnica University, Bucharest, Romania
Professor Cristina Coculescu	Romanian-American University, Romania
Professor Eduard Rădăceanu	Romanian Technical Academy, Romania
Professor George Căruțașu	Romanian-American University, Romania
Professor Ion Ivan	Academy of Economic Studies, Romania
Professor Ion Smeureanu	Academy of Economic Studies, Romania
Professor Kent Zimmerman	James Madison University, USA
Professor Lucia Rusu	Babes-Bolyai University, Romania
Professor Pauline Cushman	James Madison University, USA
Professor Ramon Mata-Toledo	James Madison University, USA
Professor Sergiu Iliescu	Politehnica University, Bucharest, Romania
Professor Traian Muntean	Universite Aix-Marseille II, France
Professor Victor Patriciu	National Technical Defence University, Romania
Professor Viorel Marinescu	Technical Civil Engineering, Romania
Associate Professor Alexandru Tăbușcă	Romanian-American University, Romania
Associate Professor Ion Bucur	Politehnica University, Bucharest, Romania
Associate Professor Irina Făgărășanu	Politehnica University, Bucharest, Romania
Associate Professor Mihaela Păun	Louisiana Tech University, USA
Associate Professor Sanda Micula	Babes-Bolyai University, Romania
Associate Professor Susan Kruc	James Madison University, USA
Senior Staff Text Processing:	
Lecturer Gabriel Eugen Garais	Romanian-American University
Lecturer Justina Lavinia Stănică	Romanian-American University

JOURNAL OF INFORMATION SYSTEMS & OPERATIONS MANAGEMENT

Journal details

No.	Item	Value
1	Complete title / IDB title	JOURNAL OF INFORMATION SYSTEMS & OPERATIONS MANAGEMENT
2	ISSN (print and/or electronic)	1843-4711
3	Frequency	semestrial
4	Journal website (direct link to journal section)	http://jisom.rau.ro
5	IDB indexation	EBSCO GALE Cengage Learning Index Copernicus ProQuest RePEC/IDEAS

Contact

First name and last name	Alexandru TĂBUȘCĂ, PhD Associate Professor
Phone	+4-0372-120.140
E-mail	alex.tabusca@rau.ro

ISSN: 1843-4711

CONTENT

<i>Prasun BHATTACHARJEE</i> <i>Somenath BHATTACHARYA</i>	ARTIFICIAL INTELLIGENCE-DRIVEN COMPETENT PLAN OF AN INDIAN WIND FARM	1
<i>Elisabeta Andreea BUDACIA</i> <i>Lucian Constantin Gabriel BUDACIA</i> <i>Marian Florin BUSUIOC</i>	CONSIDERATIONS REGARDING THE NEW CHALLENGES OF LEADERSHIP IN THE NEW ECONOMIC - SOCIAL REALITY	12
<i>George CARUȚAȘU</i> <i>Nicoleta Luminita CARUȚAȘU</i> <i>Beatrice Gabriela COTET</i>	CROSS PANDEMIC DIGITAL SKILLS NEED	22
<i>Daniela Alexandra CRIȘAN</i> <i>Justina Lavinia STĂNICĂ</i>	ANALYSIS OF THE CORRELATION BETWEEN INNOVATION AND ICT READINESS FOR THE EU-27 MEMBER STATES	35
<i>Elena Raluca CRISTIAN</i> <i>Alexandra Irina DĂNCIULESCU</i> <i>Carmen Dalia ȚÎRDĂ</i> <i>Anda Veronica DAN</i>	THE RELATIONSHIP BETWEEN THE HUMAN DEVELOPMENT INDEX (HDI) AND INTERNATIONAL MIGRATION	46
<i>Nicoleta Rossela DUMITRU</i> <i>Oana PREDA</i>	INCREASING PRODUCTIVITY THROUGH DIGITALIZATION AND ITS IMPACT ON THE FIELD OF MARKETING AT ORGANIZATIONAL LEVEL	61
<i>Nguyen Hong HUAN</i> <i>Le Dinh NGHI</i> <i>Nguyen Duy Yen LINH</i> <i>Tran Nam QUOC</i> <i>Dang Hoang Minh QUAN</i> <i>Nguyen Ngoc Duy PHUONG</i>	UNDERSTANDING CUSTOMERS' WILLINGNESS TO PAY MORE AND PURCHASE INTENTION IN BLOCKCHAIN FOOD TRACEABILITY: EVIDENCE FROM VIETNAM	70
<i>Celso Luis LADERA</i> <i>Ramon A. MATA-TOLEDO</i>	USING THE INFINITE DESCENT METHOD TO FIND CONVENIENT RATIONAL AND NON-RATIONAL NUMBERS USING DEDEKIND CUTS	85
<i>Andrei LUCHICI</i>	DEALING WITH VAGUENESS IN AGENT-BASED MODELS: A PYTHON FUZZY LOGIC ABM FRAMEWORK	96
<i>Gyongyver MÁDUȚA</i>	SHOPPING BEHAVIOUR FOR ONLINE ENGLISH LANGUAGE COURSES AND DIGITAL LEARNING PRACTICES OF ROMANIAN STUDENTS	112
<i>Pascal Muam MAH</i> <i>Iwona SKALNA</i>	ANALYSIS OF THE BEST FIT PRE-TRAIN DEEP LEARNING MODEL (DLMS) THAT CAN INTEGRATE BLOCKCHAIN TECHNOLOGY IN THE HEALTH SECTORS USING NATURAL LANGUAGE	126

<i>Tomasz PELECH-PILICHOWSKI</i>	PROCESSING (NLP) AS THE MAIN SOURCE OF DATA CLUSTERING	
<i>Alexandra MĂRGINEAN</i>	BLENDING REMOTE/HYBRID WORK AND HYBRID ACADEMIC EDUCATION	144
<i>Cezar Octavian MIHĂLCESCU</i> <i>Beatrice SION</i> <i>Ionel IACOB</i>	NON-FUNGIBLE TOKEN (NFT): OVERVIEW, OPPORTUNITIES AND CHALLENGES	157
<i>Larisa MIHOREANU</i> <i>Elena Iuliana PAȘCU GABĂRĂ</i> <i>Daniel Gabriel DINU</i> <i>Andreea STOIAN KARADELI</i> <i>Liliana STANCIU</i>	HOW TELEMEDICINE CAN SUSTAIN THE ROMANIAN TRANSFORMATIONAL REFORM	169
<i>Dumitru Mihai NEDELESCU</i> <i>Oana CIULEI</i>	ANALYSIS OF THE INFLUENCE OF NON-PERFORMING LOANS ON BANKING PERFORMANCE. CASE STUDY ON THE EXAMPLE OF THE ROMANIAN BANKING SYSTEM	184
<i>Yao Lin Ong</i> <i>Bo Hsiao</i> <i>Nguyen Hong Huan</i>	INDUSTRY 4.0 AND DIGITAL GREEN INNOVATION WITH THE MEDIATING ROLE OF DIGITAL GREEN KNOWLEDGE CREATION: AN EVIDENCE FROM VIETNAM	196
<i>Dana-Mihaela PETROȘANU</i> <i>Alexandru PÎRJAN</i>	ADVANTAGES AND CHALLENGES REGARDING THE USAGE OF DRONES IN E-COMMERCE	212
<i>Ioan-Matei PURCĂREA</i>	E-COMMERCE AND DISRUPTIVE TECHNOLOGIES FOR HIGHER EDUCATION	227
<i>Sarina ROSENBERG</i> <i>Dragoș Sebastian CRISTEA</i> <i>Cristina Gabriela ZAMFIR</i>	THE EUROPEAN WAVE OF DIGITAL TRANSFORMATION AND THE WORKFORCE MIGRATION	235
<i>Alexandru TĂBUȘCĂ</i> <i>Cristina COCULESCU</i> <i>Mironela PÎRNĂU</i>	FLUTTER TECHNOLOGY AND MOBILE SOFTWARE APPLICATIONS	250
<i>Alexandru TĂBUȘCĂ</i> <i>Gabriel GARAIȘ</i> <i>Alexandru ENĂCEANU</i>	CYBERSECURITY EDUCATION – THE NEW LITERACY	263
<i>Eric TZIMAS</i> <i>Manolis KRITIKOS</i>	TESTING THE GENERALIZATION OF AUTOMATED REAL ESTATE PROPERTY EVALUATION MODELS	273
<i>Diana Apostu-CROITORU</i> <i>Maria-Aurelia CADAR</i> <i>Iulia STANICĂ</i> <i>Costin-Anton BOIANGIU</i> <i>Nicolae TARBĂ</i>	THE INFLUENCES OF COMPETITIVE VS. COLLABORATIVE APPROACH ON THE PERFORMANCE OF EMPLOYEES AND COMPANIES	283

<i>Cătălin TUDOSE</i>		
<i>Bogdan-Costinel DRĂGHICI</i> <i>Iulia POPA</i> <i>Ștefan-Alexandru HOISAN</i> <i>Costin-Anton BOLANGIU</i> <i>Mihai-Lucian VONCILĂ</i> <i>Nicolae TARBĂ</i>	THE INVESTMENT FIELD OF COMPANIES WITHIN SOFTWARE PROJECTS	293

ARTIFICIAL INTELLIGENCE-DRIVEN COMPETENT PLAN OF AN INDIAN WIND FARM

Prasun BHATTACHARJEE¹

Somenath BHATTACHARYA²

Abstract

India is at the moment the fifth largest economy and sustains the second biggest population in the world. To uphold its phenomenal economic growth, it would need cheap and reliable energy resources in the coming decades like any other nation. Moreover, the central government of India has announced its goal to attain carbon neutrality by 2070 following the pledges of the Paris treaty of 2015. To realize such a great aim, India needs to use its environment-friendly energy generation technologies rapidly and efficiently. Wind energy can help coastal states of India to generate electricity with a minimal carbon footprint and boost their economic progress. This current paper focuses on designing a wind farm in the western part of India using artificial intelligence methodologies. An innovative technique to escalate the efficiency of the genetic algorithm has been proposed to augment the economic output of the wind farm.

Keywords: Annual Profit, Genetic Algorithm, Indian Power Generation Businesses, Profit Development, Wind Energy.

JEL Classification: O13, Q42

1. Introduction

The wind power generation market used to be dominated by the United States of America and European nations till the initial years of the current century. It is at present enormously guided by Asian countries like the People's Republic of China and India. Due to high industrialization and economic advancement in the past few decades, they are consuming an unprecedented amount of energy every year.

The rapid influx of fossil fuels is expediting the greenhouse effect and is greatly responsible for the abnormal increase of the surface air temperature of the planet. This temperature increment is also affecting the weather patterns and causing Climate Change in every continent of the Earth.

To restrain the calamitous effect of Climate Change, most of the members of the United Nations have agreed to sign an international treaty in Paris in 2015. This agreement mandates the efficient usage of renewable resources like wind energy to check the emission throughout the Globe.

¹ Ph.D. Scholar, Jadavpur University, prasnubhatta@gmail.com

² Associate Professor, Jadavpur University, snb_ju@yahoo.com

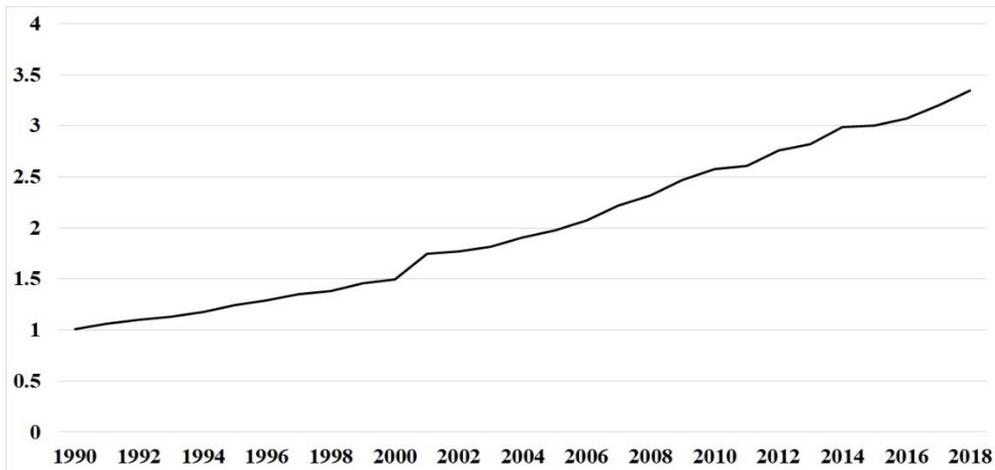


Figure 1: Total Greenhouse Gas Emissions of India in Billion-Ton from 1990 to 2018

One of the most alluring qualities of wind energy in India is that the generation expenditure is nearly 35% lesser than the electricity produced by thermal power plants, and this is projected to drop by 7% by the end of this year.

In 2020, Moth Flame Optimization Algorithm was utilized for the power generation capacity of both onshore and offshore places in India. In the similar year, a bigger offshore wind farm arrangement for the western shore of Gujarat was evaluated with weather analysis and generation outlay was predicted.

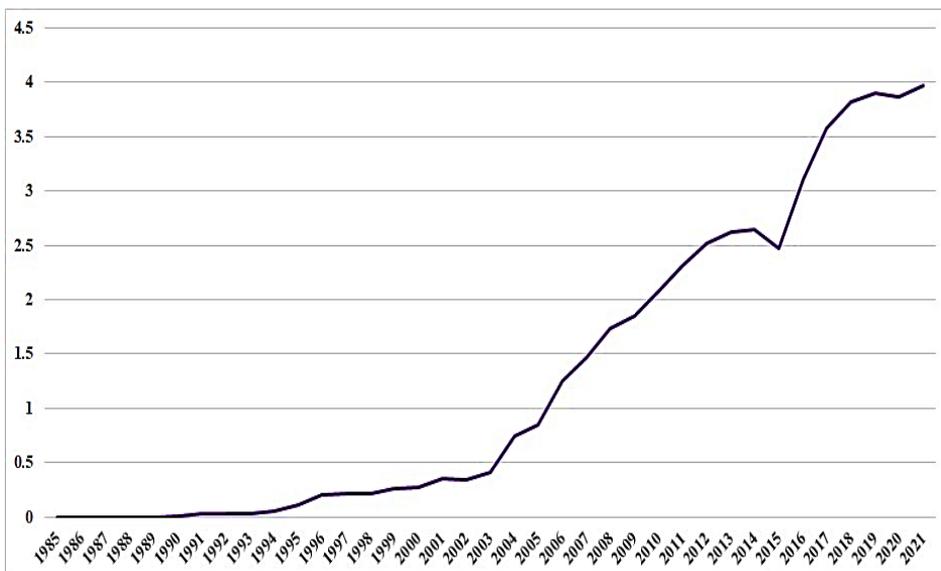


Figure 2: Portion of Electricity Generation from Wind in Percentage

Researchers have tried to improve the design of wind farm layouts and enhance financial efficiency. The assessment of the offshore wind energy generation capacity and restriction of the generation expenditure in the Indian shoreline region through conventional algebraic

modelling have been endeavored. The wind energy generation possibility in the Jafrabad area of India has been discovered with Artificial Intelligence-based techniques.

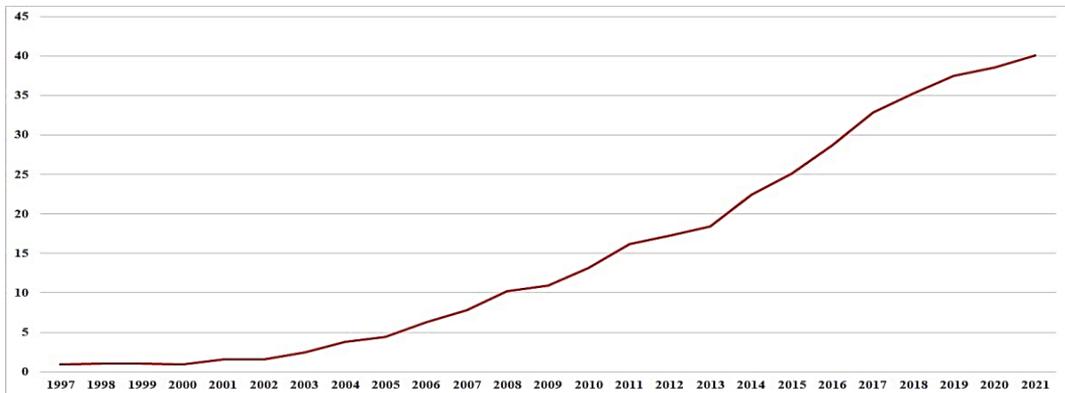


Figure 3: Growth of Indian Wind Power Installed Capacity in GW

2. Objective Formulation

The objective of the current study is to enhance the yearly financial output of the wind farm and it can be calculated as per Eq. (1).

$$\text{Maximize } A = [B - C] \times E_{yr} \quad (2)$$

Where A represents the annual profit, B suggests the selling charge per unit of wind power, C signifies the generation charge per unit of power and E_{yr} terms the annual generated wind energy. The present study deemed the expenditure function acknowledged by Wilson et al. (2018) for the Jafrabad area. The flow of air form deemed in the existing study has been shown in Fig. (4).

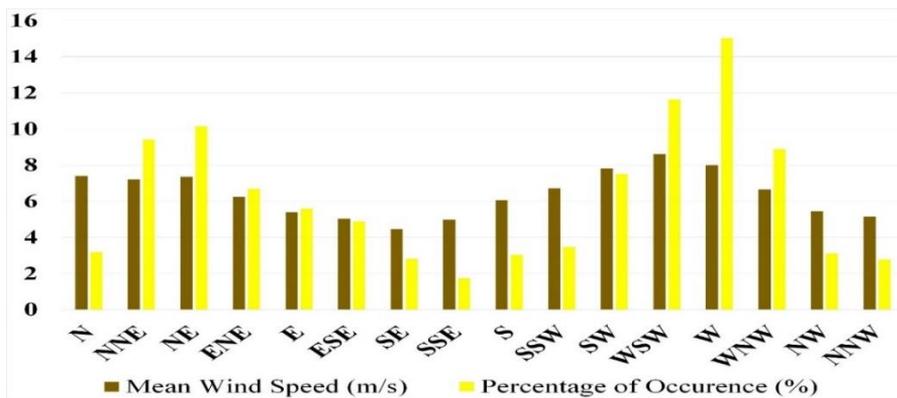


Figure 4: Wind Flow Configuration for Jafrabad Area of Gujarat, India

3. Optimization Algorithm

Genetic Algorithm (GA) has been exercised to optimize the yearly profit for onshore wind farms in Jafrabad, India. This nature-motivated Artificial Intelligence (AI) meta-heuristic

algorithm has been applied in several engineering domains. GA has been briefly expressed in the following manner.

1. Determine the critical components like populace quantity and recurrence quantity.
2. Recruit the population unsystematically.
3. Review the relevance of the discrete chromosomes.
4. Start the crossover system.
5. Accomplish the mutation scheme.
6. Review the suitability of the fresh chromosomes shaped by crossover and mutation approaches.
7. Stipulate the most enhanced consequence concerning the choice-maker's fondness.

This research has betrothed a state-of-the-art dynamic technique for placing the magnitudes of crossover and mutation factors. The dynamic crossover probability has been calculated as per Eq. (2).

$$c_v = c_s + \left\{ 0.1 \times (R_c/R_m)^{\frac{8}{7}} \right\} \quad (2)$$

Where c_v means the growing crossover prospect. c_s denotes the static value of the crossover factor. R_c indicates the contemporary recurrence count and R_m symbolizes the maximum reiteration count. The dynamic mutation probability has been considered as per Eq. (3).

$$m_v = m_s + \left\{ 0.01 \times (R_c/R_m)^{\frac{8}{7}} \right\} \quad (3)$$

Where m_v means the mounting mutation prospect, m_s denotes the static value of the mutation factor.

4. Results and Discussions

1500 W wind turbine of wheel radius 38.5 m has been involved for the existing research. To decline the wake loss concern, the distance between the two nearby turbines has been upheld as 8 times the wheel radius. The cut-in airstream speed has been considered as 3.5 m/s whereas the cut-off airstream speed for the deemed turbine is 20 m/s to avert conceivable ravages.

The wind farm cost-related features and their values obligatory for calculating the generation charge function have been considered as demarcated by Bhattacharjee et al. (2021). Three layouts of dimensions 3000 m x 3000 m, 4000 m, and 5000 m x 5000 m have been considered. The static values for crossover and mutation factors have been considered as 0.4 and 0.05 respectively.

The maximum generation count has been deemed as 50. The optimal layout plans have been displayed in Figs. (5)-(10).

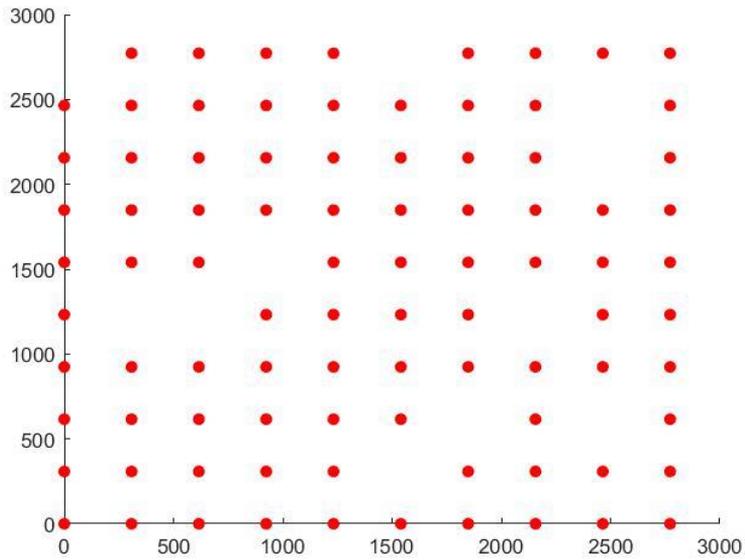


Figure 5: Optimal Placement of Wind Turbines Using Genetic Algorithm with Static Values of Crossover and Mutation Factors for Layout of Dimension 3000 m x 3000 m

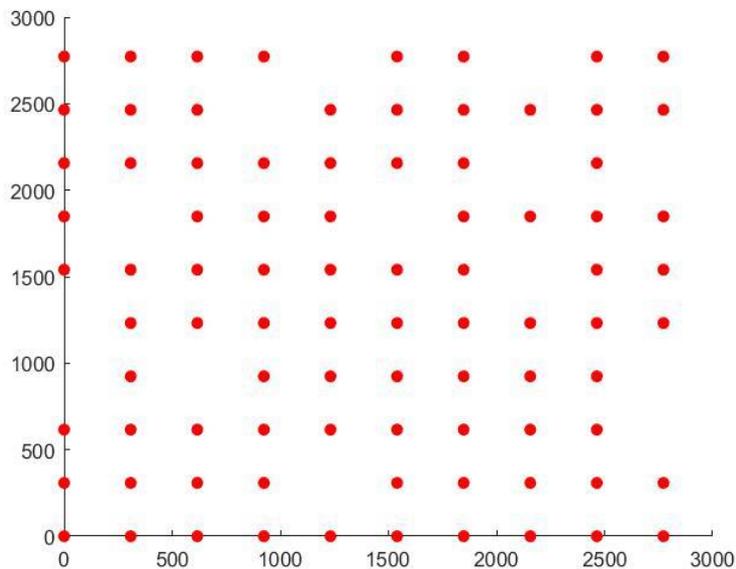


Figure 6: Optimal Placement of Wind Turbines Using Genetic Algorithm with Dynamic Values of Crossover and Mutation Factors for Layout of Dimension 3000 m x 3000 m

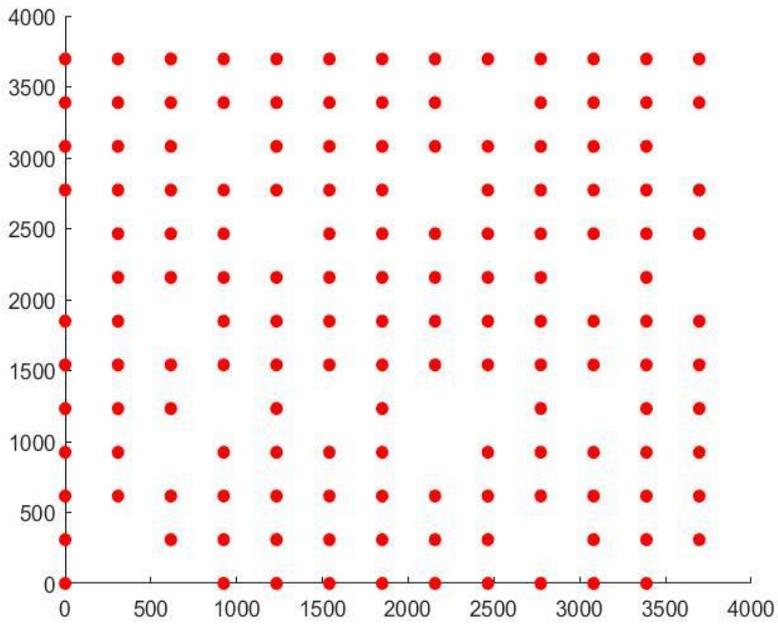


Figure 7: Optimal Placement of Wind Turbines Using Genetic Algorithm with Static Values of Crossover and Mutation Factors for Layout of Dimension 4000 m x 4000 m

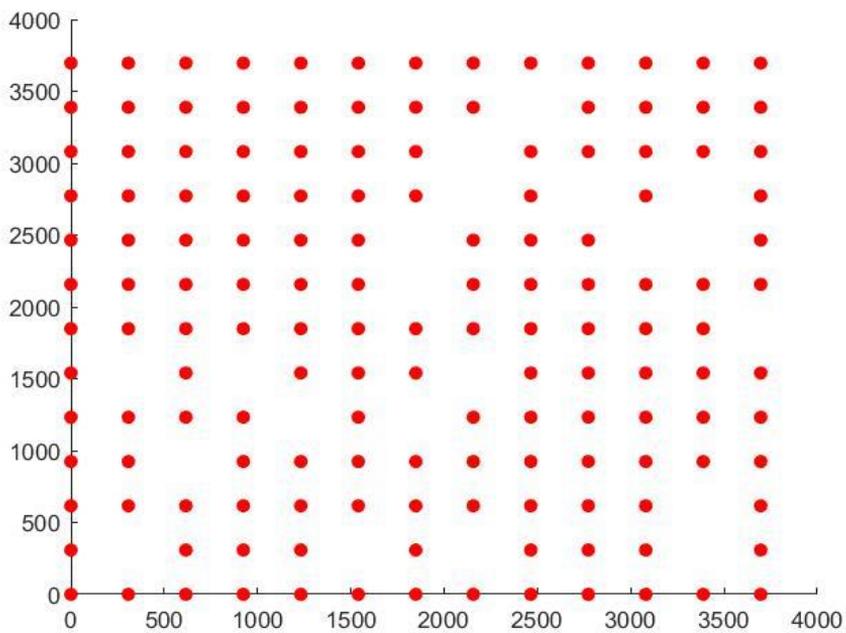


Figure 8: Optimal Placement of Wind Turbines Using Genetic Algorithm with Dynamic Values of Crossover and Mutation Factors for Layout of Dimension 4000 m x 4000 m

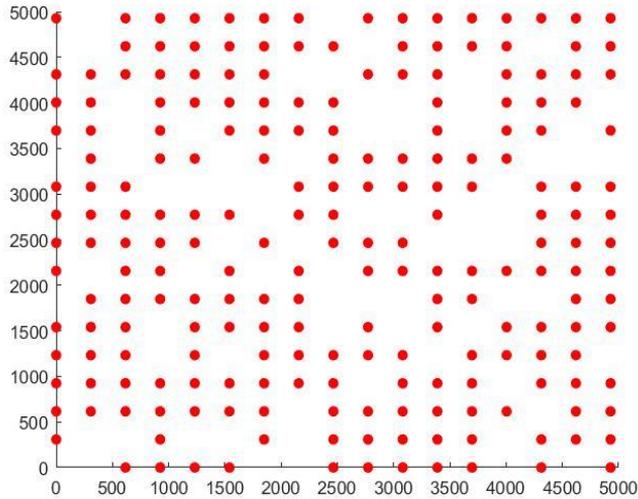


Figure 9: Optimal Placement of Wind Turbines Using Genetic Algorithm with Static Values of Crossover and Mutation Factors for Layout of Dimension 5000 m x 5000 m

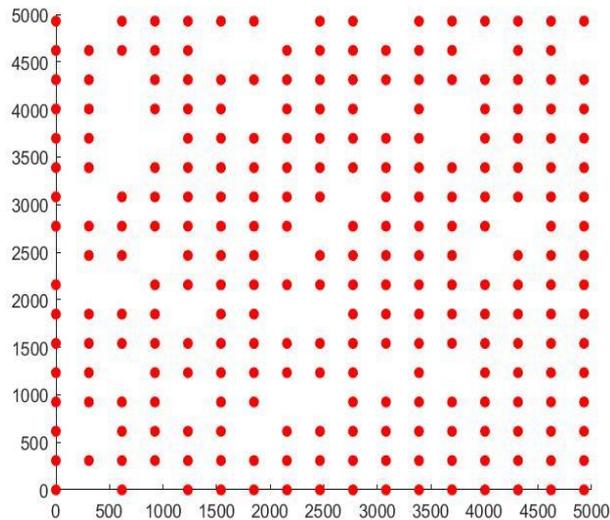


Figure 10: Optimal Placement of Wind Turbines Using Genetic Algorithm with Dynamic Values of Crossover and Mutation Factors for Layout of Dimension 5000 m x 5000 m

The selling price for wind energy in India has been considered as USD 0.033/kWh for computing the annual profit of the wind farm. The optimal values of annual profit and consequent count of wind turbines attained by both approaches of GA have been presented in Table 1.

Optimization Method	Optimal Yearly Profit for Layout of 3000 m x 3000 m (in USD)	Optimal Amount of Wind Turbines Layout of 3000 m x 3000 m	Optimal Yearly Profit for Layout of 4000 m x 4000 m (in USD)	Optimal Amount of Wind Turbines Layout of 4000 m x 4000 m	Optimal Yearly Profit for Layout of 5000 m x 5000 m (in USD)	Optimal Amount of Wind Turbines Layout of 5000 m x 5000 m
Standard GA with Static Factors for Crossover and Mutation	20647	89	32989	147	53511	213
Proposed Enhanced GA with Dynamic Factors for Crossover and Mutation	20944	86	33567	148	57885	250

Table 1 Assessment of Optimal Outcomes

The research consequences confirm the advantage of the proposed dynamic approach over the static method of appointing the factors of crossover and mutation approach for GA as it attained a better annual profit as revealed in Table 1.

5. Conclusion

The study aims to augment the yearly profit of a wind farm in Jafrabad, India. The optimization consequences approve the higher suitability of the proposed dynamic methods of allocating the prospects of crossover and mutation of GA to enhance the financial output of the farm. The present work can create immaculate possibilities for wind farm plan enrichment and monetary constancy of wind power projects.

6. Acknowledgement

The first author acknowledges the monetary assistance of Jadavpur University, India for sustaining the existing study.

References

- [1] Bhaskar, U. (2021). Adani Renewable places lowest bid in SECI's wind auction. Mint. Retrieved October 10, 2021, from

<https://www.livemint.com/companies/news/adani-renewable-bids-the-lowest-tariff-of-rs-2-77-per-unit-in-seci-wind-auction-11615823955810.html>

- [2] Bhattacharjee, P., Jana, R., & Bhattacharya, S. (2021). A Relative Analysis of Genetic Algorithm and Binary Particle Swarm Optimization for Finding the Optimal Cost of Wind Power Generation in Tirumala Area of India. *ITM Web of Conferences*, 03016. doi:10.1051/itmconf/20214003016
- [3] Bhattacharjee, P., Jana, R., & Bhattacharya, S. (2021). An Enhanced Genetic Algorithm for Annual Profit Maximization of Wind Farm. *Journal of Information Systems & Operations Management*, 15(2).
- [4] Bhattacharjee, P., Jana, R., & Bhattacharya, S. (2021). An Improved Genetic Algorithm for Yearly Profit Maximization of Wind Power Generation System. *The 31st ACM SIGDA University Demonstration*. New York, USA.
- [5] Bhattacharjee, P., Jana, R., & Bhattacharya, S. (2022). A Novel Artificial Intelligence Technique for Enhancing the Annual Profit of Wind Farm. *27th International Conference on Information Technology (IVUS 2022)*. Kaunas, Lithuania.
- [6] Bhattacharjee, P., Jana, R., & Bhattacharya, S. (2022). A Novel Artificial Intelligence-Assisted Meta-heuristic Method for Augmenting the Annual Profit of Wind Farm. *National E- Conference on "Recent Trends in Computer Engineering & Applications"*. Maharashtra, India.
- [7] Bhattacharjee, P., Jana, R., & Bhattacharya, S. (2022). A Relative Assessment of Genetic Algorithm and Binary Particle Swarm Optimization Algorithm for Maximizing the Annual Profit of an Indian Offshore Wind Farm. *Second International Conference on Applied Engineering and Natural Sciences*. Konya, Turkey.
- [8] Bhattacharjee, P., Jana, R., & Bhattacharya, S. (2022). Amplifying the Financial Sustainability of a Wind Farm near the Coast of Gujarat with an Augmented Genetic Algorithm. *International Symposium on Information & Communication Technology 2022*. Greater Noida, India.
- [9] Bhattacharjee, P., Jana, R., & Bhattacharya, S. (2022). An Enriched Genetic Algorithm for Expanding the Yearly Profit of Wind Farm. *Second International Symposium on Intelligence Design (ISID 2022)*. Tokyo, Japan.
- [10] Bhattacharjee, P., Jana, R., & Bhattacharya, S. (2022). Augmenting the Yearly Profit of Wind Farm. *The 14th Regional Conference on Electrical and Electronics Engineering of Chulalongkorn University*. Bangkok, Thailand.
- [11] Bhattacharjee, P., Jana, R., & Bhattacharya, S. (2022). Boosting the annual profit of an offshore wind farm in India with a bio-inspired meta-heuristic scheme. *Environmental Challenges*, 9, 100642. doi:10.1016/j.envc.2022.100642
- [12] BP. (2022). *BP Statistical Review of World Energy*. Retrieved April 19, 2022, from <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>

- [13] Central Electricity Authority. (2022, April 16). *Power Sector at a Glance All India*. Retrieved May 3, 2022, from Ministry of Power, Government of India: <https://powermin.gov.in/en/content/power-sector-glance-all-india>
- [14] Climate Focus. (2015). *The Paris Agreement Summary*. Retrieved May 2, 2022, from Climate Focus: <https://climatefocus.com/sites/default/files/20151228%20COP%2021%20briefing%20FIN.pdf>
- [15] Climatelinks. (2019, January 31). *Greenhouse Gas Emissions Factsheet: India*. Retrieved May 3, 2022, from Climatelinks: <https://www.climatelinks.org/resources/greenhouse-gas-emissions-factsheet-india>
- [16] *Electricity Production by Source*. (2022). Retrieved April 19, 2022, from Our World in Data, World: <https://ourworldindata.org/grapher/electricity-prod-source-stacked>
- [17] Emission Database for Global Atmospheric Research. (2019). *GHG Emissions per Capita*. Retrieved May 3, 2022, from Emission Database for Global Atmospheric Research: <http://edgar.jrc.ec.europa.eu/>
- [18] Enerdata. (2020). *Electricity Production*. Retrieved July 23, 2021, from Global Energy Statistical Yearbook 2021: <https://yearbook.enerdata.net/electricity/world-electricity-production-statistics.html>
- [19] Enerdata. (2020). *Global Energy Statistical Yearbook*. Retrieved September 05, 2020, from Enerdata: <https://yearbook.enerdata.net/>
- [20] Germanwatch e.V. (2021, November 9). *Climate Change Performance Index 2022*. Retrieved April 30, 2022, from Climate Change Performance Index: <https://ccpi.org/download/climate-change-performance-index-2022-2/>
- [21] Global Wind Energy Council. (2014). *Global Wind Energy Outlook*. Retrieved September 06, 2020, from Global Wind Energy Council: http://www.gwec.net/wp-content/uploads/2014/10/GWEO2014_WEB.pdf
- [22] Global Wind Energy Council. (2020). *India Wind Outlook Towards 2022: Looking beyond headwinds*. Retrieved July 23, 2021, from GWEC: <https://gwec.net/india-wind-outlook-towards-2022-looking-beyond-headwinds/>
- [23] Google Earth. (n.d.). *Jafraabad*. Retrieved May 16, 2022, from Google Earth: <https://earth.google.com/web/search/Jafarabad,+Gujarat/@20.86907745,71.3649666,7.05425093a,5244.91936058d,35y,0h,45t,0r/data=Cn0aUxJNCiUweDNiZTI1MjNiZTBhZDU3ZjU6MHhiNzg1ZTllMWU3NzYxNTViGTKmBdRA3jRAIQkoHmFii1FAKhJKYWZhcMFiYWQsIEdlamFyYXQYAiABliYKJAKsSNPmHDg>
- [24] *GWEC Global Wind Report 2019*. (n.d.). Retrieved September 06, 2020, from Global Wind Energy Council: <https://gwec.net/global-wind-report-2019/>
- [25] International Energy Agency. (2021). *Global Energy Review 2021*. Retrieved July 30, 2021, from International Energy Agency: <https://www.iea.org/reports/global-energy-review-2021/renewables>

- [26] IRENA Renewable Power Generation Costs in 2017. (2018). Retrieved September 07, 2020, from International Renewable Energy Agency: <http://www.irena.org/publications/2018/Jan/Renewable-power-generation-costs-in-2017>
- [27] Jana, R., & Bhattacharjee, P. (2017). A multi-objective genetic algorithm for design optimisation of simple and double harmonic motion cams. *International Journal of Design Engineering*, 7(2), 77-91. doi:10.1504/ijde.2017.089639
- [28] Kumar, R., Stallard, T., & Stansby, P. (2020). Large-scale offshore wind energy installation in northwest India: Assessment of wind resource using Weather Research and Forecasting and levelized cost of energy. *Wind Energy*, 24(2), 174–192. doi:10.1002/we.2566
- [29] R, K., K, U., Raju, K., Madurai Elavarasan, R., & Mihet-Popa, L. (2020). An Assessment of Onshore and Offshore Wind Energy Potential in India Using Moth Flame Optimization. *Energies*, 13(12), 3063. doi:10.3390/en13123063
- [30] United Nations. (2015). *The Paris Agreement*. Retrieved May 2, 2022, from UNFCCC: https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf
- [31] United Nations Statistics Division. (2022). Retrieved May 1, 2022, from <https://unstats.un.org/sdgs/indicators/database/>
- [32] United Nations Statistics Division. (2022, April 11). *Installed renewable electricity-generating capacity (watts per capita)*. Retrieved May 4, 2022, from United Nations Statistics Division: <https://unstats.un.org/sdgs/metadata/files/Metadata-07-0b-01.pdf>
- [33] WHO. (2015, November). *Climate change and human health*. Retrieved April 30, 2022, from WHO: <https://web.archive.org/web/20210103002854/https://www.who.int/globalchange/global-campaign/cop21/en/>
- [34] Wikipedia. (n.d.). *Climate Change*. Retrieved April 29, 2022, from Wikipedia: https://en.wikipedia.org/wiki/Climate_change
- [35] Wikipedia. (n.d.). *Climate change in India*. Retrieved April 30, 2022, from https://en.wikipedia.org/wiki/Climate_change_in_India
- [36] Wilson, D., Rodrigues, S., Segura, C., Loshchilov, I., Hutter, F., Buenfil, G., Cussat-Blanc, S. (2018). Evolutionary computation for wind farm layout optimization. *Renewable Energy*, 126, 681-691. doi:10.1016/j.renene.2018.03.052

CONSIDERATIONS REGARDING THE NEW CHALLENGES OF LEADERSHIP IN THE NEW ECONOMIC - SOCIAL REALITY

Elisabeta Andreea BUDACIA¹

Lucian Constantin Gabriel BUDACIA²

Marian Florin BUSUIOC³

Abstract

In the last decades, specialized works by established authors have addressed the subject of leadership, either from the perspective of effectiveness in terms of leadership, or from the perspective of behavioral patterns. Studies related to transformational leadership gained momentum in the 90s; currently the problem addressed is regarding aspects such as the applicability of the concept in different fields. Compared to traditional forms of leadership, transformational leadership is a participatory and democratic process. Transformational leadership effects not only the transformation of employees, but also of organizations, by increasing their efficiency and ability to adapt to changes. Today, leaders must demonstrate their involvement and commitment to the management system, to the organization they belong to. True leaders know the importance of human resources, which today has become human capital. They understand the need for respect and compassion, trust and autonomy of those in the team. From the point of view of the research methodology, we had in mind a balanced mix on the quantitative - qualitative axes.

Keywords: Leader, Leadership, Transformation, New Reality

JEL Classification: M10, M20

1. Introduction – About Leadership

In the last decades, specialized works by established authors have addressed the subject of leadership, either from the perspective of effectiveness in terms of leadership, or from the perspective of behavioral patterns. J. Kouzrs and B. Posner identified 10 truths about leadership, considering the person of the leader and what he does or must do:

- 1) Change things up
- 2) Credibility is fundamental
- 3) Values drive commitment
- 4) Focusing on the future characterizes exceptional leaders

¹ PhD, Senior Lecturer, Romanian American University, andreea.budacia@rau.ro

² PhD, Junior Lecturer, Romanian American University, lucian.constantin.budacia@rau.ro

³ PhD, Senior Lecturer, Romanian American University, marian.florin.busuioc@rau.ro

- 5) You can't do it alone
- 6) Trust is crucial
- 7) Greatness is forged in challenges
- 8) You either lead by example or you don't lead at all
- 9) The best leaders know how to learn best
- 10) Leadership is about the soul

We can thus extract the most relevant keywords, which turn into actions, from the vocabulary of a leader: change, trust, values, vision, orientation towards the future, team, assumed challenges, the power of example, empathy and soul. Also, the most relevant qualities of a modern leader are very well summarized:

- humility – the ability to distribute authority and invite feedback;
- trust – leaders must earn the trust of their teams through their actions:
- transparency - which is essential to build trust;
- empowerment – leaders empower their people to take responsibility, make decisions, lead and innovate;
- activation – employees must be activated to make a difference;
- prioritizing well-being – staff well-being must be a priority for leaders;
- mentoring – when a leader is an active mentor, employees perceive their leader more favorably;
- empathy – by showing empathy, leaders develop stronger bonds with their teams;
- recognition – appreciation is essential to nurturing a happy and healthy team.

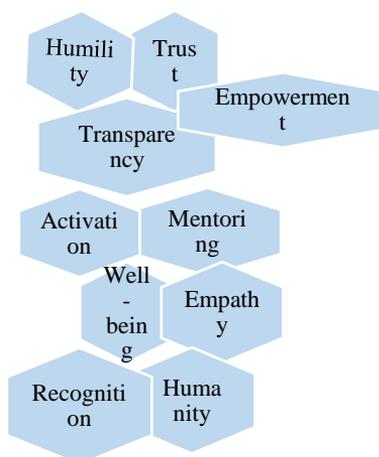


Fig. no. 1. The qualities of a modern leader

2. Methodological aspects

From the point of view of the research methodology, we had in mind a balanced mix on the quantitative - qualitative axes. The quantitative part is based on the analysis of secondary data (various studies, reports, articles and research in the specialized literature) relevant to the research topic, combined with the critical and creative reinterpretation and reinterpretation of the assessments in the scientific literature. The qualitative part focused on providing relevant information through the following concrete methods: comparative analysis, and the collection of examples of good practices in the field (throughout the documentation and elaboration of the research). The research was based on the use of secondary sources and data and entailed reviewing the existing literature. The research was mainly based on the following research methods:

- a) analysis method;
- b) the historical method;
- c) comparison method;
- d) the descriptive method/analysis, used in particular for the description/presentation of the specific elements of the addressed research topic.

The main limits of the research are related to the dynamism of the problem addressed and the impossibility of analyzing, processing and interpreting all the data and information and studies available in the field, the issue of leadership enjoying enormous interest among specialists and the scientific community.

3. Literature review - The concept of transformational leadership

The concept of transformational leadership was introduced by James MacGregor Burns, in 1978, being associated with a study about political leaders, and in the mid-80s the methodological and theoretical framework for studying this form of leadership was developed in the field of organizational psychology [Bass, 1985]. Studies related to transformational leadership gained momentum in the 90s; currently, the issue addressed concerns aspects such as the applicability of the concept in different fields, including the educational one [Hallinger, 2003; Vanderheide, 2017], as well as the differences induced by some socio-demographic variables (age, gender, position occupied in the organization) in the orientation of preferences towards certain forms of leadership (transformational, transactional, laissez-faire) – Northouse, 2018.

Joseph Rost of the University of San Diego, in his book *Leadership for the 21st Century* (1991), defines leadership based on the post-industrial perspective; thus, "leadership is a relationship of influence between leaders and subordinates who intend real changes that reflect their mutual goals." This is a new stage, namely the transition from the industrial concept of leadership (leader-centered view) to the post-industrial concept of leadership. Analyzing this definition more closely, we can deduce a series of essential elements:

- (1) This relationship is based on multidirectional influence; thus, the relationship is not based on authority, but rather on persuasion.
- (2) Leaders and subordinates are partners in this relationship, so leaders and subordinates do leadership.
- (3) The goal is to achieve/determine some changes, which must generate visible, important reactions.
- (4) The changes that leaders and subordinates follow reflect their mutual goals. The key is that these desired changes must not only reflect the desires of the leader, but also the desires of subordinates.

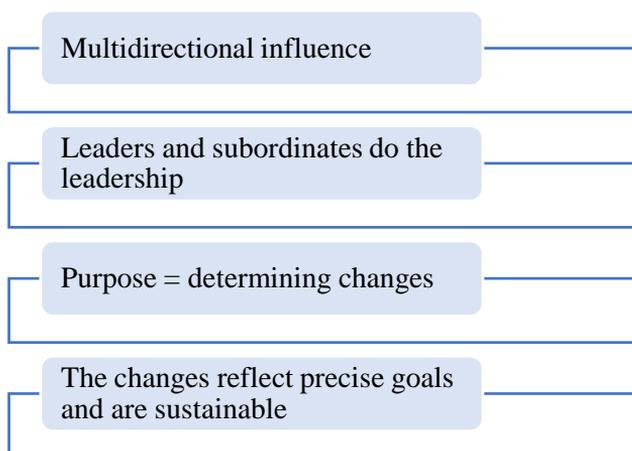


Fig. no. 2. The essential elements of transformational leadership

Zlate [2007, p. 235] observes that "the new form of leadership goes beyond cost-benefit exchanges, focusing on the leader's inspiration of subordinates to perform above set standards. Transformational leadership involves increasing subordinates' emotional attachment to the organization, increasing their motivational resources, subordinates' personal identification with leaders, sharing the leaders' vision and translating it into reality." For Burns (2003) change in leadership is closely related to creativity; creative leaders are those whose insight is able to generate transformation, "new spaces and new perspectives for action", which allow finding vital answers to fundamental questions, in the context of situations of crisis and change.

A close concept is that of charismatic leadership, which has a longer history than transformational leadership. Over time, the components and sources of charismatic leadership have been described differently. Thus, Weber (1947) considers charisma as the "divine gift" of leading in new, inspiring ways. Shamir, House, and Arthur (1993) discuss how charismatic leaders use followers' self-concept, social identification, and value internalization to exert and strengthen their influence.

Conger and Kanungo (1987) believed that leaders' influence is based on the process by which followers attribute charismatic qualities to them. Last but not least, the existence of a potential negative, destructive effect of charisma, associated with egocentric leaders, who exploit the acquired influence over followers in their own interest, has been suggested [Khoo & Burch, 2008]. Such practices, oriented to the manipulation of subordinates, not to their inspiration or development, were also identified by Bass (1998), who describes them under the name of pseudo-transformational leadership.

The main characteristics of charismatic leaders are [Conger & Kanungo, 1998]: self-confidence; the vision; articulating the vision; strong convictions; unconventional behavior; agents of change; sensitivity to environmental and resource constraints. Some of these characteristics were later incorporated by the components of transformational leadership. For example, focusing on the exceptional qualities of the leader [Yukl, 2010], implied, to a certain extent, the development of followers' dependence on the charismatic leader.

4. Leadership challenges in the new post-pandemic and economic crisis context

The pandemic period, which we recently went through, which seems not to have ended definitively (in fact, the time horizon is not so clearly visible) has brought a series of more important changes, some of which are worth highlighting : work from home (telework) or in a hybrid system, the expansion of online commerce, greater concern for product hygiene, greater interest in one's own health, but also in the health of those around, online education, digitization, etc.

The new post-pandemic context, amplified by the new crisis determined by the war in the proximity of national borders, as well as by the energy crisis, has determined new challenges for leaders, bringing leadership into a new paradigm. In this situation, the allocation of resources for the development of the activity will be much more important, and the saving and judicious allocation will be in the foreground.

Thus, we can observe certain aspects that are more clearly defined: new human resource demands, the acceleration of digitization, the perpetuation of uncertainty.

The issue of human resources seems to be extremely important, because we are considering new demands of employees, which are becoming important challenges.

Employee motivation is a decisive factor for finding competitive strategies and implementing them. Investing in people, promoting a healthy organizational climate based on communication and trust, and a realistic vision regarding the development of a business are basic, priority conditions for motivating employees.

Another element, which has become increasingly important, is time management; thus, organization, prioritization and planning require more attention and effectiveness. The expansion of remote work brings to the fore, more obviously, the previously mentioned issues.

Time management requires self-discipline, perseverance and punctuality. The benefits of correct time management are multiple; among the most eloquent are: greater productivity,

a better professional reputation, less stress, better communication; balance in professional and personal life.

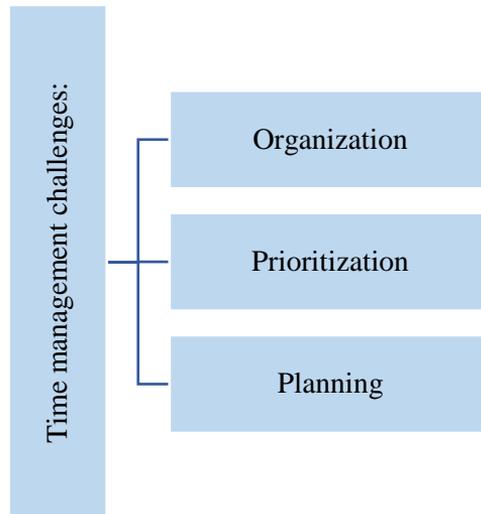


Fig. no. 3. Time management challenges

The elements that will be at the forefront of the leaders' concerns now and in the near future are: digitization and its implementation, the prudent allocation of the company's resources, in general, but especially of the energy ones, in particular, the resilience and sustainability of the business, the retention and attraction of the resource quality human resources, compatible with the profile of the respective company.

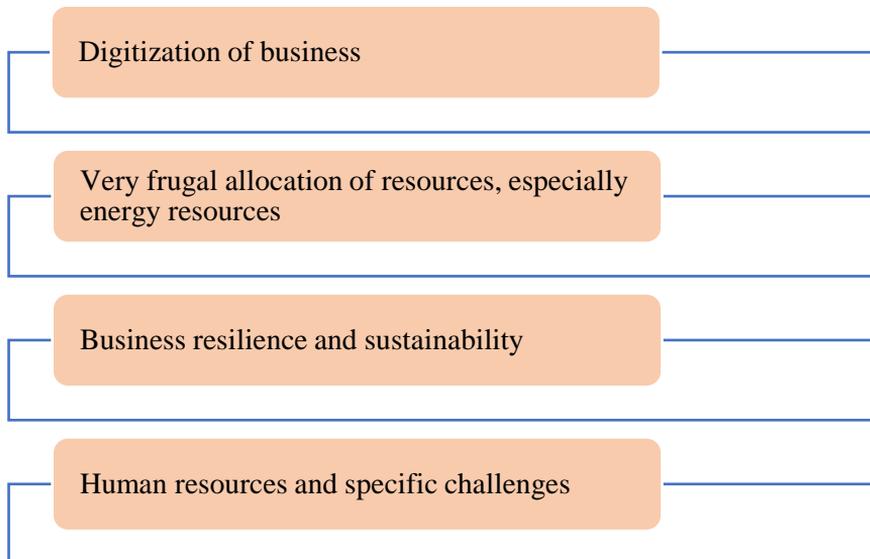


Fig. no. 4. The foreground of leaders' concerns in the new context

■ **Business digitization** involves activating, improving or transforming the business process through the use of digital technologies (software, equipment, etc.) and digitized data. Digitizing and transforming the business process to create an outstanding customer experience is absolutely necessary for any company that wants to evolve.

■ **Very frugal allocation of resources, especially energy resources**

Judicious, prudent allocation of resources is vital in the new context of energy scarcity; this implies the elimination of non-essential consumption, the reduction of consumption on the business components that allow this, the serious analysis of the potential profit, in the situation of the development of new products, which presuppose energy consumption and new commitments of the organization in this direction.

■ **Business resilience and sustainability**

Increasing the level of resilience of a business is an imperative, but also a complicated process in equal measure, as it involves all departments of a company. Even though digital technology contributes significantly to achieving this goal, experience shows us that true resilience requires a balanced focus on several levels: financial, operational, technological, organizational, reputational and business model.

The sustainability of a business has the role of ensuring a sustainable development of businesses in the community in which they operate. Its purpose is to value profit, community and the environment. A business is sustainable by using innovative techniques, by switching to ecological technologies and by investing in the future.

■ **Human resources and specific challenges**

The existing reality in renowned companies in the world shows us that a company remains competitive only if it has a high-performance management in the use of human resources. Within these resources, individual performance must be high enough for the organization to achieve excellence. Individual performance depends on the motivation system, on the willingness of employees to put in the necessary effort at work, on the development and training of employees, as well as on their ability to perform what is asked of them. The trend in recent years shows that jobs that require skills and high skills are increasing, while those requiring low qualification are decreasing. Technological changes determine a need for multi-skilled labor, and the role of human resources management becomes more and more important. Thus, the personnel qualification evolves in the direction of increasing the qualification level, acquiring new qualifications, as well as broadening the qualifications.

5. Conclusions

Compared to traditional forms of leadership, transformational leadership is a participatory and democratic process. Transformational leadership effects not only the transformation of employees, but also of organizations, by increasing their efficiency and ability to adapt to changes. Therefore, transformational leaders are able to achieve superior performance,

having the ability to generate, among employees, awareness, and acceptance of the organization's mission, as well as to motivate employees to look beyond their own interests, focusing on the interests of the group.

Today, leaders must demonstrate their involvement and commitment to the management system, to the organization they belong to, in ways that:

- to ensure that the business processes of the organization are perfectly integrated and that they are approached holistically;
- to promote awareness of the process-based approach;
- to ensure that the management system fulfills its intended results;
- to support other relevant management roles to demonstrate their own leadership;
- to ensure that the policy is communicated, understood and applied by the entire organization.

The pandemic has changed the way companies relate to technology. For many companies it was the only chance of survival and they had to implement technology for a resilient management and better communication. Thus, digital skills have become very important for all employees of a company.

The future is uncertain, and change is coming fast, hard and irreversible. Companies need to look beyond short-term results. They must be able not only to withstand threats or unpredictable changes, but also to emerge stronger from these difficult, uncertain times. to be more resilient, but also sustainable.

The duality of the economic environment and the leaders, the complex links between the environment and the organization developed through the leaders, can be summarized in the figure below:

The leader of the future		The future economic environment
Proactively	↔	Uncertain
Professional	↔	Diverse
Flexible	↔	Challenging
Agile	↔	Dynamic
Digitally competent	↔	Digitized

Fig. no. 5. The duality of the economic environment and the leaders

High performing leaders have a clear vision of the future and communicate it with passion to the people on their team. Basically, he inspires them to follow, then creates the conditions

for them to get results and love their work, to feel safe to express their opinions, concerns and vulnerabilities. They give them the courage to admit their mistakes, to look constructively at corrections, feedback and prompts for discipline as means to improve their performance and develop.

True leaders know the importance of human resources, which today has become human capital. Human capital is a measure of a person's professional skills and competencies. An employee's education, experience, and skills have economic value. Thus, labor is more than a cost in business, it is a core business activity, a value that can be maximized through strategic approaches. They understand the need for respect and compassion, trust and autonomy of those in the team. To demonstrate and develop their skills, people need appropriate conditions; it matters enormously that they are paid fairly, but it is essential that they are treated with humanity.

Leadership must consider that investing in a strong IT infrastructure is necessary to manage cyber threats and avoid technology malfunctions. Resilient companies maintain and use high-quality data in a way that ensures confidentiality, in compliance with all regulatory requirements. At the same time, it implements IT projects large and small – with quality, on time and on budget – to keep up with customer needs, competitive requirements and regulatory requirements.

The business environment is constantly changing, so leaders must also adapt to keep up with the changes. It is absolutely necessary that the leaders of the future have new approaches, because it is more and more obvious that the future is not only uncertain but also very dynamic and different. Keeping up with the challenges of the future must be a priority on a leader's agenda. We believe that leaders who are open to challenges are more likely to succeed in a future characterized by diversity and uncertainty. In this situation, the clear definition of the organization's purpose and vision acquires new values, and their communication to employees and collaborators is the key to success.

Leaders often cannot list all the possibilities that the economic reality can propose for the business they represent. Precisely for this reason, leaders have the obligation to have a proactive, anticipatory approach, evaluating the potential disruptive effects, responding to disruptions in the business environment or to a certain economic setback, they can create a competitive advantage that leads to a superior performance in the next cycle technological and economic.

References

- [1] Bass, B.M. (1985), *Leadership and performance beyond expectations*, New York: Free Press
- [2] Hallinger, P. (2003), *Leading educational change: Reflections on the practice of instructional and transformational leadership*, Cambridge Journal of education, 33(3), 329-352.

- [3] Vanderheide, G. M. (2017), *The Need For Transformational Leaders In Education During Times of Change in British Columbia* (Doctoral dissertation, City University of Seattle).
- [4] Zlate, M. (2007), *Tratat de psihologie organizațional-managerială*, Volumul II, Iași: Polirom
- [5] Conger, J. A., & Kanungo, R. N. (1998), *Charismatic leadership in organizations*, Thousand Oaks, California: Sage.
- [6] Yukl, G. A. (2010), *Leadership in Organizations*, London: Pearson

Bibliography

- Bass, B.M. (1985), *Leadership and performance beyond expectations*, New York: Free Press
- Burns, J. M. (1978), *Leadership*, New York: Harper & Row
- Conger, J. A., & Kanungo, R. N. (1998), *Charismatic leadership in organizations*, Thousand Oaks, California: Sage.
- Hallinger, P. (2003), *Leading educational change: Reflections on the practice of instructional and transformational leadership*, Cambridge Journal of education, 33(3), 329-352.
- J. Kouzrs, B. Posner (2010), *Adevărul despre leadership*, BMI Publishing, traducere din 2015
- Northouse, P. G. (2018), *Leadership: Theory and practice. Thousand Oaks, California: Sage Publications.*
- Shamir, B., House, R. J., & Arthur, M. B. (1993), *The motivational effects of charismatic leadership: A self-concept-based theory*, Organizational Science, 4, 1–17.
- Vanderheide, G. M. (2017), *The Need For Transformational Leaders In Education During Times of Change in British Columbia* (Doctoral dissertation, City University of Seattle).
- Zlate, M. (2007), *Tratat de psihologie organizațional-managerială*, Volumul II, Iași: Polirom
- Yukl, G. A. (2010), *Leadership in Organizations*, London: Pearson
- Yukl, G. (2012). Effective leadership behavior: What we know and what questions need more attention. *Academy of Management Perspectives*, 26(4), 66-8

CROSS PANDEMIC DIGITAL SKILLS NEED

George CĂRUȚAȘU¹

Nicoleta Luminita CĂRUȚAȘU²

Beatrice Gabriela COTET³

Abstract

The pandemic of COVID 19 is perceived by the literacy as digital improving skills toward the change off lifestyle and workflow. Nevertheless, beyond the personal attitude regarding those changes, the digital skills perceived usefulness and use rose as a direct result. The digital skills, covered in The Digital Economy and Society Index, published by EU Commission since 2014, are divided into private life, employee and learning scope of usage. The analyses also comprise the human capital, connectivity, integration of digital technology, and digital public services. This article presents the findings of a cross-pandemic research, in the period of 2019-2022, regarding the digital skills perceived usefulness, profiling depending on the scope of usage and the intention to enhance the digital skills by assisted training. The paper presents the research results of an enquiry made among the students regarding perceived usefulness, use and training intention for digital skills enhancements. It covers the bachelor and master's degree programs, with the Computer Science, Social Sciences and Engineering as field of study. The study was made using 266 answers from the above-mentioned categories.

Keywords: digital competences, training need, digital economy, COVID pandemic

JEL Classification: M15

1. Introduction

The EU Commission defined the digital competence as “the confident, critical and creative use of ICT to achieve goals related to work, employability, learning, leisure, inclusion and/or participation in society” [14]. Furthermore, the report of DigComp states as main areas for digital competence the information and data literacy, communication and collaboration, digital content creation, safety and problem solving, with a division in specific and transversal competences [24].

However, from the organizational point of view, the Digital Economy and Society Index (DESI) 2022 [9] introduces the framework to measure the society digitization which includes the human capital, digital infrastructures, integration of digital technology, and digital public service. Nevertheless, the human capital is assessed using the Digital Skills Indicator, based on the above mentioned DigComp framework. Also, it is introducing a

¹ Prof. PhD, Romanian-American University, george.carutasu@rau.ro

² Prof. PhD, University POLITEHNICA of Bucharest, nicoleta.carutasu@upb.ro

³ Lect. PhD, University POLITEHNICA of Bucharest, beatrice.cotet@upb.ro

scale to assess the citizen lacking digital skills: individuals with low digital skills, individuals with narrow digital skills, individuals with limited digital skills, individuals with no digital skills and not assessed. This category of citizen lacking digital skills is important for the paper objective because they are the primary target for training plan assessment. Furthermore, the individual is using digital skills in private life, as an employee and as a student.

The concept of digital competence and digital literacy is in depth analyzed in [17] where authors provide a literature review for examining in a structured fashion the usage of the above-mentioned terms in the scientific approach. In their article [18], the authors proposed instead of the digital skills the concept of digital intelligence. The composition of digital intelligence covers algorithms, and evaluation, abstraction, decomposition, and using patterns, emotional communication, cybersecurity, and digital identity. The need of digitalization for all ages categories transpired from the article [11] the authors emphasizing the age division and peculiarity for 50+ digital skills. The identification and self-assessment of the digital skills is also presented in [23], enhancing the results for a survey made among more than one thousand professionals. In addition to DigComp, the authors introduce the creative thinking as a digital skill.

The gap between the required digital skills by new emerging jobs and acquired skills during the conventional education is highly debated in literacy [12]. In the report Bridging the digital skills gap, the authors describe the situation in Canada and the development of “digital careers”. Moreover, because of the rapid development of the requirements regarding new digital technologies, the formal education cannot provide digital skills enhancement for the student for not invented or not spread technologies. Nevertheless, the same report, offers a collection of educational programs and frameworks used in Canada to enhance the digital skills.

The response of the EU Commission is presented in [4] with a high regard for the appropriate approach for different target groups. In this context, it is underlined that several groups were identified: young age 16-24 years old with no or low-level education, 55+ years old individuals, unemployed or low level 25-64 years old, individuals inactive, nationals of non-EU countries, rural areas, and employees in low-skilled occupation. Even the digital skills are present during the academic period, another issue raised in the literacy is the assessment of individual skills. In [16] the authors make a systematic review of existent assessment methods for digital competence in universities. Nevertheless, the study showed that the most used form is the self-assessment using quantitative methods, being noted that more substitute forms of assessments, based on summative, diagnostic, or peer-reviewed assessments. An example of the educators’ skills in Norway is presented in [22]. Also, the K-12 digital skills programs are presented in [8] with a special focus on STEM education.

The evaluation of the digital skills is a continuous process where several scales are used. The ECDL (European Computer Driving License tests were used in [20] to assess the real level of digital skills in Poland for students enrolled in pedagogical studies. The students had also filled a self-assessment for general competences, office suite, and the ability to use new hardware and software. The study revealed that between self-assessed perceived competence and the tested one exists a gap, indicating a lower level of digital competences of the enrolled students.

Nevertheless, according to [13], even between the age cohorts exists differences between the perceived level of digital skills and the usefulness in learning activities. Moreover, in the study the authors used also DigComp as framework, using simple task to perform the assessment of three different age cohorts. The results indicate that the digital skills are developed over time with higher enhancement for the student in secondary school. Anyway, the study indicates a flatten dispersion for the group in case of determining the competence level for higher competence level.

The present study aims to envisage the evolution of the digital skills perceived by the students, both technological and economic fields of study, during the period of 2018-2022. The origin of this inquiry was to determine if it existed a market for extracurricular courses and to determine the perceived value for the students.

Instead of starting with the peer-reviewed assessment of the digital skills of the students which was passed to academic staff during the ordinary examination, we assessed the perceived usefulness and actual use of technology in the student's life, dividing it into private life, as an employer and as a student.

The study used a questionnaire available on-line, the students being assisted during the response. The paper structure includes the methodology of the research, experimental, debates and comparisons with similar research, and conclusions.

2. Determining the cross-pandemic students' digital skills need

As a theoretical model for the research an adapted TAM (Technology Acceptance Model) was used, illustrated in Fig. 1. The model is inspired by [6]. Subsequentially, our previous research [3], which covered only pre-pandemic and pandemic time, showed that- a good correlation exists between the perceived usefulness, usage of technology, attitudes toward using on technology, intention to participate on short term (six months) at an extracurricular level for a training program.

Additional, to our previous research, our objectives were stated below:

GO.1 Determining if the pandemic of COVID 19 influenced the digital skills perceived usefulness and use in private life, as an employee and in the learning process:

SO1.1 Determining the perceived usefulness of digital skills depending on the scope of use,

SO1.2 The correlation between the perceived of use and the intention to enhance digital skills.

GO.2 Identification of cross-pandemic student training attitude regarding digital skills enhancement,

SO 2.1 Digital skills for which respondents have indicated that they are intended to participate in extra-curricular courses,

SO2.3 Specify a value threshold for which respondents are willing to pay for the training or improvement of specified digital skills

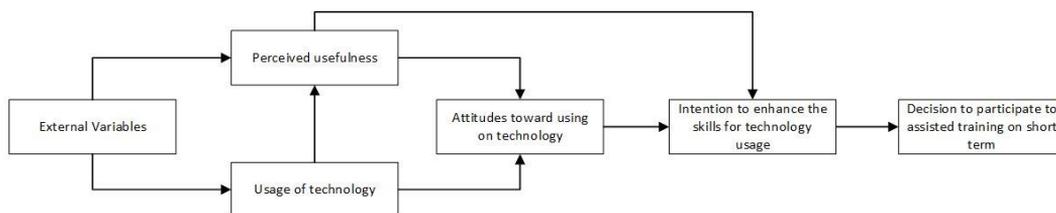


Figure 1. Adapted TAM for decision to participate to assisted training

The experiment took place in the period 2019-2022, in a form of an assisted answering questionnaire [7]. The respondents were distributed according to the Tab.1. As it can be seen, most of the respondents were enrolled to a study program (95.48%), especially to bachelor (74.18%). Also, the most respondents are male (78,19) in the age category of 16-30 years, with residence in the urban are. The distribution of the target group corresponds to the data recorded to the universities, both technical and computer science field of study being renowned by gender inequity. The study comprises student from Romanian-American University, and University POLITEHNICIA of Bucharest. The envisaged study programs were Computer Science for Business Management and Industrial Engineering.

Characteristics	Frequency	Percentage
The level of the last graduate studies. according to ISCED Classification 2011		
ISCED 3 - High School Education	180	66.67%
ISCED 4 - Post-secondary Education	11	4.13%
ISCED 5 - General Higher Education	9	3.38%
ISCED 6 - Bachelor or equivalent studies	56	21.05%
ISCED 7 - Master or equivalent level	8	3.00%
ISCED 8 - PhD or equivalent level	2	0.75%
Gender		
Male	208	78.19%
Female	58	21.81%
Age category		
16-30 years	246	92.48%
31-40 years	17	6.39%
41-50 years	3	1.13%
Residence		
Urban	215	80.82%
Rural	51	19.18%
Study program enrolment		

Yes	254	95.48%
No	12	4.52%

Table 1. Target group distribution

The reason of selecting the programs was for a better understanding of digital skills division and because of Industry 4.0 concept implementation in technical academic learning programs [5]. However, the forms used to collect responses is available, and used yearly to enhance the evolution of the digital skills training need. To have a clear view over the digital skills, we proposed the index presented in Tab. 2, considering a division of them, more oriented to technologies, which later can be designed in extracurricular courses. We started with foundation level, having as base the Computer Science curriculum, with using operating systems, Office software and electronic communication. More specialized digital skills were added to identify the purpose of use: private life, as an employee or as a student. At the time of designing the digital skills index we have in mind the emerging technologies presented by leading software companies, as Microsoft [15], or Autodesk [1]. The same companies foreseen for the next period, in [19] a big push of hybrid work tools and a rapid spread of smart technology. The report of Autodesk shows that new digital skills will be needed soon, to enhance the man-to-machine collaboration, as digital twin, augmented reality, and artificial intelligence as a part of new emerging Industry 5.0 concept. It is foreseen that the index to be updated with new skills, however, now being part of the general category of Smart technologies. As a result of the presented arguments, it can be concluded that the digital skills selected cover the entire spectrum of everyday activities.

No.	Digital skill
1	Using operating systems (e.g. Windows)
2	Using the Office Software (e.g. Word, Excel, PowerPoint, etc.)
3	Electronic communications and correspondence (e.g. email, SMS, WhatsApp, Skype, Internet)
4	Social Networks and content platforms (e.g. Facebook, Instagram, YouTube, LinkedIn)
5	Online Payment Systems and Banking
6	Integrated customer or resource management systems (e.g. ERP, CRM)
7	Business planning systems (Calendar, project planner)
8	Remote Access Systems to resources and cloud computing
9	Dedicated programs for software production and content creation
10	Smart Technologies (smart home, sensors, Artificial Intelligence)

Table 2. Digital skills index

2.1. Perceived usefulness of digital skills

The perceived usefulness of digital skills was introduced in the questionnaire at the beginning as a starting point in the TAM model. Using the digital skills index the respondents were asked to indicate which of the following skills they perceive as useful for the private life, as an employee or as a student. The goal of the inquiry is to determine whether digital skills are profiled to a certain scenario. The results of the MultiChoice question were deployed in Fig. 2-4, with an overview of the usefulness in Fig. 5.

As it can be observed, almost all digital skills have gained several percentage points in the perceived usefulness in the four years, considering the pandemic as having a positive impact over students' awareness regarding the usefulness of the digital skills. However, should be underlined that more and more students evolve from digital immigrants to digital natives, the year of birth migrating from 2001 to 2004, for most of respondents. Furthermore, the Fig.5 shows a first profiling of digital skills.

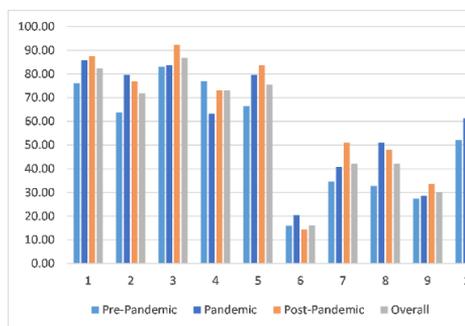


Figure 2. Private life necessary skills

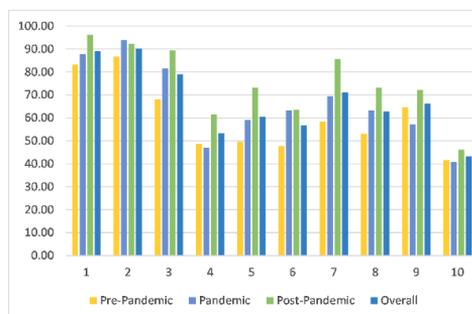


Figure 3. Employee necessary digital skills

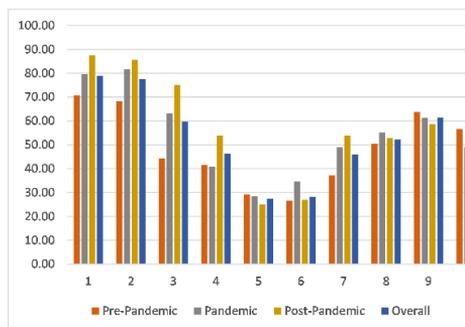


Figure 4. Student necessary digital skills

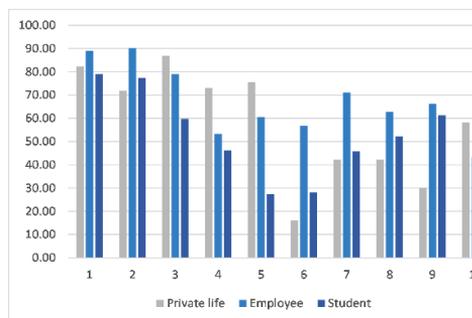


Figure 5. Overall necessary digital skills

2.2. Usage of technology

Also, another point that was important in our inquiry was to determine if the respondents are using the digital skills in the aspects mention of everyday life. The MultiChoice question answers are indicated in Fig.6-9. The usage of technology variates as a direct result of the pandemic situation, registering, as it was expected, higher rated for the electronic

correspondence and online payment and banking in the private life, during the pandemic, being correlated with the increase of the e-commerce sector [21].

The usage of the digital skills as an employer increased steadily during the envisaged period, for most of the digital skills, exception being countered for integrated customer or resource management systems, case that could be explained by hybrid work reorganization and the migration to simpler solutions as business planning systems, as direct results of pandemic work fashion [10].

The digital skills used in the learning process, also registered a steadily increase for the majority, the respondents being enrolled during the pandemic period (March 2020-2022) in on-line forms of learning. The universities adapted to on-line learning systems using various solutions, to maintain the learning process [2]. The overall use of the digital skills indicates a clear profile for the scope, registering a common body of skills used for all scenarios and dedicated ones for a specific or two scenarios. As such, with over 70% usage for overall scenarios, the use of the operating systems, Office software and electronic communications using different platforms, cover the foundation of digital skills despite of scope of use. Moreover, the online payment and banking is seen as skill used in the private life only, being correlated that at work (majority of student are employed during the last year of study) they are not using as software designers or engineers the on-line banking directly.

3. Results and discussions

For the specific objective of the research SO1.1 Determining the perceived usefulness of digital skills depending on the scope of use, the inquiry shows a dependence of the perceived usefulness regarding the scope of use for a part of the digital skills, rest of them being common for all purposes. As such, the first three skills from the index, a large majority of the respondents (over 70%), indicate a perceived usefulness despite the scope of use (Fig.9). The fundamental digital skills are using operating systems, Office software and electronic communications.

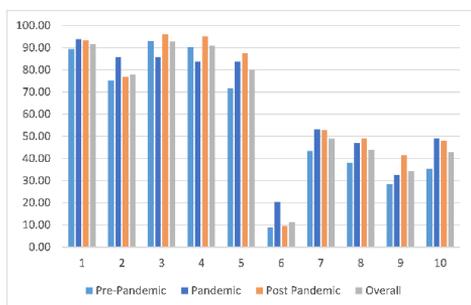


Figure 6. Student use of digital skills

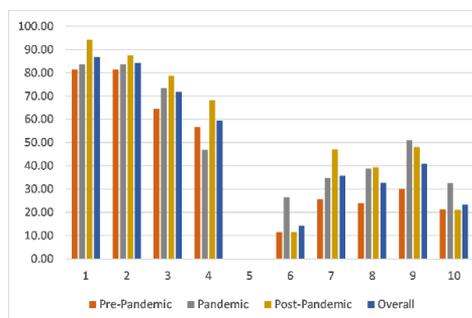


Figure 8. Student use of digital skills

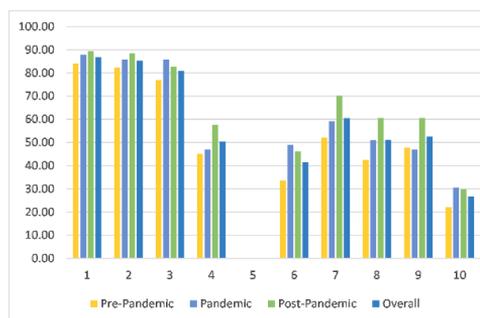


Figure 7. Employee use of digital skills

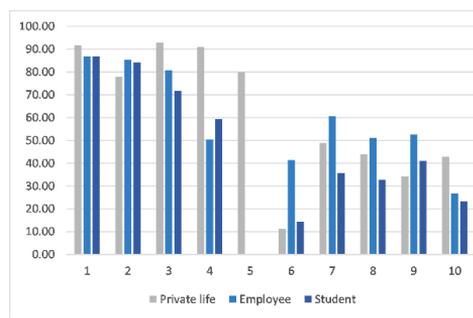


Figure 9. Overall use of digital skills

Specific for the scenario as an employee, as it was expected, we found the integrated customer or resource management systems and business planning systems. The respondents appreciate that social networks and content platforms is more often perceived as useful in the private life. For both scenarios, as an employee and the private live, the on-line payment and banking systems (75.56% overall private life and 60.53% overall as an employee). The Smart technologies are placed between the private life and student activity (58.27% overall private life and 46.62% overall as a student), considering that the perceived usefulness of smart technologies is not yet linked with the employee posture, because the lack of exposure of workers of such technologies or low awareness of the implied technologies. The last skills, Remote Access Systems and dedicated programs for software production and content creation are seeing as dedicated for employee and student scenarios, this perceive coming before the pandemic period and sustained after (Fig.3-4).

Regarding SO1.2 The correlation between the perceived of use and the intention to enhance digital skills, in the Fig. 9 is presented the declared intention of the future to acquire or to enhance a specific digital skill. As it can be seen, specific to pandemic time, the interest for enhancing the fundamental skills is higher with almost 10%, a slightly increase for the employee specific scenario and a drop for the skills perceived as being useful in the learning process. However, with an overall value of 59.48% for all the digital skills, we can assume that is positive corelation between perceived usefulness and intention to acquire or to enhance digital skills, with a steady increase of the intention during the period of report (53.98% pre-pandemic, 59.81% pandemic and 63.16% post pandemic).

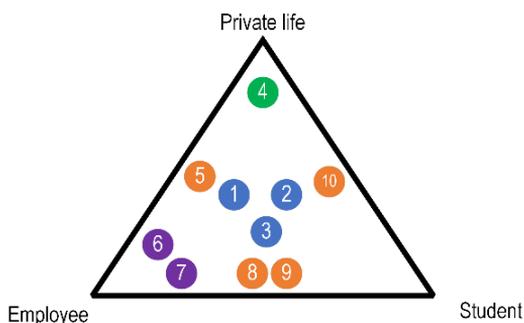


Figure 10. Digital skills profiling

- 1 Using operating systems (e.g., Windows)
- 2 Using the Office Software (e.g., Word, Excel, PowerPoint, etc.)
- 3 Electronic communications and correspondence (e.g., email, SMS, WhatsApp, Skype, Internet)

4 Social Networks and content platforms (e.g., Facebook, Instagram, YouTube, LinkedIn)

5 Online Payment Systems and Banking

6 Integrated customer or resource management systems (e.g., ERP, CRM)

7 Business planning systems (Calendar, project planner)

8 Remote Access Systems to resources and cloud computing

9 Dedicated programs for software production and content creation

10 Smart Technologies (smart home, sensors, Artificial Intelligence)

For SO 2.1 Digital skills for which respondents have indicated that they are intended to participate in extra-curricular courses, our inquiry found that the decision to acquire or enhance the digital skills in the next six months is dependent on the skills, the respondents (Fig.10) showed more interest (over 50%) in enhancing digital skills for new technologies (Remote access systems, dedicated programs for software production and smart technologies) for all reporting period, with a special interest, during pandemic for fundamental skills (using operating systems and Office software). An exception is made by on-line payment and banking systems for which the respondents didn't show any interest. To ease the identification of the digital skills for which the respondent intent to participate on short term is presented Fig. 11. The chart clearly indicates a higher conversion rate (average 79.28% decision/perceived usefulness) for new emerging digital skills (Remote access systems, dedicated programs for software production and smart technologies). For fundamentals skills the conversion rate is lower, with average value of 42.54%, but with a grater base of respondents that appreciates the perceived usefulness of the digital skills. However, this aspect might be explained by the early development of such digital skills during the high school or secondary school. With smaller percentage of the decision versus total respondents came in the last, the digital skills specific for the employee scenario. In this case, the integrated customer and resource management systems had 35.71% plan to participate to an assisted training program and 34.21% for business planning systems. For the last research secondary objective, SO2.3 Specify a value threshold for which respondents are willing to pay for the training or improvement of specified digital skills the questionnaire offer the possibility to the respondents to indicate a perceived value for an assisted training. The results are presented in Fig.12. The evolution of the perceived value during pandemic is indicating an increase of the category which are disposed to pay up to 350 EUR with a rise of 12.54% in comparison with the pre-pandemic and post pandemic period.

Nevertheless, the second question regarding the perceived value, was the collection of the opinion regarding 200 EUR as a price for an assisted training program to enhance or to acquire digital skills. The answers were recorded using Likert scale. 72.56 % of the respondents offer a positive opinion (Partially agree, Agree, Strongly Agree), regarding the threshold of 200 EUR as a attendance fee for an assisted training.

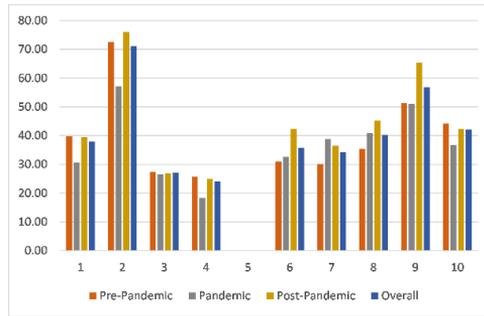


Figure 11. Decision to acquire or enhance of digital skills in the next six months

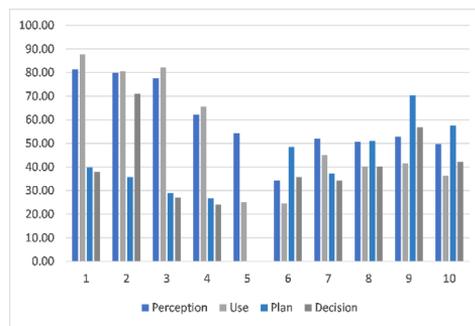


Figure 12. Perception-Use-Plan-Decision (6M)

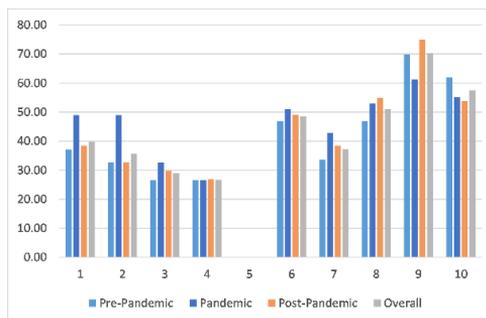


Figure 13. Plan to acquire or enhance of digital skills

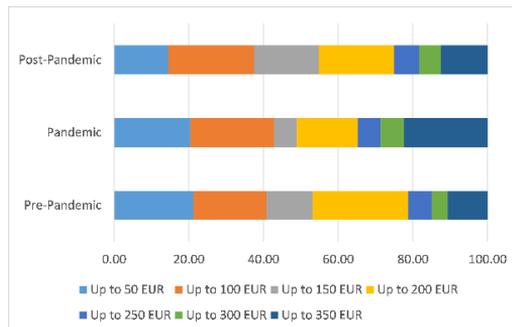


Figure 14. Perceived value of the assisted training

4. Conclusions

The paper presents the research results of an enquiry made in the period 2019-2022 among the students regarding perceived usefulness, use and training intention for digital skills enhancements.

The common digital skills, which correspond to the foundation digital skill, have a large use rate among the respondents. In this case are situated: using operating systems, office software and electronic communications and correspondence. In the private life, the specific digital skills are social networks and content platforms, online payment and banking systems, and smart technologies. Furthermore, as employee, the respondents indicate as necessary to perform their activity Online payment and banking systems, integrated customer and resource management systems, business planning systems, remote access systems to resources, dedicated programs for software production. In addition of foundation digital skills, in the student life they considered as useful remote access systems to resources, dedicated programs for software production, and smart technologies. The use rate threshold of 0.5 is enhancing that all digital skills defined in the study, are used by at least 50% at least for one scope.

Distinction between the use of the digital in the private life, as an employee or in the learning process, makes possible a deeper analysis to emphasize the influence of the intention of training in a certain skill on the respondent attitude regarding the private life or the professional development. The study revealed that all digital skills perceived usefulness rose from 2019 to 2022 with an average of 9.18%, starting with an average value of 53.59% in 2019.

It covers the bachelor and master's degree programs, with the Computer Science, Social Sciences and Engineering as field of study. The study was made using 266 answers from the above-mentioned categories. The study revealed that all digital skills perceived usefulness rose from 2019 to 2022 with an average of 9.18%, starting with an average value of 53.59% in 2019.

Also, the trends for declared use of digital skills also indicate a rose from the 2019 average value of 48.55% to 52.88 in 2022. It should be noted that all digital skills grown in this period. Nevertheless, even was expected that the training behaviour wasn't change significantly in this period, the average intention to participate for a training session, is 38.23% in 2019 and 39.90 in 2020. However, the decision to participate in the next 6 months is almost steadily between 35.75% and 39.90%. The self-estimation of the training session price was also very slow rising, from 165.93 EUR to 174.52 EUR in 2022.

References

[1] Adobe, *Experience Index 2020 Digital Trends, 2020*. From <https://www.adobe.com/content/dam/www/us/en/offer/digital-trends-2020/digital-trends-2020-full-report.pdf> accessed on 2021-01-11.

- [2] Carutasu, G. Tabusca, A., Botea, L. *Pandemic Response to On-Line Education at Romanian-American University*, in UNDER THE PRESSURE OF DIGITALIZATION: CHALLENGES AND SOLUTIONS AT ORGANIZATIONAL AND INDUSTRIAL LEVELS, FIRST EDITION, pp. 26–31, 2021.
- [3] Carutasu, G., Cotet, G. B., Carutasu, N. L. *Pandemic impact over digital skills training needs*, in 15th International Technology, Education and Development Conference, pp. 515–524. doi: 10.21125/inted.2021.0130, 2021.
- [4] Centeno, C., Karpinski, Z., Brancati, C. U., *Supporting policies addressing the digital skills gap – Identifying priority groups in the context of employment*, JRC Research Reports, 2022, from <https://ideas.repec.org/p/ipt/iptwpa/jrc128561.html> accessed on 2020-09-20, 2022.
- [5] Cotet, G. B., Carutasu, N. L., Chiscop, F. *Industry 4.0 Diagnosis from an iMillennial Educational Perspective*, Education Sciences, vol. 10, no. 1, p. 21, doi: 10.3390/educsci10010021, 2020.
- [6] Davis, F. D. *Perceived usefulness, perceived ease of use, and user acceptance of information technology*, MIS Q, vol. 13, no. 3, pp. 319–339, 1989, doi: 10.2307/249008, 1989.
- [7] Digital Skills Survey Microsoft Form. from https://forms.office.com/Pages/DesignPage.aspx?auth_pvr=OrgId&auth_upn=carutasu.george%40profesor.rau.ro&lang=ro-RO&origin=OfficeDotCom&route=Start#FormId=-Z8cEsEFkUaq9d4D2Z6YXXMzsv2cIeFEi-QEs2MOcz9UMkNBSUkzSzlWSIVSQ1cyNFY0UExDVFRPQS4u, accessed on 2022-10-07, 2022.
- [8] Dornian, K., Moshirpour, M., Behjat, L. *K-12 Digital Skills Programs as Preparation for Engineering Study: A Systematic Literature Review*, ASEE Annual Conference and Exposition, Conference Proceedings, vol. 2020-June, doi: 10.18260/1-2—34889, 2020.
- [9] European Commission, *Digital Economy and Society Index – DESI, 2021*. from: <https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2021> accessed on 2022-09-05, 2021.
- [10] Fink, L. *Conducting Information Systems Research in the Midst of the COVID-19 Pandemic: Opportunities and Challenges*, Information Systems Management, vol. 37, no. 4, pp. 256–259, Oct. 2020, doi: 10.1080/10580530.2020.1814460, 2020.
- [11] Hämmerle, V., Reiner, J., Ruf, E., Lehmann, V., Misoch, S. (2022) *Beyond the Digital Divide: Digital Skills and Training Needs of Persons 50+*, in ICT4AWE 2022 - 8th International Conference on Information and Communication Technologies for Ageing Well and e-Health, pp. 276–282. doi: 10.5220/0011068200003188, 2022.
- [12] Jackman, J. A., Gentile, D. A., Cho, N. J., Park, Y. Addressing the digital skills gap for future education, Nat Hum Behav, vol. 5, no. 5, pp. 542–545, doi: 10.1038/S41562-021-01074-Z, 2021.
- [13] Jin, K. Y., Reichert, F., Cagasan, L. P., de la Torre, J., Law, N. Measuring digital literacy across three age cohorts: Exploring test dimensionality and performance

differences, *Comput Educ*, vol. 157, p. 103968, doi: 10.1016/J.COMPEDU.2020.103968, 2020.

[14] Joint Research Centre, Institute for Prospective Technological Studies, Ferrari, A., *DIGCOMP: a framework for developing and understanding digital competence in Europe*, <https://data.europa.eu/doi/10.2788/52966>, 2013.

[15] Microsoft, *2019 Manufacturing Trends | Microsoft Dynamics 365, 2020*. From <https://info.microsoft.com/ww-landing-DynOps-Manufacturing-Trends-eBook.html> accessed on 2021-01-11.

[16] Sillat, L. H., Tammets, K., Laanpere, M., *Digital Competence Assessment Methods in Higher Education: A Systematic Literature Review*, *Education Sciences*, vol. 11, no. 8, p. 402, doi: 10.3390/EDUCSCI11080402, 2021.

[17] Spante, M., Hashemi, S. S., Lundin, M., Algers, A. *Digital competence and digital literacy in higher education research: Systematic review of concept use*, *Cogent Education*, vol. 5, no. 1, pp. 1–21, doi: 10.1080/2331186X.2018.1519143, 2018.

[18] Stiakakis E. and Barboutidis, G. *Exploring the construct of the new way of thinking in the digital environment,” Behaviour & Information Technology*, doi: 10.1080/0144929X.2021.1949042, 2021.

[19] Teevan, J. et al., *Microsoft New Future of Work Report 2022*, From <https://www.microsoft.com/en-us/research/publication/microsoft-new-future-of-work-report-2022>. accessed on 2022-10-06, 2022

[20] Tomczyk, Ł., Vázquez Toledo, S., Latorre Cosculluela, C. *Declared and Real Level of Digital Skills of Future Teaching Staff*, *Education Sciences*, vol. 11, no. 10, p. 619, doi: 10.3390/EDUCSCI11100619, 2021.

[21] Tran, L. T. T. *Managing the effectiveness of e-commerce platforms in a pandemic*, *Journal of Retailing and Consumer Services*, vol. 58, p. 102287, doi: 10.1016/J.JRETCONSER.2020.102287, 2021.

[22] Tveiterås, N. C., Madsen, S. S. *From Tools to Complexity? A Systematic Literature Analysis of Digital Competence Among Pre-service Teachers in Norway*, *Lecture Notes in Educational Technology*, pp. 345–389, doi: 10.1007/978-981-19-1738-7_18/COVER, 2022.

[23] van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., de Haan, J., *Determinants of 21st-century digital skills: A large-scale survey among working professionals*, *Comput Human Behav*, vol. 100, pp. 93–104, doi: 10.1016/J.CHB.2019.06.017, 2019.

[24] Vuorikari, R., Kluzer, S., Punie, Y. *DigComp 2.2: The Digital Competence Framework for Citizens*, EUR 31006 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-48882-8, doi:10.2760/115376, JRC128415, 2022.

ANALYSIS OF THE CORRELATION BETWEEN INNOVATION AND ICT READINESS FOR THE EU-27 MEMBER STATES

Daniela Alexandra CRIȘAN¹

Justina Lavinia STĂNICĂ²

Abstract

Investing in research, development, education, and skills is a key policy area for the EU, as it is essential for economic growth and the development of a knowledge-based economy. But how investments in R&D and the most qualified segment of the workforce will influence innovation? Is there a link between these factors? In the last years, we investigated how Innovation and ICT are linked. Results obtained proved that there is a linear correlation between the two factors. In this paper we'll continue our research, extending the analysis with more recent data and using new indicators.

The analysis presented here refers to the EU-27 Member States and the indicators used are the Summary Innovation Index, published by the European Commission in the European Innovation Scoreboard and two indicators that measure the ICT Readiness, namely: the Human Resource Science and Technology Index (HRST) and the Gross Domestic Expenditure on R&D (GERD), both published by the Eurostat organism.

Keywords: ICT, innovation performance, correlation, Summary Innovation Index (SII), Human Resource Science and Technology Index (HRST), Gross Domestic Expenditure on R&D (GERD)

JEL Classification: M15

1. Introduction

The European Union has prioritized pursuing growth based on innovation and directing resources to promote research and development. Investing in research, development, education and skills is a key policy area for the EU, as it is essential for economic growth and the development of a knowledge-based economy.

In this paper we'll investigate how investments in R&D and the workforce influence innovation. We consider the models provided as a first step in our effort to better understand the demand for and the supply of people with strong qualifications in science and technology and the necessity of investments in R&D.

¹ Associate Professor, PhD, School of Computer Science for Business Management, Romanian-American University, e-mail: crisan.daniela.alexandra@profesor.rau.ro

² Lecturer, PhD, School of Computer Science for Business Management, Romanian-American University, e-mail: lavinia.stanica@rau.ro

Regarding the material and method, all graphics and charts presented in this paper are realized by the author using MS Excel and data published in European Innovation Scoreboard (EIS) 2022 and Eurostat. The values for the HRST indicator have been updated on 27-09-2022. The values for the HRST indicator have been updated on 21-10-2022.

Measuring the innovation performance

The European Innovation Scoreboard is an initiative created by the European Commission aimed to offer a comparative analysis of innovation performance in European countries, at national and regional levels. The project was launched in 2010 and until 2015; it was published under the name “Innovation Union initiative”.

The European Innovation Scoreboard provides, yearly, a set of indicators, grouped into dimensions and blocks, aimed to offer an image over Research and Innovation in Europe. The EIS 2022 report was launched in September 2022 and it is the second edition published using the new measurement framework introduced in 2021. The EIS 2022 measures the innovation performance using 32 indicators, grouped in 12 innovation dimensions and 4 main types of activities. Every main type has 3 dimensions cumulating 8 indicators. The composite indicator Summary Innovation Index (SII) is an equal weight average of those indicators:

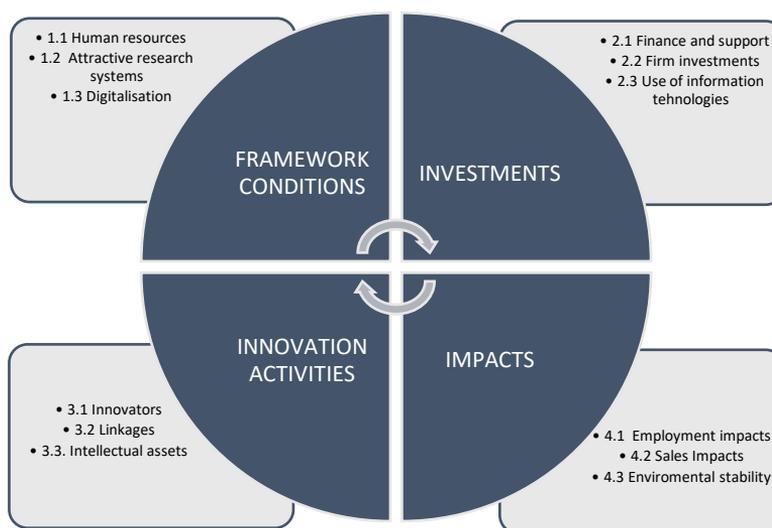


Figure 1. The structure of the Summary Innovation Index (SII) in 2022

Based on their innovation performance, the 27 Member States fall into four different performance groups (Figure 2):

- *Innovation leaders* (Belgium, Denmark, Finland, the Netherlands, and Sweden) – perform in innovation well above the EU average;

- *Strong Innovators* (Austria, Cyprus, France, Germany, Ireland, and Luxembourg) – innovate below the leaders, but above the EU average;
- *Moderate innovators* (Czechia, Estonia, Greece, Italy, Lithuania, Malta, Portugal, Slovenia, and Spain) – perform in innovation below or equal to the EU average;
- *Emerging innovators* (Bulgaria, Croatia, Hungary, Latvia, Poland, Romania and Slovakia) – innovate well below the EU average.

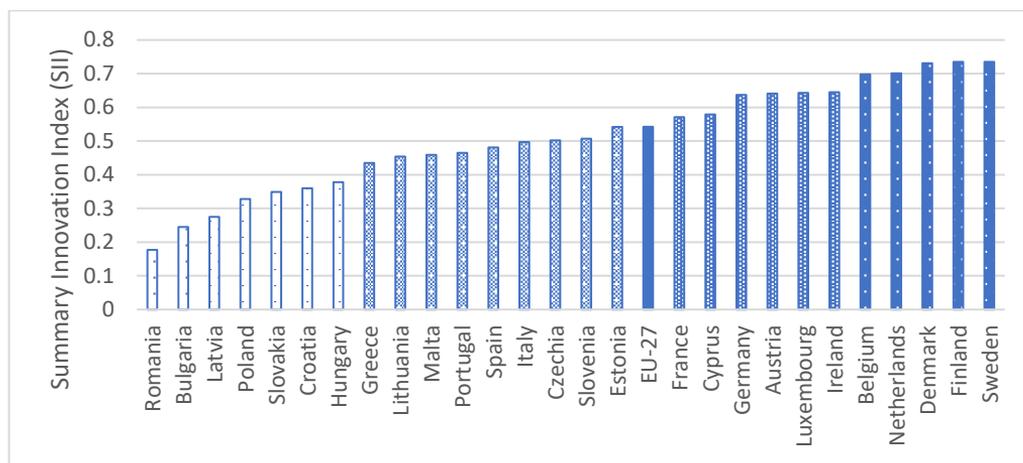


Figure 2: The four groups of EU-27 countries by their innovation performance (SII), in 2022

Next, we are studying the dynamics, at national level, for the 27 EU countries, in the period 2018-2022:

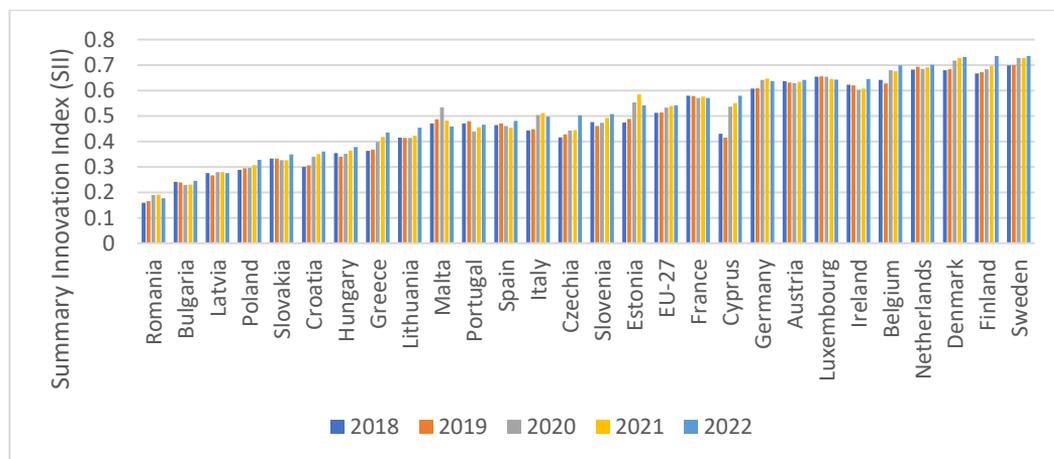


Figure 3: The dynamic of the innovation performance for the EU-27 countries for the period 2018-2022

We notice that in the last five years, most of the countries kept their position in the hierarchy. As exceptions, we can think at Cyprus, which rose in ranking from the Moderate Innovators group in the years 2018-2019 to the Strong Innovators group.

Estonia also moved between groups: it improved its innovation performance in 2020-2021 comparing to the previous years, becoming a Strong Innovator. But, in 2022 it recorded a decrease, Estonia's current SII value is similar to that of EU and, therefore, it has been classified as a Moderate Innovator country in 2022.

We also notice that some countries (France, Luxemburg, Bulgaria, Romania) kept their profile during the years.

Measuring the readiness in Science and Technology

In order to measure the Science and Technology readiness we used two indexes published by the Eurostat organism:

- The Human Resource Science and Technology Index (HRST) and
- The Gross Domestic Expenditure on R&D (GERD)

The Human Resource Science and Technology Index (HRST) describes the current stock of people who have successfully completed tertiary education (IESCD) and or who are employed in science and technology. In our analysis, we used the Y15-74 set of data, corresponding to population between 15-74 years, measured in thousands of individuals.

Using the HRST index, we can rank the 27 Member States as follows:

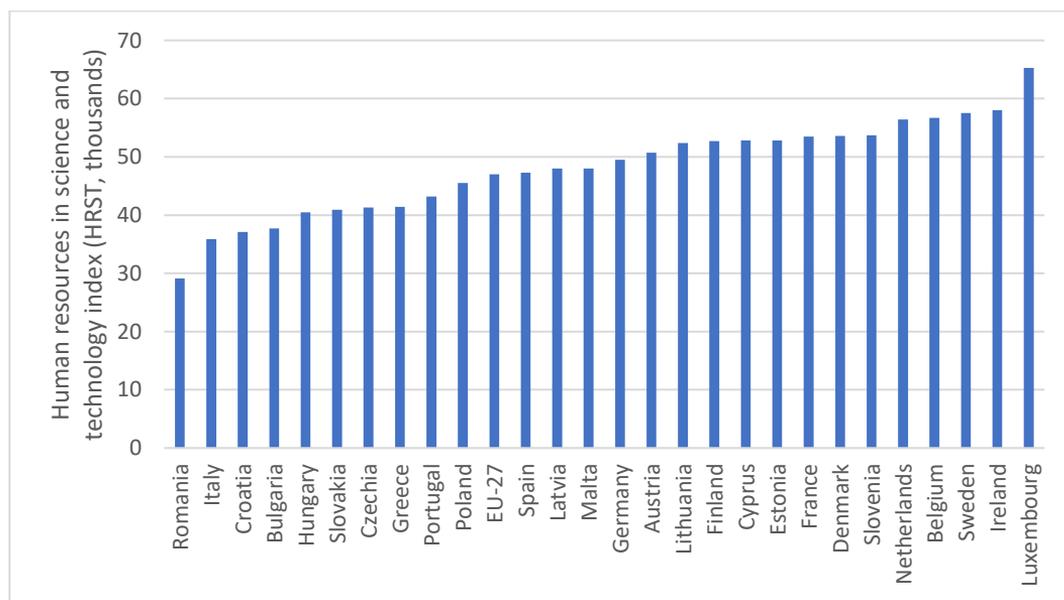


Figure 4: The EU-27 countries ranked by their S&T performance (HRST Index 2021)

The Gross domestic expenditure on R&D (GERD) is total expenditure (current and capital) on R&D performed by all resident companies, research institutes, university and government laboratories, etc., in a country during a specific reference period. In our analysis, we used the data published by Eurostat for the 27 Member States during 2015-

2020, for all sectors of performance (business enterprise, government, higher education and private non-profit sectors), measured in Euro per inhabitant.

The ranking for 2020 is presented below:

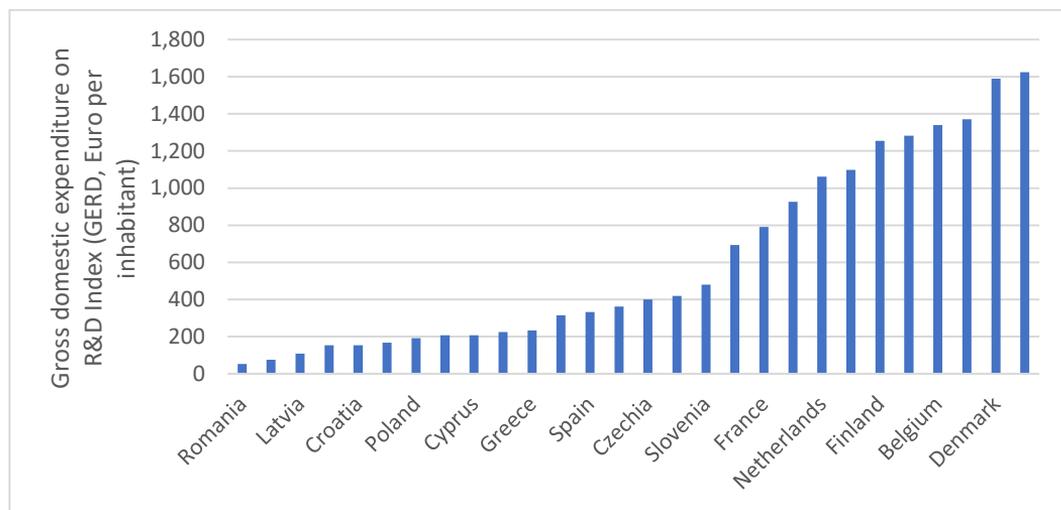


Figure 5: The EU-27 countries ranked by their S&T performance (GERD Index 2020)

2. Correlations between innovation and S&T for the EU-27 Member States

2.1 SII vs HRST

In the next section, we investigate if there is a linkage between the Summary Innovation Index (SII) and the Human Resource in Science and Technology Index. The diagram representing the two indicators for the 27 Member States in 2022 suggest that such a linkage exists.

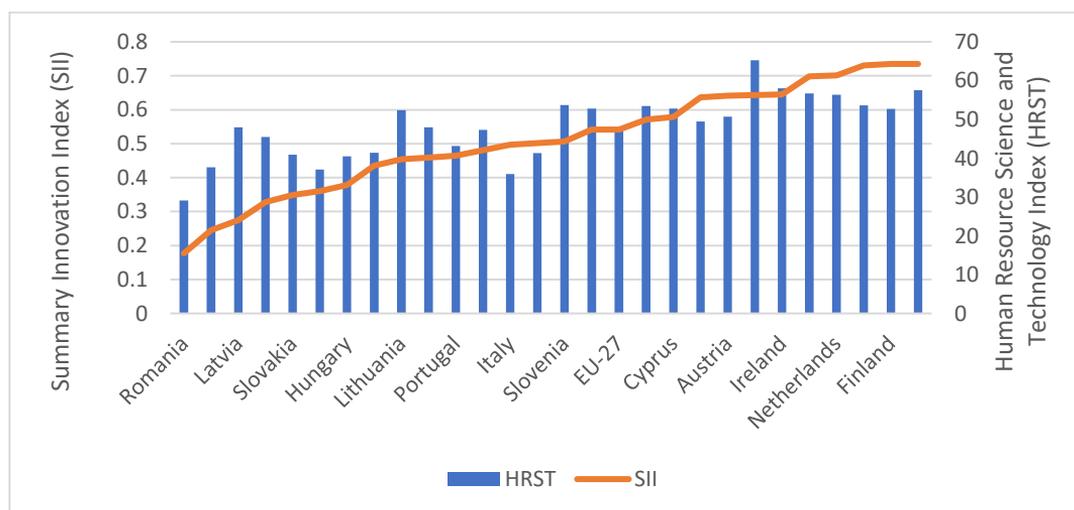


Figure 6: Correlation between SII and HRST indicators for the EU-27 Member States

Our next attempt was to describe this linkage with a linear model: the figure below shows that the Summary Innovation Index and the Human Resources in Science and Technology Index for 2022 are linearly correlated. The equation of the linear regression is:

$$SII = 0.015 \times HRST - 0.21$$

Correlation coefficient: 0.78

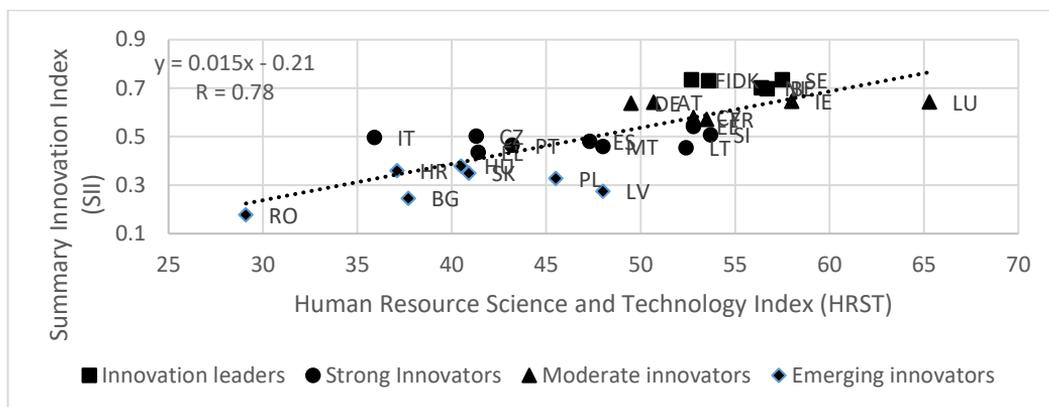


Figure 7: Correlation between SII and HRST indicators for the EU-27 Member States

The historical data of the two indicators considered proved that this linkage is constant; it was confirmed for the last 8 years as well:

Year	2015	2016	2017	2018	2019	2020	2021	2022
Correlation Coefficient	0.79	0.81	0.82	0.83	0.82	0.81	0.82	0.78
Slope	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01
Intercept	-	-0.24	-0.25	-0.26	-0.25	-0.23	-	-

Table 1: Correlation between SII and HRST at national level, for the EU-27 countries in the period 2015-2022

2.2 SII vs GERD

The second part of the analysis refers on how the Gross domestic expenditure on R&D (GERD) index influences innovation.

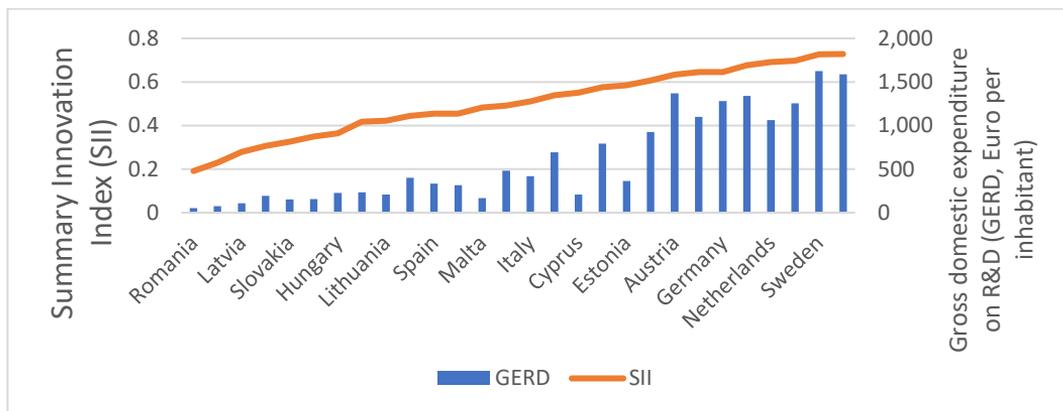


Figure 8: Correlation between SII and GERD indicators for the EU-27 Member States for the year 2020

The linear regression below is described through the model:

$$SII = 0.0003 \times GERD + 0.3349$$

Correlation coefficient: 0.8825

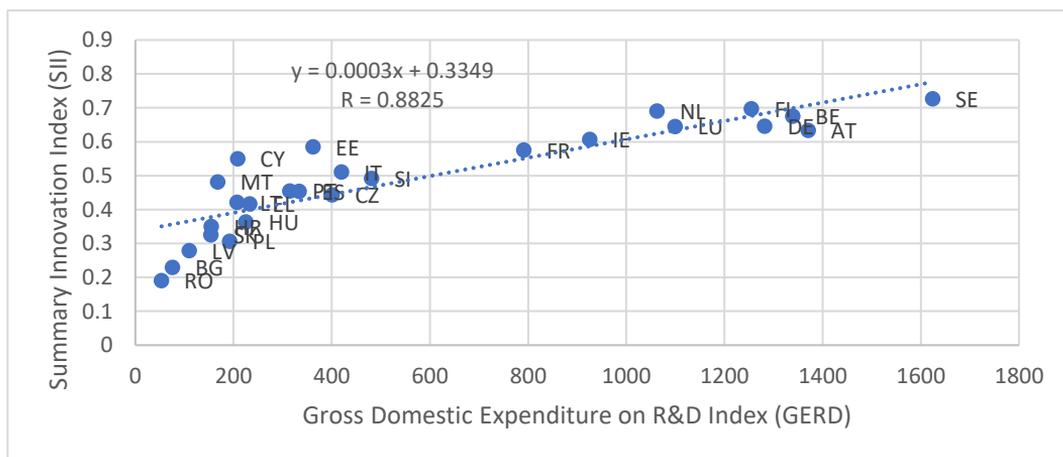


Figure 9: Correlation between SII and GERD indicators for the EU-27 Member States, in 2020

Year	2015	2016	2017	2018	2019	2020
Correlation Coefficient	0.9153	0.9085	0.8928	0.8907	0.8768	0.8825
Slope	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Intercept	0.3056	0.3163	0.3264	0.3202	0.3332	0.3349

Table 2: Correlations between SII and HRST at national level, for the EU-27 countries, computed yearly in the period 2015-2020

3. Analysis of historical data

Next, we've performed tests on historical data for the 27 Member States in the period 2015-2022, considering the SII-ICT performance pairs. Results show that for some countries, a linear regression can be described, but the relationship cannot be extrapolated to all of them.

Country	Correlation SII - HRST	Correlation SII - GERD
Romania	0.200	0.410
Bulgaria	0.001	-0.851
Latvia	0.795	0.409
Poland	0.888	0.856
Slovakia	0.561	-0.948
Croatia	0.790	0.975
Hungary	0.910	0.475
Greece	0.970	0.990
Lithuania	0.924	0.708
Malta	0.653	0.389
Portugal	0.484	0.344
Spain	0.728	0.530
Italy	0.938	0.882
Czechia	0.915	0.953
Slovenia	0.283	-0.124
Estonia	0.902	0.941
France	-0.593	-0.712
Cyprus	0.889	0.933
Germany	0.911	0.832
Austria	0.849	0.655
Luxembourg	-0.486	0.465
Ireland	0.344	-0.846
Belgium	0.872	0.890
Netherlands	0.885	0.820
Denmark	0.854	0.846
Finland	0.587	0.957

Sweden 0.920 0.651

Table 3: Historical correlations between SII and the ITC performance indicators, at national level, for the EU-27 countries, in the period 2015-2020

Let's consider one of the Innovation Leaders, Netherland (see figure below). In this case:

- SII and HRST are strongly correlated, following the model:

$$\text{HRST} = 162.82 \times \text{SII} - 59.305, R = 0.885$$

- SII and GERD are strongly correlated, following the model:

$$\text{GERD} = 4777.1 \times \text{SII} - 2287.8, R = 0.820$$

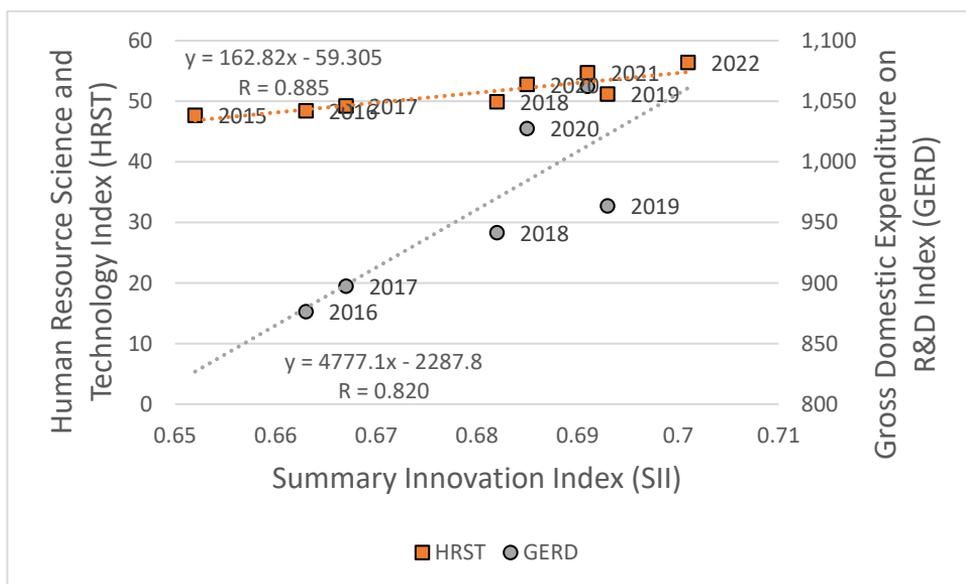


Figure 10: Correlation between SII and ITC indicators for Netherland, in the period 2015-2022

On the other hand, there are countries where there is no evidence of a linear linkage. For instance, Romania, one of the Emerging Innovators, neither SII and HRST, nor SII and GERD are linear correlated, as the next figure shows:

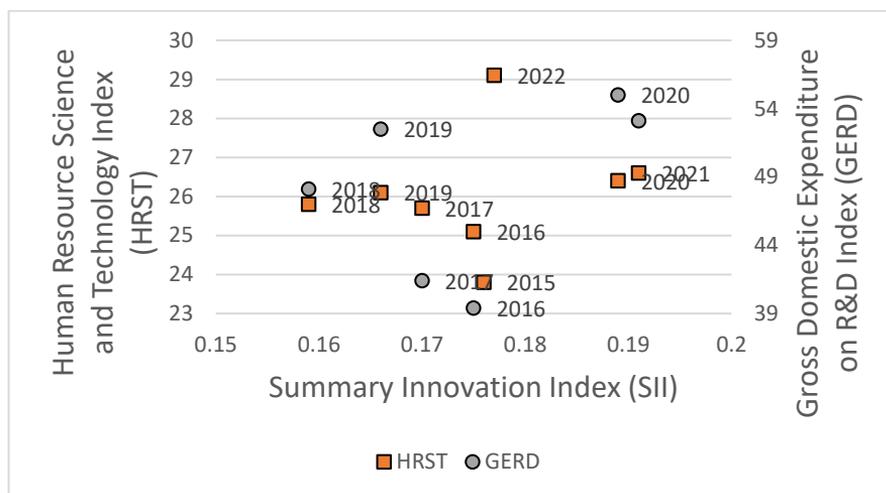


Figure 11: The dynamic of the SII and ITC indicators for Romania, in the period 2015-2022

4. Conclusions

Previous steps we performed proved a strong link between innovation and ICT:

In 2019 we investigated the relationship between SII and the ICT Development Index (IDI), a composite index computed yearly, since 2009, by the International Telecommunication Union and published in the “Measuring the Information Society Report” (MISR), at European level (28 Member States).

In 2016 we investigated the relationship between the Networked Readiness Index (NRI), created by the World Economic Forum, in collaboration with INSEAD, and published yearly since 2002 and: (1) the Global Innovation Index (GII), published yearly since 2007, by INSEAD in collaboration with WIPO, Cornell University and their Knowledge Partners, and (2) the Summary Innovation Index (SII).

Results over the transactional relationships are confirmed for the SII and the Eurostat indicators HRST, respectively GERD, yearly, after 2015. Historically, for some countries there is a relationship, for other, this is not evident. We include here Romania, one of the Emerging Innovators.

References

- [1] COM (2010) 546 final, “Europe 2020 Flagship Initiative Innovation Union”. Available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0546:FIN:EN:PDF>
- [2] COM (2010) 2020 final, “EUROPE 2020 - A strategy for smart, sustainable and inclusive growth”. Available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF>

- [3] Crișan D.A., Potecea O., Preda A.M., Stănică J.L., “*ICT determining factors in increasing the innovation in Romania*”, Journal of Information Systems and Operations Management (JISOM), Vol. 5 No. 1 / May 2011, 2011, pp. 94-99, 2011.
- [4] Crișan D.A., Preda A.M., Coculescu C., Altăr-Samuel A.N., “*Some aspects concerning the correlation between ICT and innovation in Europe*”, The 6th International Conference "European Integration – New Challenges", 28 - 29 May 2010, Univ. Oradea, Romania, pp. 2436-2442, ISBN 978-606-10-0149-1, 2010, published in „Analele Universității din Oradea, Seria Științe Economice”(Journal: Annals of the University of Oradea : Economic Science Year: 2010 Vol: 1 Issue: 2 Pages/record No.: 1183-1189), ISSN-122569, vol I, issue 2, pp. 1183-1189, 2010;
- [5] European Commission (2021)
<https://ec.europa.eu/docsroom/documents/46013/attachments/1/translations/en/renditions/native>
- [6] European Commission (2022)
<https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/european-innovation-scoreboard>
- [7] Eurostat, <https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do>
- [8] Preda A.M., Crișan D. A., Stănică J.L., “The Impact of ICT on Innovation Performance in Europe. Case of Romania”, Journal of Information Systems and Operations Management (JISOM), Vol 8 No 1, 2014, pp. 1-12, Ed. Universitara, 2014.
- [9] Preda A.M., Crișan D.A., Potecea O., “A study on the relationship between ICT and innovation in Europe”, The 17th International Economic Conference – IECS 2010 "Economic world' destiny: Crisis and Globalization", May 13-14, 2010, Univ. Lucian Blaga, Sibiu, Romania, proceedings: pp.178-183 (CD Version), 2010.
- [10] Preda A.M., Crișan D.A., Stănică J.L., “Modeling the impact of ICT on innovation performance”, presented at the 19th International Economic Conference – IECS 2012, “The persistence of the global economic crisis: causes, implications, solutions”, June 12 2012, Univ. Lucian Blaga, Sibiu, Romania, published in proceedings: (CD Version), 2012;
- [11] Preda A.M., Stănică J.L., Crișan D.A., Coculescu C., “*E-Government: A Driving Factor For Stimulating Innovation Performance In Romania?*”, Proceedings of the 7th International Conference *European Integration – New Challenges*, 7th Edition, May 2011, Univ. Oradea, Romania, 2011, pp. 125-130, ISBN 978-606-10-0521-5; Journal: Annals of the University of Oradea : Economic Science Year: 2011 Vol: 1 Issue: 1 Pages/record No.: 125-130, ISSN (print): 1222-569X, 2011.
- [12] EUAgenda, <https://euagenda.eu/publications/european-innovation-scoreboard-2022>

THE RELATIONSHIP BETWEEN THE HUMAN DEVELOPMENT INDEX (HDI) AND INTERNATIONAL MIGRATION

ELENA RALUCA CRISTIAN¹

ALEXANDRA IRINA DĂNCIULESCU²

CARMEN DALIA ȚÎRDĂ³

ANDA VERONICA DAN⁴

Abstract

This research analysis the impact of the human development index on the labour migration. The research focuses on 23 countries, on the last few years. Human Development Index and its components, ranks countries by HDI value and details the values of the three HDI components: longevity, education (with two markers) and income per capita. The last couple of years have proven that uncertainty is a certainty. Because of Covid-19 pandemic and the war in Ukraine, for the first time ever, the value of the Human Development Index has declined for two years straight.

Many countries were going through declines of the Human Development Index in 2021. Even before the pandemic insecurity rose everywhere. Many people are still feeling alienated from their political systems, from each other. This paper tries to discover if the Human Development Index has some influence on labour migration. The paper tries to demonstrate that no country so far, has a high human development index, thus humankind needs to pursue other ways to develop.

Keywords: international migration, human development index (HDI), flow of immigrants, labour migration, increase in population income.

JEL Classification: I14, I31, J6, J61, O15

1. Introduction

From a multitude of other factors that influence the upward trend of labour migration, we have considered the human development index as a determining factor in the socio-economic evolution of a state. The Human Development Index⁵ (HDI) is a marker developed by the United Nations for Development Program (UNDP) whose main purpose is to measure the level of development for each country according to a series of variables

¹ PhD, Teaching Assistant, Romanian-American University, Bucharest, elena.raluca.cristian@rau.ro

² PhD, Teaching Assistant, Romanian-American University, Bucharest, alexandra.danciulescu@rau.ro

³ PhD, Lecturer, Romanian American-University, Bucharest, carmen.dalia.tirda@rau.ro

⁴ PhD, Teaching Assistant, Romanian-American University, Bucharest, anda.veronica.dan@rau.ro

⁵ <https://hdr.undp.org/content/human-development-report-2021-2022>

considered standard, namely: education, life expectancy at birth or the personal income of each resident citizen for the analyzed country⁶:

- health / longevity (measured by life expectancy at birth), which can indirectly measure the satisfaction of basic or physiological needs, access to food, health, water, decent housing, good hygiene, and medical care.
- the level of knowledge or children's access to education, which is measured by the average duration of schooling of adults over 25 years.
- standard of living (logarithm of the gross income per capita calculated in the purchasing power parity of the population). This synthetic marker includes aspects related to the quality of life, the level of income, the evolution of the minimum wage in the economy, the increase in labour productivity, the purchasing power, the level of inflation.

The other variable considered in the analyzed model is the number of foreign immigrants permanently settled in countries with a very high human development index (HDI), above 0.9. As stated from the very beginning, we will try to find the direct link between the human development index and the number of immigrants who settle every year in these countries that have a high degree of economic development.

International migration has multiple causes, in addition to economic ones, we can also list socio-political, demographic, religious or environmental factors.

According to data provided by the International Labour Organization, the number of migrant workers, defined as people who migrate for employment, was approximately 164 million people in 2017, accounting for almost two-thirds of international migrants. Almost 70% of them are in high-income countries, 18.6% in upper-middle-income countries, 10.1% in lower-middle-income countries and 3.4% in low-income countries⁷.

On the European continent alone, on 1 January 2019, the number of people residing in an EU country with third-country citizenship was 21.8 million, representing 4.9% of the EU-27 population. In addition, 13.3 million people, residents in an EU-27 country on 1 January 2019 were citizens of another EU country.⁸

In specialized literature, the main factors for which people migrate are divided into Push Pull factors, or in other words, factors of pressure and attraction in another country for the future immigrant.

The Push model consists of a series of internal factors existing in the emigrant's country of origin, which determine and influence him to emigrate to a destination country. The Push-Pull model is considered a more subjective model, which can only be applied to a certain emigrant profile or a certain type of state.⁹

⁶ https://hdr.undp.org/system/files/documents/global-report-document/hdr2021-22pdf_1.pdf

⁷ <https://blogs.worldbank.org/opendata/new-world-bank-country-classifications-income-level-2022-2023>

⁸ <https://www.europarl.europa.eu/news/ro/headlines/world/20200624STO81906/cauzele-migratiei-de-ce-migreaza-oamenii>

⁹ Cristian Elena Raluca, Iordache Ana Maria Mihaela, Dan Anda Veronica, Population migration in the year of the Covid-19 Pandemic: A case study on Romania, Proceedings of the Journal of

Among the main current socio-political factors, we can mention the persecution of the citizens of some countries for belonging to a certain ethnicity, religion, race, politics or culture.

Another major factor is war or military conflict that may occur on a country's border; these conflicts or political persecution on the part of a government to cause massive departures of many refugees for political and military reasons. People fleeing armed conflicts or major human rights violations are usually humanitarian refugees who leave their country of origin for an indefinite period. This will influence the choice of the place where they settle permanently, because there are some countries that have a more liberal or open policy towards refugee immigrants. Official statistics have shown us that these immigrants are most likely heading to the nearest country they consider safe, and which accepts political asylum seekers.

In recent years, many people flee to Europe due to conflicts, terror and persecution in their country of origin. Of the 295,800 asylum seekers granted protection in the EU in 2019, over a quarter came from war-torn Syria, followed by Afghanistan and Iraq.¹⁰

Demographic and economic migration is correlated with labour standards, unemployment, and the general state of reliability and economic development of a country. Among the pull factors are higher wages, better job opportunities, a higher standard of living and educational opportunities. If economic conditions are not favorable and are still at risk of deteriorating, the likelihood of large numbers of people migrating to countries with a better situation increases.¹¹

Environmental factors have always been a determinant of migration, since ancient times people have fled natural disasters (floods, hurricanes and earthquakes). Specialists predict that in the future, with the climate changes that will occur worldwide, these extreme weather phenomena will increase, which could also cause a greater number of people to move from different continents or countries within the same continent.

The latest official data from the European Commission for 2020 shows that intra-EU mobility continued to grow in 2018, but at a slower pace than in previous years. Thus, in 2018 there were 17.6 million European citizens of all ages, registered as living long-term in a Member State other than the one of citizenship, and of these, 12.9 million were aged between 20 and 64 years, being included in the "labour migration" category, representing 4.2% of the total working-age population quantified in the EU-28. At the same time, in 2018, over half of active intra-EU migrants (6.1 million EU citizens) came from Romania, Poland, Italy, Portugal and Bulgaria, and the most preferred destination countries were Germany, Great Britain, Spain, Italy and France.¹²

Information Systems & Operations Management (JISOM), Vol.15. No.2, 2021, p.96.

<http://jisom.rau.ro/>

¹⁰ <https://www.europarl.europa.eu/news/ro/headlines/world/20200624STO81906/cauzele-migratiei-de-ce-migreaza-oamenii>

¹¹ Idem 14

¹² Buda Daniel, Impactul pandemiei de Covid-19 asupra mobilității forței de muncă, Revista transilvană de Științe Administrative 1 (46), 2020, p.19.

2. Presentation of the analysis between the Human Development Index (HDI) and the number of immigrants

In the study that we will analyze in this article, we will focus on two variables, namely the human development index and the number of foreign immigrants with permanent residence on the territory of the respective countries, the authors considering that there is a direct connection between these variables. These analyzed variables are based on series of real statistical data, obtained from the websites of official institutions. It is very important to specify the fact that for the number of foreign immigrants (for both sexes: male and female), the number of those who live permanently on the territory of the respective countries for a period of more than 1 year, regardless of the country or continent of origin, was considered of them (Asia, Europe, Africa, America or Australia).

The data are valid for the year 2020 that we have presented in the table below, the countries analyzed are those that have a very high or high Human Development Index (HDI):

Country	Human development index (value) x	The number of foreign immigrants on the territory of the countries (Mil. people) y
Switzerland	0.962	883.751 people
Norway	0.961	2.438.702 people
Ireland	0.945	85.400 people
Germany	0.942	15.760.000 people
United States of America	0.921	50.660.000 people
Australia	0.951	6.763.663 people
Iceland	0.959	1.600.000 people
Sweden	0.947	1.639.771 people
Liechtenstein	0.935	1000 people
Netherlands	0.941	1.979.486 people
Denmark	0.948	5.725.200 people
Finland	0.940	315.881 people
Canada	0.936	7.835.502 people
New Zealand	0.937	1.039.736 people
UK	0.929	8.543.120 people
Belgium	0.937	1.387.940 people
Austria	0.916	1.492.374 people
Luxembourg	0.930	249.325 people

Israel	0.919	2.011.727 people
Japan	0.925	2.043.877 people
Spain	0.905	5.852.953 people
France	0.903	7.784.418 people
Slovenia	0.918	237.616 people

Table 1: Human development index (2020) and the number of foreign immigrants in the respective countries for the year 2020¹³

As can be seen from the table above, 23 countries of the world from almost all continents were considered for the analysis, these countries being chosen according to the human development index (HDI) calculated by the UN and provided by the international database Wikipedia. In our analysis we randomly selected the countries with the highest level of HDI development, considered by the UN to be above 0.9.

At the top of the table, the leading country by far is Norway with the highest HDI (0.957), followed by Switzerland with (0.955), followed by Ireland, Germany and the United States of America.

On the right side of the table, for variable Y in our model we have the number of foreign immigrants permanently settled in the countries considered by the UN to have the highest HDI.

The total number of immigrants in the table differs significantly from country to country, not being a constant or fixed figure, this depending a lot on the total population of each country, its territorial distribution, but also the population density in certain areas.

The total number of immigrants also includes the number of refugees from other continents, namely from Afghanistan, Iran, Iraq, China, Pakistan, of different sexes, ages, or nationalities. It is very important to specify that in the total number of immigrants there are both European citizens and those who are part of the EU countries, but also citizens who immigrated for other reasons (political, religious, social) than economic, being called temporarily settled foreign refugees in other countries.

¹³ Source: <http://hdr.undp.org/en/content/2021-human-development-index-ranking>

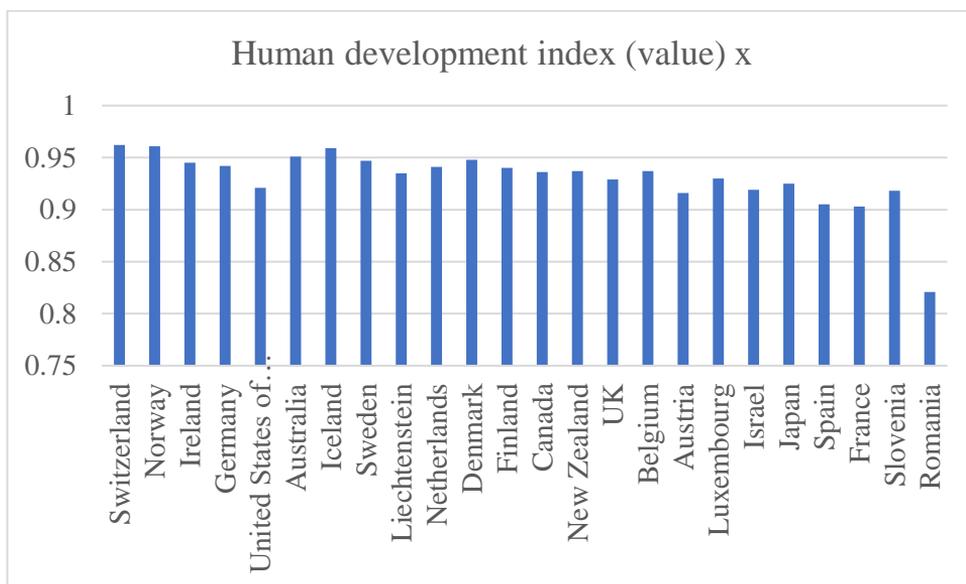


Figure 1. Human development index (2021) including Romania

3. The methodology of the simple regression model used in the research

To be able to determine to what extent there is a cause-effect relationship between the human development index and the number of foreign immigrants, we will build a simple linear regression model between an independent variable that is intended to contribute to changing the dependent variable.

We will determine a simple regression model and analyze its validity, i.e., whether there a relationship between the human development index and the number of foreign immigrants residing in the national territory exists. If it will be valid, we will make a forecast of a future flow of immigrants who will settle on the territory of the respective analyzed countries, characterized by certain values of the independent variable.

An important aspect to specify is the fact that the number of foreign immigrants is the dependent (outcome) variable, while the human development index is the independent (explanatory) variable. Thus, the simple regression model illustrates the relationship between the number of foreign immigrants and the human development index (HDI).

In this situation we have a unifactorial econometric model because we have an influence of the relative variable y – the number of foreign immigrants by a determined factor x – the human development index (HDI).

The form of the analyzed simple regression model is:

$$Y = a + bX + \varepsilon$$

The model variables, for the considered model, are:

Y – The number of foreign immigrants (persons) - the dependent variable,

a – Y intercept (the constant term),

b – the slope of the regression line,

X – Human development index (value) - the independent variable,

ε – a random variable, the variable that sums up the influence of other variables on the number of immigrants, but which are not expressly specified in the model. The variable ε expresses the deviations between the observed values and the values estimated by the model.

The parameters of the simple linear regression model, also called regression coefficients, are:

a – represents the constant or free term of the model and shows the average value of the Y variable when X = 0

b - the slope of the line - represents the average variation of the dependent variable, Y, to an absolute variation of one unit of the independent variable X, i.e., the disparity of the variable Y is relative to the variation of the variable X:

$$b = \frac{dy}{dx}$$

If $b > 0 \Rightarrow$ that there is a direct link between variable X and Y, if $b < 0 \Rightarrow$ that there is an indirect link between variable X and Y and if $b = 0$ then there is no link between X and Y.

Number of foreign immigrants = a + b* human development index + ε

Determining the parameters of the linear simple regression model is mostly done using the Least Squares Method. The use of the method starts from the following relation:

$\hat{y}_i = \hat{a} + \hat{b}x_i$, Unde „ \hat{a} ” și „ \hat{b} ” parameters of the regression line.

The actual values of the resulting characteristic are equal to the estimate obtained with the help of the regression model, corrected by the residual value:

$$y = \hat{y}_i + e_i$$

Concretely, the Method of Least Squares consists in minimizing the function $F(\hat{a}, \hat{b}) = \min \sum (y_i - \hat{y}_i)^2$

To be able to determine the two estimators, it is necessary to solve the resulting system of equations:

$$\begin{aligned} n\hat{b} + \hat{a}\sum x_i &= \sum y_i & 23\hat{b} + \hat{a} \cdot 21.284 &= 1886.1 \\ \hat{b}\sum x_i + \hat{a}\sum x_i^2 &= \sum x_i y_i & \hat{b} \cdot 21.284 + \hat{a} \cdot 19.636 &= 1742.786 \end{aligned}$$

4. Descriptive analysis and model results Human Development Index (HDI) and the number of foreign immigrants

The descriptive analysis of each variable considered in the model is done to study the characteristics of each distribution. We previously checked for missing or statistically outlier values and did not consider them in the analysis because these values would have skewed our results.

<i>Human development index (value) x</i>	
Mean	0.923826087
Standard Error	0.003803811
Median	0.925
Mode	0.939
Standard Deviation	0.018242438
Sample Variance	0.000332787
Kurtosis	-0.150571857
Skewness	-0.598009493
Range	0.072
Minimum	0.903
Maximum	0.962
Sum	21.248
Count	23

Table 2 Descriptive statistics for Human development index

<i>Number of foreign immigrants (persons)y</i>	
Mean	85.00434783
Standard Error	0.281334922
Median	82.1
Mode	82.1
Standard Deviation	1.349234888
Sample Variance	1.820434783
Kurtosis	1.383667901
Skewness	-0.687213822
Range	6.1
Minimum	1000
Maximum	50.660.000
Sum	1886.1
Count	23

Table 3 Descriptive statistics for Number of foreign immigrants

In the case of the unifactorial model analyzed above, the most used method consists in the graphic representation of the two series of values with the help of the correlogram. Using the data in Table 1 we exemplified the connection concerning the number of foreign immigrants and the human development index (HDI).

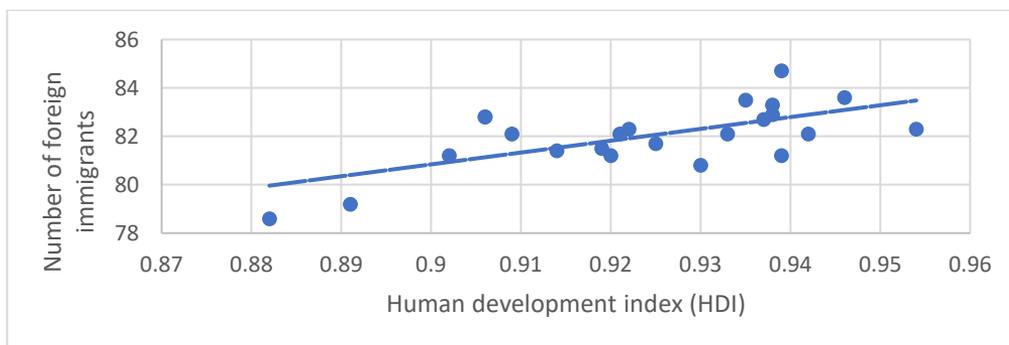


Figure 2. Link between the number of foreign immigrants and the human development index (HDI)

According to the correlogram it can be deduced that between the number of foreign immigrants and the human development index (HDI) there is a direct linear connection according to the relationship below:

$$Y_x = a + bX + \varepsilon.$$

Following the calculations performed using the function of the linear regression model, we have the following parameters $a=36.879$ and $b=48.846$, thus the regression function can be written as follows:

$$y = 48.846x + 36.879$$

<i>Regression Statistics</i>	
Multiple R	0.66042803
R Square	0.436165183
Adjusted R Square	0.409315906
Standard Error	1.036967632
Observations	23

Table 4. Regression statistics

Multiple R is the multiple correlation factor = 0.66042803. we notice that “r” is > 0 , which means that between the 2 variables: the number of foreign immigrants and human development index is a strong link. R Square (R^2) expresses how ample is the discrepancy in the frequency of immigrants, explained by the discrepancy or increase in the human development index for the countries analyzed. It can take values in the range between $[0,1]$. The closer its value is to 1, the greater the part of the variation of Y explained by X, and the stronger the connection between them. In the case presented by us, R Square has the value 0.436165183; meaning 43.61% of the discrepancy in the Human Development Index that can be explained by the flexible number of immigrants.

Adjusted R Square represents the adjusted correlation ratio = 0.409315906, shows that 0.409315906 from the entire variation is due to the regression line, taking into consideration the number of degrees of freedom.

Standard Error is designed as the standard variation of the residuals and is the approximation of the standard variation of the errors ε (assuming their normality). In our case the value is ± 1.036967632 .

Observations (number of observations from the sample) = in our case there are 23 observations in the sample, respectively 23 analyzed countries with a very high Human Development Index (HDI).

At the end, the ANOVA Test is used to validate the regression model used in the research.

The variation explained by the regression model is 17.46823, and the mean variation explained, corrected by the number of degrees of freedom (2), is 17.46823. The residual variation (variation not explained by the regression model) is 22.58133927, and the average of the residual variation corrected by the number of degrees of freedom (21) = 1.075302.

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	17.46822595	17.46823	16.24495077	0.000604044
Residual	22	22.58133927	1.075302		
Total	23	40.04956522			

Table 5. ANOVA

In the table is calculated the F test (Fisher), because $F = 16.24495077$, and Significance F (level of significance) = 6.04044 (much bigger than $\hat{\alpha} = 0,05$) the built regression model is valid for a probability of at most 95% and can be used for the analysis of the dependence between the human development index and the number of foreign immigrants.

df (number of freedom degrees): $k - 1 = 1$, $n - k = 21$, $n - 1 = 22$, where $k = 2$ is the number of model variables (variable x , respectively y), and $n = 23$ is the number of countries analysed in the model.

SS represents the sum of the squares of the deviations: Global sum of squares = Sum of squares due to regression + Residual sum of squares.

MS (the average of the sums of squares): *SS* divided by the respective number of degrees of freedom. The value on the second line (Residual) is the dispersion estimate for the error distribution and is the square of the standard error of the estimate.

F (statistic value *F*) for the test characterized by:

H_0 : the model is not statistically valid.

H_1 : the model is not statistically valid.

Significance *F* (the one-sided critical probability). If the resulting value is less than the fixed significance level, then the unfounded hypothesis is rejected in favour of the alternative hypothesis.

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0 %	Upper 95.0 %
Intercept - β_0	36.879017	11.198043	3.293345	0.0034632	13.59141	60.16662	13.59141	60.1666
x_1 – Human development for 23 countries	48.846131	12.119116	4.030503	0.0006040	23.64305	74.04921	23.64305	74.0492

index (HDI)								
----------------	--	--	--	--	--	--	--	--

Table 6. Value interpretation t-statistic

Intercept is the free term, so the coefficient $b_1 = 36.879017$. The free term is the point where the explanatory variable is 0. Since the t statistic = 3.293345, and the P-value $0.0034632 < 0.05$, it means that this coefficient is significant. The free term of the regression equation is found with a probability of 95% in the interval: [13.59141; 60.16662]

The coefficient corresponding to the independent variable (b_2) has a value of 48.846131 which means that when the number of foreign immigrants increases by one unit, the human development index will increase by 48.846131, which means that to some extent the flow of the number of foreign immigrants for certain countries is influenced by the human development index (HDI). The significance threshold has the value P-value = $0.0006040 < 0.05$, which means that this coefficient is significantly different from zero. The confidence interval for the analyzed parameter the number of immigrants is [23.64305; 74.0492].

From the analysis of the above coefficients, we deduce that the regression model is of the form:

$$\hat{Y} = 48.846 * X + 36.879$$

In other words, the link between the 2 variables analyzed in the model is a direct and powerful one. As mentioned before, at an increase of 1 unit of variable X (number of foreign immigrants), the Y variable (human development index) increases with 48.846131.

<i>Observation</i>	<i>Predicted Y</i>	<i>Residuals</i>	<i>Standard Residuals</i>
1	883.751	-1.178226736	-1.162961575
2	2.438.702	0.512542312	0.505901791
3	85.400	-0.792073163	-0.781811027
4	8.543.120	-1.54553477	-1.52551075
5	15.760.000	1.95446523	1.929143087
6	50.660.000	0.603311361	0.595494831
7	6.763.663	0.203311361	0.200677249
8	1600	0.052157492	0.051481737
9	1.639.771	0.949849754	0.937543456
10	1000	-0.352457984	-0.347891522
11	1.979.486	-1.505919591	-1.486408827

12	5.725.200	-0.361688936	-0.357002878
13	315.881	0.384849457	0.379863329
14	7.835.502	0.233695588	0.230667817
15	1.039.736	-0.617458281	-0.609458463
16	1.387.940	-0.26861215	-0.265131999
17	1.492.374	-0.124381495	-0.122770003
18	249.325	0.81984916	0.809227156
19	2.011.727	1.666387553	1.644797758
20	2.043.877	1.666387553	1.644797758
21	5.852.953	0.261772077	0.258380546
22	7.784.418	-1.200920482	-1.185361301
23	237.616	-1.361305303	-1.343668169

Table 7. Residual output

In Table 7 RESIDUAL OUTPUT we will find listed all the observations considered for the 23 countries considered, respectively we will find the values adjusted according to the regression equation, the residual value and the standard residual value.

For each observation made in the initial table for each observation in the initial data table, the following is displayed:

Observation (the observation's sequence number), respectively the 23 analyzed countries with very high HDI.

Predicted \hat{y} value (number of foreign immigrants settled in the 23rd countries) forecast for the specific sequence; (this can be achieved by substituting the observation X values into the estimated model)

Residuals – the difference between the observed value in the model and the forecasted value.

Standard Residuals – the standardized error value which is obtained by dividing the residual to the standard deviation of the residuals.

Below we analyzed the quality of the chosen model using the graphical representation obtained in EViews:

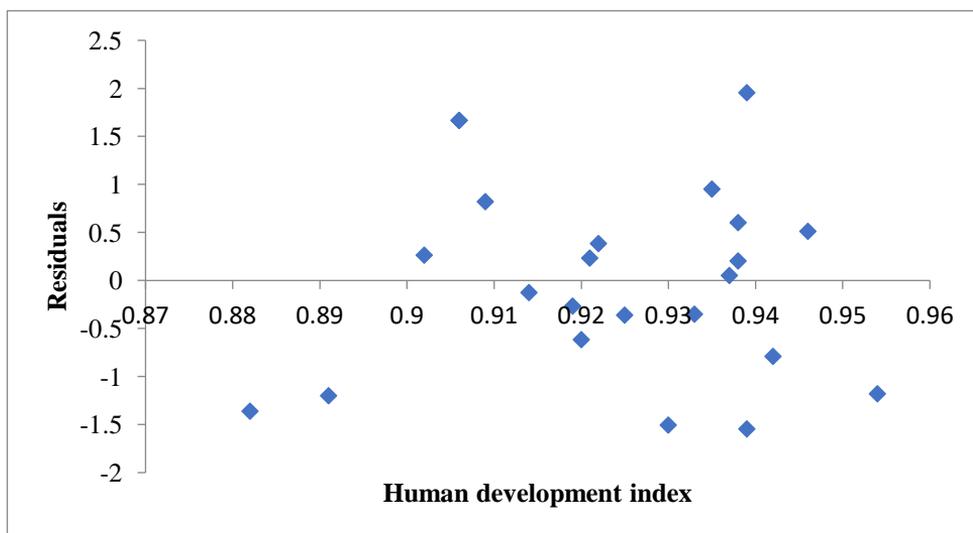


Figure 3. The independent variable versus residuals plot

According to the shape of the points represented in Figure 2, there is no correlation between the independent variable x and the obtained residuals, which indicates that the model, respectively for the two variables analyzed (Y and X) was a well-chosen one.

5. Conclusions

With the intensification of globalization worldwide, labour migration represents an important component in the economy of contemporary society, respectively this leads to the stimulation of the labour force from the national and international market of the states.

Migrant labour, or if we are talking about cheap labour here, can bring a series of benefits and advantages for entrepreneurs in the host or destination countries, namely the increase in the production of goods and services, the increase in labour productivity and consumption.

From the results of the analysis, we can see that there is a strong and direct link between the Human Development Index (HDI) and the number of immigrants for the year 2020, for the 23 selected countries.

We can affirm the fact that if we want to bring in a flow of foreign immigrants, i.e., workforce, it is necessary to increase the human development index, in other words, it is necessary to raise the standard of living for the citizens of a country.

If we were to make a comparison of the HDI between Romania (0.810) and Switzerland (0.962) which occupies the first place, we can see that there is a big gap between them.

Norway ranks second in terms of HDI with 0.961 which means that it has a high standard of living, registering the second GDP/place after Luxembourg among European countries, being fourth (4) in the world registering \$67,987. Norway held first place in the Human Development Index (HDI) for six consecutive years (2001-2006), and then regained this

position in 2009 until 2015. Norway's standard of living is among the highest in the world. Foreign Policy Magazine ranked Norway last in the Failed States Index for the year 2009, considering Norway to be the most functional and stable state.

The data presented by the UN for 2022, reveals that most world states have a slight regression after the Covid-19 pandemic, regarding education, economic development, life expectancy at birth.

Romania's HDI value for 2021 is 0.821— which put the country in the Very High human development category—positioning it at 53 out of 191 countries and territories. Between 1990 and 2021, Romania's HDI value changed from 0.703 to 0.821, a change of 16.8 percent.

Between 1990 and 2021, Romania's¹⁴ life expectancy at birth changed by 4.5 years, mean years of schooling changed by 2.8 years and expected years of schooling changed by 2.3 years. Romania's GNI per capita changed by about 125.9 percent between 1990 and 2021.

UN warns world States, that the most affected countries will be poor countries and the ones in development, that have an HDI bellow 0.7 compared to 0.9. As we stated before, in most countries the economic growth markers have made null all economic progress registered worldwide in the last 5 years (GDP/place, unemployment level, inflation rate, life expectancy in the last few years, income level).

All these transformations are due to Covid-19 pandemic, along with the Ukraine war, climate change, energy crisis and economic recession. They impact every labour market in each country.

If we were to analyse from an economic point of view the labour market for countries that receive an important migratory flow of people every year, we can say with certainty that these immigrants who do not find a stable job in a certain period or cannot integrate in the long term on the labour market will end up increasing the number of unemployed in that country, contributing decisively to the increase in unemployment.

This equation includes foreign immigrants of other nationalities - national citizens resident in the analysed countries (23), of course some are winners and losers alike, all are equally affected by the decrease in GDP/place, the standard of living and the decrease in income.

Bibliography

- [1] Cristian Elena Raluca, Iordache Ana Maria Mihaela, Dan Anda Veronica, *Population migration in the year of the Covid-19 Pandemic: A case study on Romania*, Proceedings of the Journal of Information Systems & Operations Management (JISOM), Vol.15. No.2, p.96, 2021. <http://jisom.rau.ro/>
- [2] Buda Daniel, *Impactul pandemiei de Covid-19 asupra mobilității forței de muncă*, Revista Transilvană de Științe Administrative 1 (46), p.19, 2020.

¹⁴ https://hdr.undp.org/system/files/documents/global-report-document/hdr2021-22pdf_1.pdf

- [3] Cristian, Elena, Raluca, Baragan, Laura, Georgeta; Mustea - Serban, Razvan, *The Socio-Cultural Consequences of the Migrations Phenomen on the Romanian Emigrants*, Ovidius University Annals Economic Sciences Series, 2017.
- [4] Cristian, Elena, Raluca; Baragan, Laura, Georgeta; Mustea - Serban, Razvan, *The Criteria Underlying the Romanians Emigration Intent*, Ovidius University Annals Economic Sciences Series, 2017.
- [5] Cristian, Elena, Raluca; Dănciulescu, Alexandra, Irina; Dan, Anda, Veronica, *Romanian Migration Before and After the Covid-19 Pandemic*, Romanian Economic and Business Review (REBE), Vol.17. No.1, p.18, 2022. (www.rebe.rau.ro).
- [6] Comisia Europeană, „2019 Annual Report on Intra-EU Labour Mobility”, Final Report January 2020, Elena Fries-Tersch, Matthew Jones, Birte Böök, Linda de Keyser, Tugce Tugran, EUROPEAN COMMISSION Directorate-General for Employment, Social Affairs and Inclusion Directorate D – Labour Mobility Unit D1 – Free movement of workers, EURES, <https://www.romania-serbia.net/wp-content/uploads/implementation/labour%20mobility/KE-BQ-21-001-EN-N.pdf>, Date of last access 06-11-2022.
- [7] *Tendințe sociale*, Institutul Național de Statistică din România, 2019. www.insee.ro, Date of last access 29-10-2022.
- [8] *Annual Report on Migration and Asylum 2021* Statistical Annex Co-produced by Eurostat and European Migration Network, June 2022, Date of last access 05-11-2022.
- [9] <https://hdr.undp.org/content/human-development-report-2021-2022>, Date of last access 30-10-2022
- [10] https://hdr.undp.org/system/files/documents/global-report-document/hdr2021-22pdf_1.pdf, Date of last access 15-11-2022.
- [11] <https://blogs.worldbank.org/opendata/new-world-bank-country-classifications-income-level-2022-2023>, Date of last access 13-11-2022.
- [12] <https://www.europarl.europa.eu/news/ro/headlines/world/20200624STO81906/cauzele-migratiei-de-ce-migreaza-oamenii>, Date of last access 27-10-2022.
- [13] <http://hdr.undp.org/en/content/2021-human-development-index-ranking>, Date of last access 01-11-2022.
- [14] <https://ec.europa.eu/eurostat/data/database>, Date of last access 06-11-2022.
- [15] <https://insse.ro/cms/ro/tags/comunicat-populatia-rezidenta-si-migratia-internationala>, Date of last access 25-10-2022.
- [16] https://ro.frwiki.wiki/wiki/Indice_de_d%C3%A9veloppement_humain, Date of last access 21-10-2022.
- [17] <https://ro.wikipedia.org/wiki/Norvegia#Economia>, Date of last access 21-10-2022.
- [18] <https://ro.wikipedia.org/wiki/Elve%C8%9Bia>, Date of last access 21-10-2022.

INCREASING PRODUCTIVITY THROUGH DIGITALIZATION AND ITS IMPACT ON THE FIELD OF MARKETING AT ORGANIZATIONAL LEVEL

Nicoleta Rossela DUMITRU¹

Oana PREDA²

Abstract

No matter if we are talking about entrepreneurs or managers in a company, their main goal is to improve productivity and increase profitability, respectively an increase in the results obtained with the same consumption or a lower consumption of resources in order to obtain the same results.

In this sense, new technologies have the role of increasing the efficiency of production processes, thus ensuring productivity growth, and we refer here to digitization as a continuous process, in which companies must adapt and integrate new technologies into their activities. This is necessary to streamline the work processes and to respond more effectively to the requests from consumers. We are talking about digital solutions, which through data analytics, machine learning, etc. manage to be of real help especially in the situation of recurring activities, offering companies new opportunities to improve the performance of operational processes and achieve significant savings.

Keywords: digitization, digital technologies, productivity, digital marketing

JEL Classification: M19, M21, O31, O49

1. Introduction

Digitization has been the watchword of the last year and a half regardless of the companies' field of activity and regardless of the degree of development of the world's economies. The COVID-19 pandemic thus accelerated a series of processes and hastened actors around the world to adopt new technologies in order to function in the new normality.

Companies accelerated digitization at a surprising speed, two or three years ahead of the plans they had for the next five years. Thus, it becomes more and more obvious that this is the only solution at the level of an organization to be able to remain competitive both locally and internationally; digitization improves the performance of companies, helping to reduce financial obstacles. [5]

Thus, more companies are keen to optimize the methods of using their assets to boost productivity, with digital technologies being seen as ideal mechanisms for changing energy consumption patterns. [2]

¹ Associate Professor PhD, Romanian-American University, nicoleta.rossela.dumitru@rau.ro

² Associate Professor PhD, Romanian-American University, oana.preda@rau.ro

Regardless of whether we are talking about entrepreneurs or managers in a company, their main goal is to improve productivity and increase profitability, respectively an increase in the results obtained with the same consumption or a lower consumption of resources in order to obtain the same results. In this sense, new technologies have the role of increasing the efficiency of production processes, thus ensuring the increase of productivity and, implicitly, of sales and profit of companies. Consequently, today's world is mainly influenced by digital technologies, which lead to the digital transformation of business sectors and the economy as a whole. [1]

Thus, more and more companies are incorporating digital solutions, leading to an estimate of productivity growth of at least 2% per year in all countries over the next decade. [4]

Digitization is a continuous process, in which companies must adapt and integrate new technologies into their activities. This is necessary to streamline the work processes and to respond more effectively to the requests from consumers. We are talking about digital solutions, which through data analytics, machine learning or RPA (Robotization of the Automation Process)³ manage to be of real help, especially in the situation of recurring activities, offering companies new opportunities to improve the performance of operational processes and achieve significant savings.

Recalibration processes based on new technologies, digital economy, highly skilled workforce, should take the place of routine operations, activities with low added value and conservative business models. The key role of the transformations is played by the transfer of knowledge, the incorporation of knowledge into processes and the configuration of the so-called knowledge-based economy. There is no doubt that this knowledge will be accumulated and amplified by computers, artificial intelligence, digitization, the use of the Internet, the virtual economy and the 4th industrial revolution, but all this will happen with the accumulation of intellectual capital instead of physical capital. [10]

Thus, the digitization and automation of processes will become an integrated part of every organization in order to remain competitive both locally and internationally.

The phenomenon of digitization of business has introduced increasingly dynamic changes throughout the global economic sphere, while its content continues to increasingly affect the competitiveness of national economies. At the microeconomic level, digital technologies lead to a change in the economic structure and the quality of the factors of production, based on knowledge and innovation. [7]

Today, technological developments have changed their dimensions with the digitization process, technological transformation has happened faster than seen in the past, man-machine cooperation in working life has started to shift in favor of machines and mechanization and automation production. For this reason, it is believed that the digitization process will positively affect both total factor productivity and labor productivity. [3]

In our country, whether we are talking about business processes or working from home, companies increasingly rely on technology (35%) stating that they accelerate automation to reduce costs. The majority (85%) of Romanian company decision-makers plan an

³ Automation Process Robotization - system that can automate almost any computer activity, eliminating human errors and saving money and human resources.

increase in investments in digital transformation, in the next three years. (CEO Survey 2021)

Thus, digital transformation rises to first place in the top of the fields for which executives will allocate more funds. In 2021, the digital transformation surpassed the operational efficiency that was a priority in recent years, the orientation towards digitization being an effect of the situation of the last year and a half, in which technologies meant, in many situations, the survival of businesses. At the same time, there is also a greater awareness, thanks to this recent context, that the future belongs to digitization, companies in Romania are aware of this fact and are going to allocate at least 10% more funds for investments. (CEO Survey 2021)

In the era of digitization, companies adapt to the fast pace and changes of the market; in order to develop, they implement effective technological solutions that visibly improve the activity. Such technological solutions that provide intelligent management of the entire business can target:

- data security and cloud computing, ensuring their flexibility and safety, being protected by a constantly maintained system;
- customer management and customer service - a dedicated management system (CRM software) and a platform where customer information is stored;
- employee management – through human resources software that saves time invested with administrative procedures, centralizes information about employees and eases the work of human resources staff. www.one-it.ro

The next leap in the evolution of mobile and wireless communications is represented by 5G technology. PwC estimates show that the use of 5G technology, along with investments in artificial intelligence (AI) and the Internet of Things (IoT), can lead to the optimization of business models, new products, and fast and efficient services, with gains expected to accelerate from 2025. At the same time, it should also be mentioned that the idea of digital transformation is also found in the context of the Green Pact of the European Union (europa.eu) in the multitude of smart digital solutions that support the sustainability of companies, in multiple variants: 5G solutions, big data. [9]

The main expected results, at the organizational level, of the adoption of sustainability supported by digitization come from: cost reduction, more effective risk management, adaptation to consumer expectations, stimulation of innovation, attraction and engagement of staff, better reputation, etc., against the background of a strategic visions of these companies. [6]

However, the growing dependence on digital services exposes companies to increasingly numerous and complex cyber threats. Companies are now spending more than ever on cyber security and privacy, and in the immediate future, continued investments in people, processes and technology are expected. It is obvious that the direction in which organizations from all fields of activity are heading is to be more and more efficient and flexible, using more and more technology.

However, although these cutting-edge technologies offer significant advantages to businesses, some risks may arise as these technologies continue to develop and eventually it becomes harder to control the pace of development. There are growing concerns about cases of artificial intelligence infringing on personal privacy.

In this sense, using customer data without informing the customer is behavior that violates the rules of ethics; at the same time, the ads in the field of commercial advertising, which can also be sent via smartphone, can analyze the psychology of the consumer and can exploit the weak points of some people. Companies like Facebook, Google and Amazon use algorithms to influence the consumer in viewing advertisements. [8]

Therefore, most of the companies are only at the beginning of this road to digitization and require larger investments. For example, at a global level, the (CEO Survey 2021) 2021 studies show that only 5% of companies are now truly digital". In the new context, it is expected that the use of advanced data analysis will be more intensive and the adoption of Artificial Intelligence (AI) in the foundation of management decisions, including those of risk management, will be made on a large scale.

Following this transformation, it is clear that this is the optimal way to prime the engines for increased productivity, then distribute the results to improve living standards and prosperity. At the same time, a series of changes are required, primarily in the remodeling of the educational system and the emphasis on research policy, the spread of digitization and the improvement of innovation, making the main power of the new system to be knowledge. [10]

2. Digital transformations in the field of Marketing

In 2021, most companies recalibrated their marketing efforts to the new economic context, but also to the transformations brought by the new way of working of marketing teams. The results were not slow to appear, through digitization and the constant use of data to make the necessary corrective decisions.

In 2022, under the pressure of changes in supply chains, marketing managers understood that they must focus on the effective delivery of results, giving importance to the content intended for their current customers (acquiring new customers is known to be 5 times more expensive than keeping current; increasing retention rates by just 5% can increase profits by 95%).

In this context, the current challenges in the field of marketing could be:

- efficient generation of results (79%)
- execution of omnichannel strategies (75%)
- understanding new customer buying preferences (72%)
- obtaining engagement on content (70%)
- creating content that best meets customer needs (63%)

It becomes essential for brands to know how their target audience engages with their content. Understanding user intent and experience is an emerging marketing trend that will stick around for the long term. There are three types of user intent to consider when creating content: transaction/purchase, navigation, and information.

In the content strategy companies must take into account the intention of the potential customer and what he wants to do with the information provided, in order to create a positive experience for him. That's why other challenges mentioned by marketing managers include integrating storytelling into sales (44%) and implementing multimedia marketing tactics (35%). (www.mindshop.ro)

In addition to the challenges, marketing specialists must also follow the trends that are manifested in this field, in the context of technological development, respectively⁴:

- 86% of companies say that this year they are focusing on optimizing their online presence
- 65% on content marketing that addresses customer needs
- 52% will rely on the advanced use of CRM platform functions in the management of sales processes
- 44% will do video marketing with an emphasis on measuring results
- 41% will specialize in managing micro-moments in the experience of current and potential customers.

In the first place 61% of the responding companies put their marketing on social networks, followed in second place by 60% who focus on content marketing and in third place by 47% who rely on influencer marketing.

Regarding the budgets allocated to the adaptation to the new conditions imposed at the moment, the situation is outlined as follows⁵:

- 4% of companies have annual marketing budgets of over EUR 1,000,000
- 3% have budgets of EUR 500,000–1,000,000
- 9% of EUR 250,000–EUR 500,000
- 6% of EUR 100,000–EUR 250,000
- 27% of EUR 10,000–100,000

Another aspect identified is that, with the intensive digitization of marketing and sales processes, companies have allocated slightly larger budgets for generating sales, but also for specific platforms that allow them to measure results. (www.mindshop.ro)

Regarding this aspect, digital marketing budgets are getting bigger and bigger; by accelerating the digitization process, it is estimated that the value of the local digital market

⁴ According to a study by Mind Shop Advertising Agency, 2022

⁵ idem

will reach at least 140 million euros⁶ at the end of 2022, while in 2021 it was 125 million euros.

In the context where people spend an average of 4-8 hours a day on mobile phones alone, and 7 out of 10 minutes are spent on a social media application, online games and video streaming platforms, it is no surprise that the digital market in the world, and implicitly in Romania, is in permanent growth.

In 2022, 3 new websites are created every second, that is 175 websites per minute. There are over 1.18 billion websites worldwide, but only 17% of them are active. The online environment is increasingly crowded. There are many opportunities, but also many issues with data security, limiting online consumer tracking, and a pervasive problem of trust. Those who manage to gain the trust of their customers and have direct communication with them will be the biggest winners.

In 2021, the most downloaded app was TikTok (according to statistics, its users spend 90% more time on it compared to 2020), while YouTube is the most popular video streaming app worldwide.

According to her, a positive trend that emerged in 2021 and continued in 2022 is that the local digital market is becoming more educated, and entrepreneurs are much more willing to listen to the advice of specialists.

A trend that also arose from the need for businesses to take quick measures in order not to disappear from the market under the conditions imposed by the "new normal". Thus, in the context where in the first 10 months of 2021 more than 50,000 companies were written off (30% more compared to the same period of 2020), many entrepreneurs understood that you can no longer exist as a business if you do not invest constantly in online.

Paradoxically, although time spent online has increased, for many businesses it is increasingly difficult to reach the right audience. Thus, the skills of digital marketing experts to succeed in bringing results for their clients, no matter how high the competition is, assumes great importance.

As for the mistakes that entrepreneurs make in the online environment, they are considered to be about copying market trends and lack of personalization of messages; according to a study published by Forbes in 2020, a person sees around 4,000 to 10,000 online and offline advertising messages per day. (www.forbs.ro)

At the same time, in the current context, it is expected that the events will be in a hybrid format and, practically, the budgets allocated in the past in the organization of a physical event, are reoriented in the online promotion of the event. This is where Virtual Reality has its say, so that everything seems as true as possible from the comfort of your home. Current trends include:

✓ **aligning the content** according to the Venn Diagram, which can start with the first properly written sentence⁷

⁶ www.forbs.ro, 2022

⁷ According to New marketing trends in 2022 - Bogdana Corcoz



Sursa: www.relevance.com

It's a somewhat natural trend for content creators, as brand visibility, credibility and authority must overlap to differentiate yourself in the market. Basically, to be a dominant brand in the market, its credibility is mandatory - that is, doing what you say you do!

At the same time, brand visibility is the effort of digital PR; it means the brand needs to 'talk' to people on social media, respond to complaints and offer solutions. Authority – to become an authoritative brand you must have consistency and unified communication.

✓ **non-profit actions** will become an essential part of marketing planning; more and more companies will look to partner with NGOs and it will be a win-win for both sides;

✓ **AI (Artificial Intelligence)** will become an important component in marketing trends - the era of influencers is already coming to an end and will be replaced by the "influencer identification" tool that tracks millions of videos and content materials that have an outlet public, and further displays them to the relevant public.

Furthermore, another option would be for past customers to promote your product or service as an affiliate. In this way, they feel motivated to talk about the products and services that they have directly interacted with and openly promote them. People who are truly excited about promoting the product will deliver the best results every time. (Creative Advertising)

3. Conclusions

The new competitive conditions in the post-pandemic market reveal the main growth factors, namely resilience, adaptability and flexibility, factors that are based on innovation, creativity, and entrepreneurship. In the current context, they are translated into the ability to act in the online environment, and to prioritize new opportunities generated by abrupt market changes. [10]

In conclusion, the NEW seems to be the current engine of the world economy, the new paradigm of creativity putting originality first, without forgetting quality.

In this sense, the digital transformation of recent years has a major impact on economies around the world, including in Romania, offering new opportunities to organizations, according to data from the Microsoft Digital Future Index Report that indicates the existence of a strong correlation between the level of digital development and economic results and societal of a country.

The constant integration of advanced digital technologies - such as Cloud, IoT and AI - in the activity of organizations plays a key role in increasing the impact of digital governance, an objective that is on the public agenda in Romania through the National Resilience and Recovery Plan (PNRR). (<https://mfe.gov.ro/pnrr>)

References

1. Corejova, Tatiana and Chinoracky, Roman, (2021), Assessing the Potential for Digital Transformation, Sustainability, 13, issue 19, p. 1-15, <https://EconPapers.repec.org/RePEc:gam:jsusta:v:13:y:2021:i:19:p:11040-d:650422>
2. Gunasilan, Uma, (2019), Entrepreneurship as a Driver of the Digital Transformation, International Review of Management and Marketing, 9, issue 5, p. 23-29, <https://EconPapers.repec.org/RePEc:eco:journ3:2019-05-4>
3. Yilmaz, Yasin, (2021), Transition to the Digital Economy, Its Measurement and the Relationship between Digitalization and Productivity, Istanbul Journal of Economics-Istanbul Iktisat Dergisi, 71, issue 1, p. 283-316, <https://EconPapers.repec.org/RePEc:ist:journl:v:71:y:2021:i:xi:p:283-316>.
4. Jaana Remes, Jan Mischke and Mekala Krishnan, (2018), Solving the Productivity Puzzle: The Role of Demand and the Promise of Digitization, International Productivity Monitor, 34, issue, p. 28-51, <https://EconPapers.repec.org/RePEc:sls:ipmsls:v:35:y:2018:2>
5. Maiti, Moinak and Kayal, Parthajit, (2017), Digitization: Its Impact on Economic Development & Trade, Asian Economic and Financial Review, 7, issue 6, p. 541-549, <https://EconPapers.repec.org/RePEc:asi:aeafvj:v:7:y:2017:i:6:p:541-549:id:1575>.
6. Maassen, M.A., (2018), Sustainable Business Models: An Imperative in the Strategic Management of Companies and Organizations. Management Dynamics in the Knowledge Economy, [e-journal] 6(2), pp.323-335. <https://doi.org/10.25019/MDKE/6.2.09>
7. Mastilo, Zoran, (2017), Impact of Digital Growth in Modern Business, Business and Management Studies, 3, issue 4, p. 59-63, <https://EconPapers.repec.org/RePEc:rfa:bmsjnl:v:3:y:2017:i:4:p:59-63>. <https://redfame.com/journal/index.php/bms/article/view/2650/2967>

8. Pinar Aytekin, Florina Oana Virleanuta, Huseyin Guven, Silviu Stanciu si Ipek Bolakca, (2021), Consumers' Perception of Risk Towards Artificial Intelligence Technologies Used in Trade: A Scale Development Study, *Amfiteatru Economic*, Vol. 23, No. 56/2021, <https://www.amfiteatruconomic.ro/ArticolEN.aspx?CodArticol=2979>
9. Pînzaru, F., Dima, A.M., Zbucnea, A. and Vereş, Z., 2022, Adopting Sustainability and Digital Transformation in Business in Romania: A Multifaceted Approach in the Context of the Just Transition, *Amfiteatru Economic*, 24(59), pp. 28-45. DOI: 10.24818/EA/2022/59/28, (Analysis of quality management services industry in materials by method bcg dot-matrix (amfiteatruconomic.ro))
10. Şerban, Octavian, (2022), Global productivity and competitiveness, between "creative destruction" and "collaborative complementarity", *Revista de Economie Mondiala / The Journal of Global Economics*, 14, issue 1, p. 90-104, <https://EconPapers.repec.org/RePEc:iem:journal:v:14:y:2022:i:1:p:90-104>.
11. <http://www.one-it.ro> (2021), 4 soluții tehnologice practice pentru ușurarea activității companiei (one-it.ro), accessed on 23.11.2022
12. <http://www.europa.eu> (2022), Pactul verde european | Comisia Europeană
13. CEO Survey (2021) (pwc.com.cy), accessed on 25.11.2022
14. <http://www.mindshop.ro>. Provocări în Marketing 2022 (valoria.ro), accessed on 25.11.2022
15. <http://www.forbs.ro>, Bugetele de marketing digital, din ce în ce mai mari. Valoarea pieței locale de digital va atinge în 2022 cel puțin 140 milioane de euro - Forbes.ro, accessed on 27.11.2022
16. <https://creativeadvertising.ro/>, Trenduri 2022 în marketingul digital - Creative Advertising, accessed on 29.11.2022
17. <https://mfe.gov.ro/pnrr>, Inovația, tehnologia cloud și creșterea competențelor digitale – piloni ai strategiei de digitalizare în România și Republica Moldova - Centrul de știri Microsoft România, accessed on 27.11.2022

UNDERSTANDING CUSTOMERS' WILLINGNESS TO PAY MORE AND PURCHASE INTENTION IN BLOCKCHAIN FOOD TRACEABILITY: EVIDENCE FROM VIETNAM

Nguyen Hong Huan ¹

Le Dinh Nghi ²

Nguyen Duy Yen Linh ³

Tran Nam Quoc ⁴

Dang Hoang Minh Quan ⁵

Nguyen Ngoc Duy Phuong ⁶

Abstract

The study analyzed the influence of Blockchain usage on purchase intention and the willingness to pay a higher price for customers within the food industry. Data collected through 180 distributed surveys was processed by SPSS 26 and SmartPLS 3.3 software. It is demonstrated that there are five factors influencing consumers' intention to purchase products using Blockchain Food Traceability (BFT): (1) Performance Expectancy, (2) Facilitating Conditions, (3) Social Influence, (4) Trust, and (5) Level of Knowledge. The study showed that trust, performance expectancy, and level of knowledge variables have a strong influence on behavioral intention. Recommendations were also made for managerial purposes. The significance of this paper is insights into customers' willingness to pay more and their purchase intention in Blockchain Food Traceability.

Keywords: Blockchain technology, Food traceability, Level of knowledge, Trust, UTAUT, Willingness to pay.

JEL Classification: D1

1. Introduction

Blockchain technology has emerged rapidly in recent years, introducing a trend in the future. Blockchain is a transparent and decentralized ledger of transactions (Boucher et al., 2017). This definition is at the broadest level and can be further clarified by Lewis et al. (2017). First, the blockchain records are not simply transactions but a network of databases, distributed across multiple entities, ensuring they are kept in sync. Second, decentralization

¹ Ph.D Student, Chang Jung Christian University, 111D00111@mail.cjcu.edu.tw.

² Lecturer Ph.D, Saigon University, nghiledinh@sgu.edu.vn.

³ Lecturer, International University, Vietnam National University, ndylinh@hcmiu.edu.vn.

⁴ Lecturer Ph.D, University of Management and Technology, Ho Chi Minh City.

⁵ Lecturer, Hoa Sen University, quan.danghoangminh@hoasen.edu.vn.

⁶ Lecturer Ph.D, International University, Vietnam National University, nndphuong@hcmiu.edu.vn.

means that no single owner or person controls the data; data can then be added and written to, but there is no way to change the historical data without the consent of the network participants. More and more attention is focused on blockchain in different fields due to the fact that all transaction data is protected and secured by its immutability. One of the most common applications is digital money in financial transactions (Fosso Wamba et al., 2020). Besides, Blockchain technology is accepted and experienced broadly within other industries, such as: logistics, consumer goods, pharmaceuticals, and law. Blockchain has played and is playing a vital role in tracking and tracing the sources of products from food retailers. For instance, Walmart employs Blockchain to trace the import process of pork from China. With the support, Walmart understands the manufacturing, logistics, storing as well as transacting processes of any products. Blockchain is also exploited by Unilever, Tyson, and Dole in the pursuit of source traceability (Marr, 2018). According to previous research, it is claimed that blockchain is able to build trust, which drives the intention to purchase products with BFT (Nga & Tuan, 2019; Yeh et al., 2019). Purchase intention, on the other hand, is significantly and positively guided by performance expectancy, effort expectancy, and habit. The results drawn from this paper indicate that technographics strongly boost consumers' intention to adopt BFT (Yeh et al., 2019). Additionally, Yeh et al. (2019) have advised care when respondents lack sufficient knowledge with a particular technology. The prevalence of blockchain is still limited, therefore the majority of respondents had little to no experience with it. Second, Taiwanese customers participated in the survey. Future studies may use it in other nations and compare results. Nga and Tuan (2019) suggested a relationship between trust and the intention to consume pork with source origin based on the Theory of Planned Behavior. However, their study possessed limitations when using OLS regression to analyze the regression model and did not analyze the impact of blockchain on purchase intention in the Vietnam context. Furthermore, the desire to consume food in general, and pork in particular, are both influenced by a variety of other factors not addressed in this study. This suggests that future research should address the constraints mentioned above in order to improve the study's trustworthiness. In addition, Nguyen *et al.* (2019) claimed that pork with obvious and clear origins is paid a higher price voluntarily compared with the common ones. The aim of this paper is to identify factors affecting consumers' intention to buy products using BFT in the Ho Chi Minh City market. A fine product or an implication of innovation are both intended to improve service quality, operation excellence, or create a better customer experience. This research is the foundation for supply chains and food retailers to employ Blockchain in enhancing productivity of logistics activities as well as boosting service quality and building trust among consumers in starting to use or continuing to use products with this advanced technology.

2. Literature review

2.1. Blockchain Food Traceability

Blockchain is considered to be the key player in transparent and decentralized exchanges (Boucher et al., 2017). Lewis et al. (2017) defined blockchain with more details. First, Blockchain is not simply transaction notes, it is a network of databases distributed over a number of nodes being synchronized with each other. Second, decentralization implies that data is not controlled or owned by any entities or individuals. Data cannot be recorded

without the permission of involved personnel. In particular, historical data cannot be edited or adjusted. Many advantages of blockchain have been mentioned and discussed, but its positive effects have not been fully covered (Bashir, 2018), namely: decentralization and disintermediation; transparency and auditability; immutability and security. Decentralization and disintermediation help to save time, reduce costs, and increase the chances for market expansion. The elimination of intermediaries increases the speed of transactions and reduces redundancy (Natarajan et al., 2017). Transparency and auditability present mutual authority when making adjustments. This prevents fraud and removes conciliation costs (Natarajan et al., 2017). Immutability: it is complex and complicated to change any recorded information in a Blockchain system (Bashir, 2018). However, immutability does not block any cancellations of transactions. With newly developed solutions, administrators are allowed to access parts of the blockchain and edit them (Natarajan et al., 2017). The security of the blockchain promotes flexibility and effectiveness of the whole chain. Besides, exchanges within Blockchain are encoded and guaranteed with their integrity, hence, improving data and cyber security (Bashir, 2018; Natarajan et al., 2017). In food supply chains and retailers, the Blockchain model is an advanced innovation. It focuses on the practical implications of connecting parts within the chain (Kehoe et al., 2017). This technology enables involved personnel to track connections between suppliers and retailers during the entire process of delivery. It provides data such as suppliers' information, ingredient information, etc. All details are added and recorded in the system simultaneously, and historical activities are also logged between partners (Kehoe et al., 2017).

2.2. Unified Theory of Acceptance and Use of Technology - UTAUT

Venkatesh *et al.* (2003) introduced the Unified Theory of Acceptance and Use of Technology (UTAUT) model after reviewing and combining previous models and theories regarding technology acceptance. UTAUT was built based on the foundation of eight models that studied the acceptance of users towards technological innovations: Theory of Reasonable Action (TRA) by Fishbein and Ajzen (1975); Motivation Model (MM) and Theory of Planned Behavior (TPB) by Ajzen (1991); Technology Acceptance Model (TAM) by Venkatesh and Davis (2000); C-TAM-TPB (A model combining TAM and TPB); Social Cognitive Theory (SCT); Innovation Diffusion Theory (IDT); and Model of PC Utilization (MPCU). Among those eight employed models, the core structure of this research is founded on TAM. The UTAUT model aims to predict users' intention to use and their actual behavior on a technology innovation. The model proposed four independent variables (Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions) with four control factors (Gender, Age, Experience, and Voluntariness of Use). While performance expectancy, effort expectancy, and social influence have a direct impact on intention to use, facilitating conditions directly influence users' behavior (Venkatesh et al., 2003). In order to fit into the context of this paper regarding culture and technological innovation in Ho Chi Minh City, UTAUT is utilized with the original model and the addition of other factors.

3. Hypothesis development

3.1. Performance Expectancy (PE) and Behavioral Intention (BI)

Venkatesh et al. (2003) defines performance expectancy as the degree to which an individual believes that adopting technological advancement will help to improve and boost their productivity. In the research of applying blockchain technology to food retailers and supply chains, the authors expected that the performance expectancy of consumers in retailers using source tracing technology has a strong influence on behavioral intention as they believe they will gain more benefits from it. Williams, Rana and Dwivedi (2015) argue that performance expectancy and behavior intention are good predictors for user behavior in technology adoption. Meanwhile, Bartlett, Julien and Baines (2007) claimed that the transparency of blockchain leads to higher performance expectations for involved personnel to get access to needed information. Blockchain offers a solution for distributing a sole information source that is trustworthy and accurate while also improving data effectiveness.

H1: Performance Expectancy in using Blockchain Food Traceability has a positive influence on Behavioral Intention.

3.2. Effort Expectancy (EE) and Behavioral Intention (BI)

According to Venkatesh *et al.* (2003), effort expectancy is one of the vital motivators to motivate behavioral intention to use technology advancement. Consumers are willing to learn how to use any application when it is simple and easy to use. They have the tendency to accept new innovations as long as they do not require too much effort. The more accessible a technology solution is to users, the stronger the impact of effort expectancy has on their purchase intention.

H2: Effort Expectancy in using Blockchain Food Traceability has a positive influence on Behavioral Intention.

3.3. Social Influence (SI) and Behavioral Intention (BI)

When previous findings are compared with the TAM model or MPCU, IDT, Venkatesh *et al.* (2003) argue that social influence is not a crucial element affecting behavioral intention as adopting technology is voluntary. In this paper, adopting BFT to trace the origin of products is a voluntary decision, depending on personal preference and demand for qualifying products before making a purchase. However, food is commonly purchased and consumed for the whole family or a group of friends, for instance; purchase decision is concerned with others' wellbeing. Therefore, social perception affects purchase behavior in the buying process.

H3: Social Influence in using Blockchain Food Traceability has positive influence on Behavioral Intention.

3.4. Facilitating Conditions (FC) and Behavioral Intention (BI)

Since blockchain is deployed, operated, and administered on smart devices, a hi-tech accessory is needed. This possibly limits the behavior of consumers in adopting this innovation due to the lack of smart phones or tablets. Previous studies have demonstrated that facilitating conditions (i.e.: computers, Internet speed, system integration) impact technology acceptance and usage (Venkatesh et al., 2012). However, the infrastructure of Blockchain stores a copy of all exchanges on cloud service, thus, it supports anytime data query and allows product origin traceability or services providing to chain members as well as consumers effortlessly (Francisco & Swanson, 2018). This research considered whether consumers who possess better conditions to adopt BFT will have a higher intention to purchase products that utilize blockchain technology.

H4: Facilitating Conditions in using Blockchain Food Traceability has positive influence on Behavioral Intention.

3.5. Behavioral Intention and Willingness to Pay more (WTP)

Behavioral intention is defined as one's willingness to accept a service (Davis, 1989). Venkatesh *et al.* (2003) suggested that accepting the use of a technology is strongly guided by behavioral intention. Willingness to pay more is measured by the monetary unit or percentage unit paid for the product, which is higher than normal. Hence, willingness to pay more is considered as a measurement scale in assessing demand between new products and commonly used products (Athanasios Krystallis & Chrysosoidis, 2005; Athanasios Krystallis et al., 2006). The willingness to pay more variable is widely employed in studies regarding demand for environmentally-friendly products or well-being products (Krystallis, Fotopoulos and Zotos, 2006). Adopting Blockchain technology with the expectation of food safety and sanitation, consumers are more likely to purchase, and they believe that the information provided is trustworthy. It comes to a question of whether consumers are willing to pay more for Blockchain used products and how willing they are.

H5: Behavioral Intention in purchasing Blockchain Food Traceability products has a positive influence on Willingness to Pay more.

3.6. Trust (TR) and Behavioral Intention, Willingness to Pay more

Böcker and Hanf (2000) indicated that trust can reduce uncertainty to an acceptable level and simplify decisions. Lobb, Mazzocchi and Traill (2007) proved that having trust in a source of information affects the decision to buy chicken in the United Kingdom. Hypotheses were promoted about trust and behavioral intention as well as willingness to pay more:

H6a: Trust in Blockchain Food Traceability has a positive influence on Behavioral Intention.

H6b: Trust in Blockchain Food Traceability has a positive influence on Willingness to Pay more.

3.7. Level of Knowledge (LK) and Performance Expectancy, Effort Expectancy, Trust, Behavioral Intention

Level of knowledge is measured using a knowledge survey tool called LOKUS developed by Stone (2013). The model was designed to measure the current degree of awareness, notice, and usage of new knowledge introduced in the technology field (Stone, 2013). LOKUS is shared among involved personnel through a web-based platform to evaluate their awareness. Participants will be asked a series of questions and grouped into a distinguished degree of knowledge based on their responses. Stone described 10 different degrees, ranging from non-awareness to modified use. Since the development and deployment process of Blockchain is still new, the degree of knowledge used in this paper is framed within the first 5 levels: (1) Not being aware of Blockchain, (2) Being aware of Blockchain, (3) Interest in using Blockchain, (4) Intended to use Blockchain, (5) Modified use of Blockchain (already participated in using Blockchain). Simplifying and adjusting models are made in order to fit within the proposed framework, Stone (2013) specifies that language and replacement have to be modified to be suitable in the context of a specific technology area (Stone, 2013). As mentioned earlier, being familiar with Blockchain or having encountered Blockchain builds a certain level of trust in it. Low levels of knowledge can lead to suspicion. Therefore, hypotheses were proposed to predict the influence of knowledge:

H7a: Level of Knowledge in Blockchain has positive influence on Performance Expectancy in using Blockchain Food Traceability.

H7b: Level of Knowledge in Blockchain has positive influence on Effort Expectancy in using Blockchain Food Traceability.

H7c: Level of Knowledge in Blockchain has positive influence on Trust in Blockchain Food Traceability.

H7d: Level of Knowledge in Blockchain has positive influence on Behavioral Intention to use Blockchain Food Traceability.

Based on previous academic theories and proposed hypotheses, the conceptual framework was structured to include seven relationships reflecting independent variables, namely: Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Trust; impacting Behavioral Intention and Willingness to Pay more of consumers toward Blockchain Food Traceability. Figure 1 demonstrates the conceptual framework.

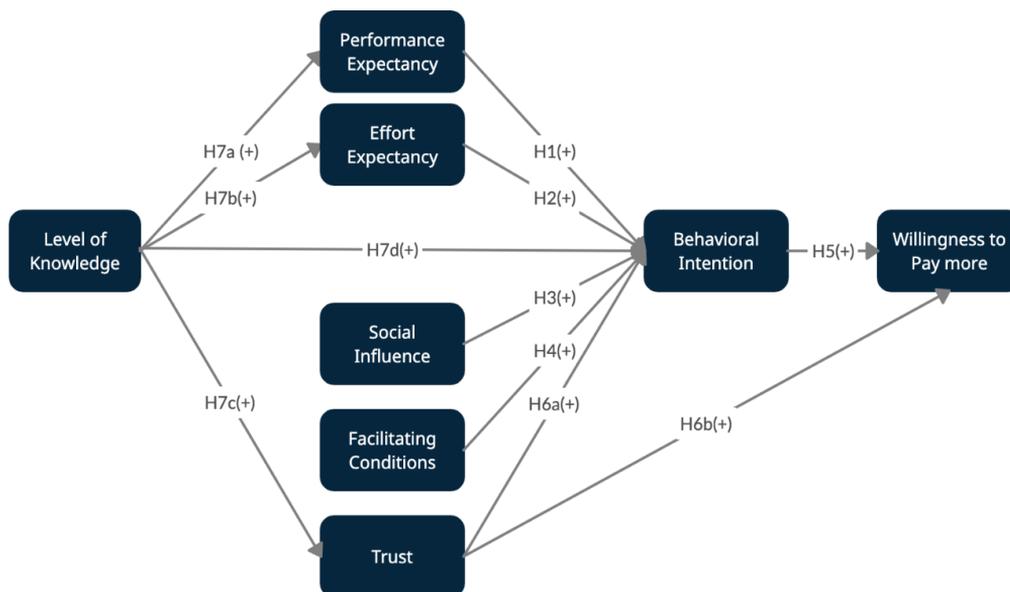


Figure 1. Proposed Conceptual Framework

4. Methodology

This paper combined quantitative research methods with qualitative research methods. The qualitative research approach employed in-depth interviews performed on experts: 10 experts in technology, enterprise managers, and food retailers. Each interview was conducted in 30 minutes. All 10 experts agreed to confirm that seven variables in the UTAUT2 model have an influence on the intention to purchase BFT. Besides, almost all experts agree that trust and level of knowledge are crucial variables in adoption and usage of BFT. Respondents also mentioned other factors such as convenience, shopping routine and culture, technology capability, habit in using smart devices and marketing, communication, etc. with discrete frequency and minority consensus, thus, the authors did not include in the model of this paper.

The quantitative questionnaire was structured with three sections: (1) demographics; (2) questions using the Likert scale from 1-5 to measure PE, EE, SI, FC, TR, BI and WTP, (3) level of knowledge. In this paper, Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed. Using a convenient sampling method, target audiences who consume food residing and working in Ho Chi Minh City were provided online forms, 100% of participants responded through Google Form navigating from the authors' personal Facebook page, indicating their frequency of using smart devices. The items for behavioral intentions, performance expectancy, effort expectancy, social influence, and facilitating conditions were adapted from Venkatesh et al. (2012). The items of trust were adapted from Kim et al. (2009). The items of Level of knowledge were adapted from a survey tool called LOKUS developed by Stone (2013) and the willingness to pay more was adapted from Laroche et al. (2001).

5. Findings

5.1. Population sampling

There were 125 respondents who had not used BFT, which accounted for 69.4%, and 55 of those who had and are still using BFT, which accounted for 30.6%. This indicated that the percentage of people who have not used BFT took up a considerable portion. The samples include 52.8% males and 47.2% females. Regarding the age range of the population, participants who were under 20 accounted for 6.1%, from 20 to under 30 accounted for 51.7%, from 30 to under 40 was 31.1%, from 40 to under 50 was 6.7%, and above 50 was the least with 4.4%. The population samples are appropriate since the authors aimed to study younger generations who are more likely to accept technology in the future. Respondents mostly pursued undergraduate programs, which accounted for 61.7%. Graduates were 22.8%, vocational and college were 8.3% and highschoolers were 7.2%. This showed that participants had a variety of educational backgrounds. Average income was mostly above 1000 USD per month, accounting for 31.1%. Average income below 250 USD per month accounted for 27.8%, from 250 USD to under 500 USD per month was 22.8%, from 500 USD to under 750 USD per month was 11.1% and from 750 USD to under 1000 USD per month was 7.2%. The distribution of occupations was even, with mostly university students and employees. This diversity was able to reflect reality and guarantee population representation.

5.2. Convergent Validity

Chin (1998) claimed that Cronbach's Alpha is not the only ratio to be concerned in empirical study, but also Composite Reliability (CR) has to be 0.6 and higher. In conducting confirmatory research, a threshold of 0.7 is appropriate for CR. (Henseler & Sarstedt, 2013). Other scholars also confirmed that 0.7 is an applicable assessment for a majority of studies like Hair *et al.* (2017).

The Average Variance Extracted (AVE) was utilized in validating PLS-SEM convergence. Höck and Ringle (2010) believe that AVE has to be above 0.5 for a measurement scale to be convergent.

Data from analytical result claimed that CA, CR, and AVE of chosen measurement scales were well performed, where CAs and CRs are higher than 0.9 and AVEs are above 0.75.

5.3. Discriminant Validity

HTMT has to be under 1.0 for a model to be well structured. Henseler *et al.* (2015), however, justify that if HTMT is below 0.9, a discriminant value is established between the chosen pair of constructs.

Heterotrait-Monotrait Ratio (HTMT) between given pairs was presented to be lower than 0.9. To be specific, ratios were mostly below 0.85, except for the pair of TR → BI (0.851), which signified that available value was satisfying for study.

5.4. Hypothesis testing and discussion

The results of the coefficient of determination R^2 showed that the framework with dependent variable BI is strongly explained by the index of $R^2 = 0.817$. With an R^2 of 0.48, WTP is adequately described. The Q^2 value of five exogenous variables (BI, WTP, EE, PE, and TR) was significantly greater than 0. The highest Q^2 values were 0.644 and 0.369 for BI and WTP, respectively. The f^2 values of most variables were excellent, with the exception of the EE variable BI, which had an effect coefficient of $f^2 = 0.017 < 0.02$ (not significant). Furthermore, in recent studies, as mentioned in the literature review, EE was claimed to have a significant impact on BI; the authors explored the significance of EE in subsequent assessments. The SRMR index of 0.059, lower than 0.08, showed that the model is well-fitting (Hair et al., 2017).

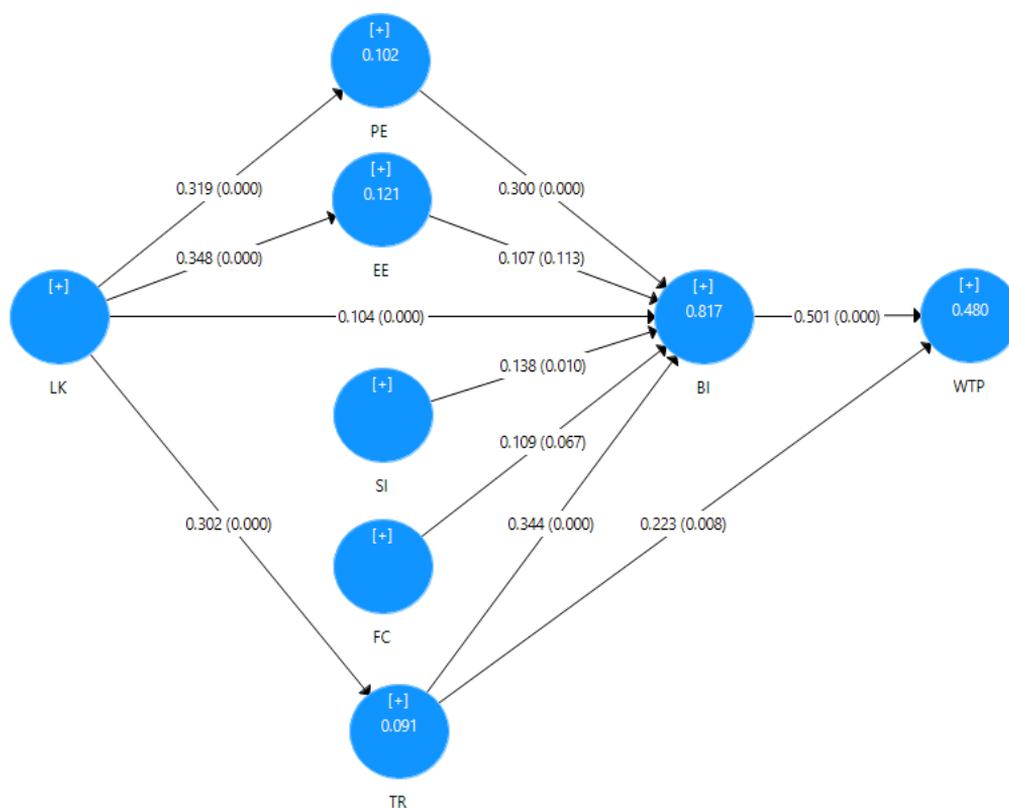


Figure 2. PLS-SEM Path Coefficient result

The relative significance of exogenous variables on behavioral intention and willingness to pay more indicated that trust is mostly critical for behavioral intention with a path coefficient of 0.344 as well as contributes positively to willingness to pay more. It can be concluded that reinforcing and enhancing trust of consumers in BFT increases intention to purchase along with the Willingness to pay more for products integrated with Blockchain

technology. These findings are aligned with the results of previous studies by Yeh *et al.* (2019), Queiroz and Fosso Wamba (2019), Nga and Tuan (2019). The outcome from Lobb, Mazzocchi and Traill's (2007) paper argued that trust in information sources had an impact on the intention to buy chicken in the UK. Research by Muringai and Goddard (2018) conducted in Canada, the United States of America and Japan suggested that trust affected pork and beef consumption. Meanwhile, Buaprommee and Polyorat (2016) claimed that trust had a positive influence on the intention to purchase.

Performance Expectancy is the variable with the second highest path coefficient of 0.300 in the Behavioral Intention model, indicating that the expectation of performance has a significant positive influence on behavioral intention. The findings are in agreement with results drawn from the research of Venkatesh *et al.* (2012), Nair, Ali and Lim (2015), Yeh *et al.* (2019), Queiroz and Fosso Wamba (2019).

Social Influence has the third highest path coefficient, indicating that concerns from family, acquaintances, and society positively influence Behavioral Intention to purchase products using BFT. This outcome is supported by the studies of Venkatesh *et al.* (2012), Nair, Ali and Lim (2015) and shows that social influence is not a significant factor. On the other hand, the findings pointed out a contradictory result in Yeh *et al.* (2019), Queiroz and Fosso Wamba (2019), where it was claimed that social influence did not show any statistical meaning in affecting behavioral intention.

The common outcome of the effect facilitating conditions variables have on behavioral intention is their light impact, with a path coefficient of 0.109, respectively. The finding of Facilitating Conditions is consistent with Venkatesh *et al.* (2012), Nair, Ali and Lim (2015), Queiroz and Fosso Wamba (2019). A compatible device or favorable support of knowledge, devices boost intention to purchase products with BFT. For the effort expectancy factor, ease of use and simplicity do not contribute to the augment of purchase intention; this can be explained by the demographic of this paper's chosen population. Respondents were mostly well-educated with good educational backgrounds, including undergrads and postgrads. The finding of facilitating conditions is inconsistent with Yeh *et al.* (2019) and supported by Sharma *et al.* (2020).

Measuring willingness to pay more and factors affecting that will be critical for new products and services introduced to the market. Analytical result illustrates that trust and behavioral intention positively influence willingness to pay more, with a path coefficient of 0.223 and 0.501, respectively. When trust and the intention to purchase are enhanced, consumers are willing to pay more for BFT.

6. Managerial Implications

Findings indicated that trust plays a vital role in influencing the intention to purchase products using BFT from individual consumers.

The level of knowledge has a positive effect on trust in BFT. Improving security, on the other hand, will increase consumers' trust in BFT service. To build trust in consumers, besides ensuring food safety and information security for customers, supply chains and food retailers need to pay attention to solutions such as: enhancing supply chain reputation, brand image; expanding network scale; not being limited geographically; reinforcing

infrastructure; and strengthening the legal framework on information corruption or insecurity. Consumers' perceptions have been shifted because of the mass of information on social media and technological encounters. Consumers love modern supply chains and food retailers that constantly innovative technology to fulfill convenience with the lowest cost. The customer service systems of the food industry at selling destinations, branches, or online channels need to be optimized to retain customers.

Nowadays, consumers' awareness of consuming safe products is being raised, especially in hard to persuade markets like the United States of America, Europe, and Japan. According to research about consumer behavior on food conducted by Hidayat (2014), there are 10 critical factors affecting their purchase intention, among which, the three most vital ones are freshness, safety and price which depend significantly on manufacturers, other factors depend on retail units. Using Blockchain to trace origin can help manufacturers solve these three factors. Supply chains and food retailers need to plan suitable marketing strategies to raise awareness about the efficiency of blockchain in adapting to consumers' expectations.

Through statistical data regarding Blockchain level of knowledge among surveyed populations, it can be seen that respondents still have a low degree of knowledge. The most common responses were (1) Not being aware of Blockchain and (2) Being aware of Blockchain, with a percentage of 59.5%. Besides, findings claim that consumers with a higher level of knowledge have a higher intention to purchase products using BFT. Therefore, enhancing awareness and level of knowledge of Blockchain is significantly meaningful in reinforcing intention to purchase and willingness to pay more. It is recommended that supply chains and food retailers plan positive communication about blockchain. Partnerships with universities or technology companies can contribute to raising awareness and the level of knowledge of potential consumers. In the context of digital transformation, utilizing technology innovations and communications to encourage consumers to seek information through events and promotions is necessary.

To attract consumers to this new innovative product, administrators should combine referral marketing and sustainable food brands with a high trust level in the market to create a strong impact on consumers. To enhance product competency, enterprises should consider using promotion codes or accumulated points when recommending products to friends and family. Good product quality, an efficient delivery process, and high service quality related to products are strong motivators for consumers to talk and discuss the products with family, friends, and the community.

Food traceability should be easy to perform and convenient for consumers of all age ranges and educational backgrounds. Managers are suggested to prepare plans for multi-platform applications in case a mobile device does not support application installation due to an incompatible operating system or is not supportive of updated versions. It is also highly recommended to focus on communication channels, such as: hotlines, customer centers, and emails; so as to support customers with the best service when they encounter troubles.

7. Conclusions, limitations, and further research

Research findings demonstrated that the effects of Blockchain on behavioral intention and willingness to pay more for BFT through UTAUT framework depend on variables:

performance expectancy, social influence, facilitating conditions, trust, and level of knowledge. Path analysis of factors influencing behavioral intention and willingness to pay more for BFT showed that chosen variables have positive impacts and different weights, except for the factor of effort expectancy, which was eliminated from the model. This is the basis and foundation for supply chains and food retailers. Strategic administrators communicate products in order to achieve more in changing customers' awareness and trust. Based on the basis of researching impacts of Blockchain on Behavioral Intention and Willingness to Pay more, this paper recommended sufficient marketing strategies for ongoing trends. Principle solutions are suggested aiming to improve product marketing processes, increase market consumption, and develop the economy to enrich the lives of consumers. It is also a way for domestic food retailers to grow and expand their potential market.

As many research, this study has several limitations. First, this paper has limitations in geographic and scope, which only focuses on the population working and living in Ho Chi Minh City without exploring other regions, especially the countryside. The research population did not represent Vietnam. Second, the limitation is target respondents. Because of the complicated circumstances of COVID-19 during the data collection process, this paper did not distribute offline surveys. 100% of participants responded through Google Form navigated from the authors' personal Facebook page, indicating their frequency in using smart devices. Hence, this study failed to evaluate segments who do not own or adopt few smart devices. Moreover, data was regarded as individual consumers and did not include enterprise customers. Third, the authors adopted the 5-Likert scale based on subjective assessment of companies about service quality; thus, undesired limitations are unavoidable. Hence, further studies should utilize other data sources to confirm the findings of this paper. Further research should be conducted in other cities or in rural areas with diverse target research segments to be universally representative of the model.

Bibliography

- Ajzen. (1991). The Theory of Planned Behavior. *Organizational Behavior And Human Decision Processes*, 50, 179–211. [https://doi.org/doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/doi.org/10.1016/0749-5978(91)90020-T)
- Bartlett, P. A., Julien, D. M., & Baines, T. S. (2007). Improving supply chain performance through improved visibility. *The International Journal of Logistics Management*, 18(2), 294–313. <https://doi.org/10.1108/09574090710816986>
- Bashir. (2018). Mastering Blockchain Second Edition. In *Birmingham: Packt Publishing*. Packt Publishing. www.packtpub.com
- Böcker, A., & Hanf, C. H. (2000). Confidence lost and - partially - regained: Consumer response to food scares. *Journal of Economic Behavior and Organization*, 43(4), 471–485. [https://doi.org/10.1016/s0167-2681\(00\)00131-1](https://doi.org/10.1016/s0167-2681(00)00131-1)
- Boucher, P., Nascimento, S., & Kritikos, M. (2017). How Blockchain Technology Could Change Our Lives. In *European Parliament*. European Parliamentary Research Service. [http://www.ep.europa.eu/stoa/%0Ahttp://www.europarl.europa.eu/RegData/etudes/IDAN/2017/581948/EPRS_IDA\(2017\)581948_EN.pdf](http://www.ep.europa.eu/stoa/%0Ahttp://www.europarl.europa.eu/RegData/etudes/IDAN/2017/581948/EPRS_IDA(2017)581948_EN.pdf)

- Buaprommee, N., & Polyorat, K. (2016). The antecedents of purchase intention of meat with traceability in Thai consumers. *Asia Pacific Management Review*, 21(3), 161–169. <https://doi.org/10.1016/j.apmr.2016.03.001>
- Chin, W. W. (1998). Issues and Opinion on Structural Equation Modeling. *European Journal of Dermatology*, 27(1). <https://doi.org/10.1684/ejd.2016.2884>
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. In *MIS Quarterly: Management Information Systems* (Vol. 13, Issue 3). MIS quarterly, 319-340. <https://doi.org/10.2307/249008>
- Fishbein & Ajzen, I., M. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. <https://people.umass.edu/aizen/f&a1975.html>
- Fosso Wamba, S., Kala Kamdjoug, J. R., Epie Bawack, R., & Keogh, J. G. (2020). Bitcoin, Blockchain and Fintech: a systematic review and case studies in the supply chain. *Production Planning and Control*, 31(2–3), 115–142. <https://doi.org/10.1080/09537287.2019.1631460>
- Francisco, K., & Swanson, D. (2018). The Supply Chain Has No Clothes: Technology Adoption of Blockchain for Supply Chain Transparency. In *Logistics* (Vol. 2, Issue 1). Logistics. <https://doi.org/10.3390/logistics2010002>
- Hair, J., Hult, G. T., Ringle, C., & Sarstedt, M. (2017). A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM) - Joseph F. Hair, Jr., G. Tomas M. Hult, Christian Ringle, Marko Sarstedt. In *Sage*.
- Henseler, J., & Sarstedt, M. (2013). Goodness-of-fit indices for partial least squares path modeling. *Computational Statistics*, 28(2), 565–580. <https://doi.org/10.1007/s00180-012-0317-1>
- Hidayat, R. (2014). *Consumer Behaviour at the Generic Level*. 22(2), 100–116.
- Höck, M., & Ringle, C. M. (2010). Local strategic networks in the software industry: An empirical analysis of the value continuum. *International Journal of Knowledge Management Studies*, 4(2), 132–151. <https://doi.org/10.1504/IJKMS.2010.030789>
- Kehoe, L., O’Connell, N., Andrzejewski, D., Gindner, K., & Dalal, D. (2017). When two chains combine: Supply chain meets blockchain. In *Deloitte*. https://www2.deloitte.com/content/dam/Deloitte/pt/Documents/blockchainsupplychain/IE_C_TL_Supplychain_meets_blockchain_.pdf
- Khuu, T. P. D. et al. (2019). Are Consumers Willing to Pay More for Traceability? Evidence from an Auction Experiment of Vietnamese Pork. *International Journal of Food and Agricultural Economics*, 7(2), 127–140.
- Kim, G., Shin, B., & Lee, H. G. (2009). Understanding dynamics between initial trust and usage intentions of mobile banking. In *Information Systems Journal* (Vol. 19, Issue 3). Information Systems Journal, 19(3), 283-311.
- Krystallis, Athanasios, & Chrysohoidis, G. (2005). Consumers’ willingness to pay for organic food: Factors that affect it and variation per organic product type. *British Food Journal*, 107(5), 320–343. <https://doi.org/10.1108/00070700510596901>
- Krystallis, Athanasios, Fotopoulos, C., & Zotos, Y. (2006). Organic consumers’ profile

and their willingness to pay (WTP) for selected organic food products in Greece. *Journal of International Consumer Marketing*, 19(1), 81–106. https://doi.org/10.1300/J046v19n01_05

Laroche, M., Bergeron, J., & Barbaro-Forleo, G. (2001). Targeting consumers who are willing to pay more for environmentally friendly products. In *Journal of Consumer Marketing* (Vol. 18, Issue 6). Journal of consumer marketing.

Lewis, R., McPartland, J., Ranjan, R., Lewis, R., & McPartland, J. (2017). Blockchain and Financial Market Innovation. *Economic Perspectives*, 7, 2–12.

Lobb, A. E., Mazzocchi, M., & Traill, W. B. (2007). Modelling risk perception and trust in food safety information within the theory of planned behaviour. *Food Quality and Preference*, 18(2), 384–395. <https://doi.org/10.1016/j.foodqual.2006.04.004>

Marr, B. (2018). How Blockchain will transform the supply chain and logistics industry. *Forbes*. <https://www.forbes.com/sites/bernardmarr/2018/03/23/how-blockchain-will-transform-the-supply-chain-and-logistics-industry/?sh=2bf56a1e5fec>

Muringai, V., & Goddard, E. (2018). Trust and consumer risk perceptions regarding BSE and chronic wasting disease. *Agribusiness*, 34(2), 240–265. <https://doi.org/10.1002/agr.21524>

Nair, P. K., Ali, F., & Lim, C. L. (2015). Interactive Technology and Smart Education Article information: *Interactive Technology and Smart Education*, 12(3), 183–201.

Natarajan, H., Krause, S., & Gradstein, H. (2017). Distributed Ledger Technology and Blockchain. In *Distributed Ledger Technology and Blockchain*. FinTech note. World Bank Group. <https://doi.org/10.1596/29053>

Nga, N. T. H., & Tuan, T. A. (2019). Consumers' purchase intention of pork traceability: The moderator role of trust. In *Studies in Computational Intelligence* (Vol. 809). In International Econometric Conference of Vietnam (pp. 886-897). Springer, Cham. https://doi.org/10.1007/978-3-030-04200-4_64

Queiroz, M. M., & Fosso Wamba, S. (2019). Blockchain adoption challenges in supply chain: An empirical investigation of the main drivers in India and the USA. *International Journal of Information Management*, 46(September 2018), 70–82. <https://doi.org/10.1016/j.ijinfomgt.2018.11.021>

Sharma, S., Singh, G., Pratt, S., & Narayan, J. (2020). Exploring consumer behavior to purchase travel online in Fiji and Solomon Islands? An extension of the UTAUT framework. *International Journal of Culture, Tourism, and Hospitality Research*, 15(2), 227–247. <https://doi.org/10.1108/IJCTHR-03-2020-0064>

Stone, V. (2013). The LOKUS instrument. *University at Buffalo - Center on Knowledge Translation for Technology Transfer*.

Venkatesh, Morris, Davis, & Davis. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, 27(3), 425–478. <https://doi.org/10.2307/30036540>

Venkatesh, V., & Davis, F. D. (2000). Theoretical extension of the Technology Acceptance Model: Four longitudinal field studies. In *Management Science* (Vol. 46, Issue 2). *Management Science Informs* vol. 46 (2), 186-204.

<https://doi.org/10.1287/mnsc.46.2.186.11926>

Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. *MIS Quarterly: Management Information Systems*, 36(1), 157–178. <https://doi.org/10.2307/41410412>

Williams, M. D., Rana, N. P., & Dwivedi, Y. K. (2015). The unified theory of acceptance and use of technology (UTAUT): A literature review. In *Journal of Enterprise Information Management* (Vol. 28, Issue 3). J. Enterp. Inf. Manag. <https://doi.org/10.1108/JEIM-09-2014-0088>

Yeh, J.-Y., Liao, S.-C., Wang, Y.-T., & Chen, Y.-J. (2019). *Understanding Consumer Purchase Intention in a Blockchain Technology for Food Traceability and Transparency context*. 1–6. <https://doi.org/10.1109/sitim.2019.8910212>

USING THE INFINITE DESCENT METHOD TO FIND CONVENIENT RATIONAL AND NON-RATIONAL NUMBERS USING DEDEKIND CUTS

Celso Luis LADERA¹

Ramon A. MATA-TOLEDO²

Abstract

It is well-known that irrational numbers play a relevant role in mathematics and basic sciences e.g., the number introduced by the Babylonians and Egyptians of ancient times, Euler's number e to explain exponentially-varying processes, and the λ of Conway's cosmological theory. Therefore, a strong understanding of real numbers is important. Many mathematicians such as R. Dedekind and W. Rudin, when introducing the real numbers via the rational and irrational numbers and the concept of Dedekind cuts, make use of "convenient numbers" such as Rudin's h which seem to be "taken out of a hat." From a pedagogical point of view, the use of these numbers has proven to be a sticky issue to both students and professors because there has been little, if any, justification for their "convenience". In this paper the authors, using Dedekind cuts explain the introduction of those "convenient" numbers using the infinite descent method. The Extended Euclidean Convergent Algorithm is used to create convergent fractions to approximate irrational numbers with a desired approximation via the computer.

Keywords: Dedekind cuts, Infinite descent, Well-ordering Principle, Extended Euclidean Convergent Algorithm, Irrationals

JEL Classification: C

1. Introduction

In elementary arithmetic we learn about the decimal expression of rational numbers: a rational number has either a finite decimal expression or an infinite periodic one. It is well known that rational numbers, its set denoted by Q , are inadequate to solve certain algebraic problems such as the existence of rational numbers which square equals 2 [1], or the existence of a rational solution of the quintic equation $x^5 - x - 1 = 0$ (whose only real root is 1.1673039782614186843...). Thus, the decimal expression of an irrational is neither finite nor ever becomes periodic. In his quest to introduce the real numbers using algebraic methods, Dedekind introduced the notion of *cuts* [2]. As stated by Dedekind, every rational number a divides Q into two classes A_1 and A_2 . The class A_1 is the set of rational numbers a_1 less than every number a_2 of the class A_2 . The rational number a itself can be associated with either class so it could be the greatest number of A_1 or the least of A_2 . Dedekind called any separation of the rational numbers into two classes, as just described, a cut or *schnitt* in its original German terminology. Dedekind

¹ Universidad Simón Bolívar, Caracas, Venezuela, clladera@usb.ve

² Rollins College, Winter Park, FL, U.S.A., rmatatoledo@rollins.edu

also pointed out that there are cuts not produced by rational numbers such as the ones produced by integers which are not a perfect square of any other integer e.g., the integer $D=2$ as shown later in this work.

Irrational numbers are important not because of the mere impossibility of expressing them exactly as ratios of integers, but also because they play important roles in mathematics, geometry, and natural sciences. Such is the case of the number $\pi = 3.1415926535\dots$ for which tables with 1000 or more decimals have been published and which the ancients already considered worth to calculate. Notably, archeologists have discovered also that ancient Babylonians and Egyptians succeeded writing π with 2-3 decimals. Many other examples of relevant irrationals can be presented, among them Euler's number e , the base of natural logarithms and key to explain all exponentially varying processes, and Conway's constant $\lambda=1.303577269034296$ [3]. In passing, these three irrationals are said to be transcendentals also. That is, they are not roots of any non-zero polynomial which coefficients are rational numbers. In Section 2 we present the Dedekind non-rational cuts. Section 3 is devoted to Rudin's treatment of cuts showing the existence of "gaps" in \mathcal{Q} . Section 4 considers the basic representation of integers in two's complement notation and indicates some of the problems of representing digitally both rationales and irrational numbers in a computer. In Section 5 we consider the rational approximations to irrational numbers. Section 6 is devoted to the Euclidean Convergent Algorithm and its application to obtain rational approximations to any irrational number using a computer. Finally, Section 7 is devoted to our concluding remarks.

2. The Existence of Non-rational cuts

The following theorem illustrates the existence of infinitely many cuts not produced by rational numbers as indicated by Dedekind. The authors have amplified the original proof and have clarified some of its details. From now on we will use the standard notation for denoting the set of integers and positive integers as Z and Z^+ respectively. Likewise, we denote the positive rational numbers as Q^+ .

Theorem 1 "Every positive integer D which is not a perfect square of any other integer lies between the square of two consecutive positive integers, moreover D is not a perfect square of any rational number."

As stated, the thesis of this theorem consists of two parts. The first is concerned with a relationship between integer numbers (D and two other integers). The second concerns the nature of the number D itself which is not a perfect square of any rational number. We will address these two issues in order.

Proof of part 1 (by the method of contradiction or reduction ad absurdum)

"Every positive integer D which is not a perfect square of any other integer lies between the square of two consecutive positive integers."

This statement can be translated into standard mathematical notation as follows:

$$(\forall D \in \mathbb{Z}^+) (\forall a \in \mathbb{Z}) D \neq a^2 \rightarrow (\exists \lambda \in \mathbb{Z}^+) \lambda^2 < D < (\lambda + 1)^2$$

To prove it let's consider the set of all positive integers which square is less than D . This set is clearly non-empty and has a maximum element λ . Therefore, we can write $\lambda^2 < D$. As required by the method of contradiction let's begin by writing the negation of the thesis. Therefore, using De Morgan's laws [4] we get:

$$(\forall \lambda \in \mathbb{Z}^+) \lambda^2 \geq D \text{ or } D \geq (\lambda + 1)^2$$

By the mere definition of the integer λ given above, the first inequality $\lambda^2 \geq D$ cannot be satisfied. Now, let's consider the second inequality $D \geq (\lambda + 1)^2$. This last statement cannot be satisfied either because $(\lambda + 1) > \lambda$ and we have assumed that λ is the maximum integer which square is strictly less than D . Therefore, D lies between the two integers λ^2 and $(\lambda + 1)^2$. Q.E.D.

Thus, this positive integer D divides the set \mathbb{Q} into two classes: Class A_1 contains all positive rational numbers a_1 such that their squares $a_1^2 < D$, and Class A_2 containing all other rational numbers. Interestingly, this number D itself cannot be the square of any rational number as we now demonstrate in the second part of the theorem.

Proof of part 2 (by the method of infinite descent)

“There is no rational number which square equals D ”

A proof by the method of infinite descent is also a type of proof by contradiction. The basic difference between a proof by this method and a standard proof by contradiction is that, in an infinite descent proof, we look for a sequence of infinite decreasing positive numbers that satisfies a previously defined condition. Because the positive integer numbers have a least element according to the Well-ordering Principle [5] an infinite sequence of decreasing positive numbers is not possible. The proof we present below follows Dedekind's [2] but has been expanded to clarify some of its steps and conclusion.

As indicated above we begin by negating the thesis. That is, we assume that there is a rational number p/q with $q \neq 0$ such that $(p/q)^2 = p^2/q^2 = D$ where, without loss of generality, we can assume that p and q are both positive integers and their $\text{gcd}(p,q) = 1$. The latter expression for D can be rewritten in quadratic-equation form as

$$p^2 - Dq^2 = 0$$

According to the infinite descent method, what we need to find is a new rational number numerically equivalent to D which denominator is less than q .

Using a positive integer λ it is possible to obtain a relationship between p and q of the following form:

$$\lambda q < p < (\lambda + 1)q$$

In fact, this latter relationship can be obtained as shown next. From part 1 of the theorem, we already showed that

$$\lambda^2 < D < (\lambda + 1)^2,$$

replacing D by its equivalent $(p/q)^2$ in this last inequality we may obtain

$$\lambda^2 < (p/q)^2 < (\lambda + 1)^2 \Leftrightarrow \lambda^2 q^2 < p^2 < q^2 (\lambda + 1)^2 \Leftrightarrow \lambda q < p < (\lambda + 1)q$$

Subtracting λq from each member of this last inequality we get

$$0 < p - \lambda q < q$$

This inequality shows that $p - \lambda q$ is a positive integer less than q . Let's call q' this positive integer. That is, $q' = p - \lambda q$. We will use q' as the denominator of the new rational number being sought. Because the denominator of this new rational number is less than q (the initial denominator of D) the numerator p' of the new rational number must be also less than the numerator p of D . This is so because the numbers must be numerically equivalent. This new numerator should be positive and of the following form:

$$p' = \frac{p(p - \lambda q)}{q}$$

That p' is less than p , the numerator assumed for D , can be easily demonstrated. In fact, knowing already that $0 < p - \lambda q < q$ and dividing this inequality by positive q , we obtain

$$0 < \frac{p - \lambda q}{q} < 1$$

Multiplying the last inequality by positive p and considering the actual value of p' defined a few lines above we have that

$$p' = \frac{p(p - \lambda q)}{q} < p$$

This last inequality indicates that p' is less than p as we wanted to show.

The values of p' and q' just found satisfy the quadratic-equation stated before for D . That is, $p'^2 - D q'^2 = 0$. Therefore, a new rational number numerically to equivalent to D and with a smaller denominator q' ($q' < q$) has been found. Continuous repetition of this procedure will allow us to find an infinite sequence of decreasing integers $q', q'', q''' \dots$ which, as we indicated before is not possible due to the Well-ordering Principle. From this contradiction, we can conclude that our hypothesis about D being the square of a rational is false. Therefore, D is an irrational number. Q.E.D.

3. Rudin rational cuts

We now want to use the concept of *Dedekind cuts* to show explicitly that the set Q of rational numbers does contain “gaps” such as the lack of a rational number whose square is a positive integer D . Consider then the rather familiar case $D=2$ and state our next theorem as follows:

Theorem 2 “Let A be the set of all positive rational numbers p such that $p^2 < 2$, and B the set of all positive rational numbers p such that $p^2 > 2$ where A and B are rational Dedekind cuts in Q .”

Like Theorem 1, this new theorem consists of two parts, one for set A and one for set B . We will address them in that order.

Proof of part 1 (for Set A)

Proof: Consider first a positive rational $p \in A \subset Q$, therefore, $p^2 < 2$. Take now another rational q such that $q > p$, and let $q = p + h$, (Figure 1), h being a rational such that $0 < h < 1$. The argument is to add this h to p is to get a larger q that would still belong to A . We then have:

$$q^2 = p^2 + 2ph + h^2 = p^2 + (2p + h)h,$$

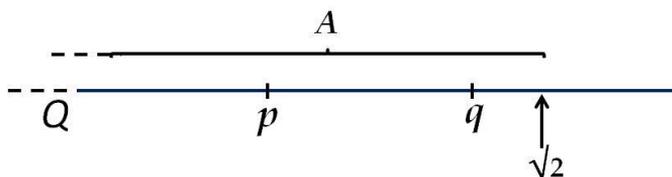


Figure 1

p lies in the set $A \subset Q$ of rational numbers which square p^2 is less than 2; q is a rational such that $p < q$ and $q - p = h$.

Since $0 < h < 1$ we may rewrite the last equation as:

$$q^2 < p^2 + (2p + 1)h$$

Because we want to show that $q \in A$ we need to eliminate the factor $(2p+1)$ as well as p^2 from the last inequality. A little thought led us to write the number h as fraction of the form $(2-p^2)/(2p+1)$. Replacing this value in the last inequality we obtain

$$q^2 < p^2 + (2p + 1) \left[\frac{2 - p^2}{2p + 1} \right] = p^2 + (2 - p^2) = 2 \Leftrightarrow q^2 < 2$$

Therefore, the rational $q > p$ that was introduced above does belong in A . Next, we consider another rational $q' > q$ and apply to it the same procedure applied to q above, to show $q'^2 < 2$. By simple iteration of the procedure, we will get the infinite succession of positive rational numbers $q, q', q'', q''' \dots$ that belong to A and are all less than 2.

Proof part 2 (for Set B)

Now we may proceed to consider the set $B \subset Q$ that will result in an infinite sequence of rational $q < p$ (Figure 2) which squares q^2 never equals integer 2. The proof follows similar steps as used before for set A where, again, a rational h is introduced.

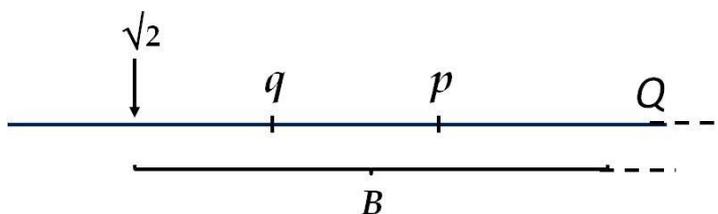


Figure 2

p lies in the set $B \subset Q$ of rational which square p^2 is larger than 2; q is a rational such that $q < p$ and $p - q = h$.

Consider a rational $p \in B$, therefore, p is positive and $p^2 > 2$. Take another rational q such that $q < p$, we need to show that $q^2 > 0$.

Thus, let $q = p - h$, h being a positive rational. We first need to show that $q > 0$ to guarantee that the chosen q , although smaller than p , do belong to the cut B (which rational elements

must be positive). Because this time $p^2 > 2$, when writing h we will subtract 2 from p^2 in the numerator, and let h be of the following form:

$$h = \frac{p^2 - 2}{2p}$$

(c.f. with the case of set A above, in which $p^2 < 2$). Thus, since $q = p - h$ we get:

$$q = p - \frac{p^2 - 2}{2p} = \frac{2p^2 - p^2 + 2}{2p} = \left(\frac{p}{2} + \frac{1}{p}\right) > 0;$$

and being positive the rational q may lie in B . Finally, we may confirm that $q \in B$ by explicitly evaluating q^2 :

$$q^2 = \left[p - \frac{p^2 - 2}{2p}\right]^2 = 2 + \left[\frac{p^2 - 2}{2p}\right]^2 > 2 \Leftrightarrow q \in B,$$

Thus, we have found a rational q less than p that lies in the set B of the cut. We may apply the mathematical procedure just above to a second rational $q' < q$ to prove that it too belongs to B . By iterating the procedure, we get an infinite descending sequence q, q', q'', \dots in which all q_i' are in cut B . However, this succession never ends in a rational q which square is $D=2$. Q.E.D.

As stated by Dedekind [2] and considered also by Rudin [1]: “whenever, we have to do with a cut (A, B) produced by no rational number, we create a new *irrational* number α , which we regard as completely defined by this cut (A, B) ; we shall say that the number α corresponds to this cut, or that it produces this cut.” In the theorem just above the cut corresponds to the irrational $\alpha = \sqrt{2}$ (see Figs. 1, 2)

4. Representing Rational and Irrational Numbers in the Computer

In the computing literature there are various finite precision representations of rational numbers. However, a representation of irrational numbers is generally achieved by approximate solutions based on finite representations, because it is not possible to represent an infinite number of decimal digits with a finite number of 'chunks' of information, be it binary, decimal or any other numerical positive integer radix β ($\beta \geq 2$). Because of this, any finite representation of an infinite domain such that of the irrational numbers must have a "rounding function" that maps that domain into a chosen finite set of values that can be represented in the computer [7].

Traditionally, when representing rational numbers p/q with $q \neq 0$, both the numerator and denominator are represented in binary using the two's complement convention which allows representation of integer numbers in the range from -2^{n-1} up to $2^{n-1} - 1$ where n is the number of bits in the memory unit. In this type of numerical representation, the most significant bit (or leftmost bit) plays a dual role. First, it indicates the sign of the number, generally 0 for positive and 1 for negative. Second, it participates in computations as any other bit. Due to the presence of zero, the positive numbers that can be represented is one less than the number of negative ones. However, for explanation purposes we will consider only positive integers in the range 0 to $2^{n-1} - 1$ and their binary representation. A typical representation of a n -bit memory unit is shown in Figure 3. The numbers in the range $0 \dots (n-1)$ indicate the position of the bits. These numbers are used as the exponents of the binary $base = 2$ when the number is expanded to obtain its decimal equivalent.

sign bit	n-2	...	2	1	0

Figure 3

Typical representation of a computer's register in two's complement convention

In this section, we will follow the Kornerup and Matula's notation [7] with a simplification of their approach. Rational numbers are then represented as a two-word encoding. Each word is represented as indicated in Figure 3. Rational arithmetic can be performed as indicated next. In this notation, φ is a rounding function and the rational numbers are irreducible. That is, $gcd(p,q) = 1$

$$\frac{p}{q} \oplus \frac{r}{s} = \varphi\left(\frac{ps + qr}{qs}\right) \quad \text{Addition} \qquad \frac{p}{q} \ominus \frac{r}{s} = \varphi\left(\frac{ps - qr}{qs}\right) \quad \text{Difference}$$

$$\frac{p}{q} \otimes \left(\frac{r}{s}\right) = \varphi\left(\frac{pr}{qs}\right) \quad \text{Multiplicati} \qquad \frac{p}{q} \oslash \frac{r}{s} = \varphi\left(\frac{ps}{qr}\right) \quad \text{Division}$$

However, the fixed format of Figure 3 is not the most efficiency for representing very large or small values. A more flexible representation such as the "floating slash" representation has been proposed. Under this new scheme the boundary between the space allocated to these two consecutive words is allowed to "float". The boundary is indicated by a "slash" and hence the name of this representation. The set of representable rational numbers is dependent on both, the radix being used and the number of available digits in a computer word. Under this scheme, at least 2^{k-2} different representations are available in binary. The efficiency of these representations is determined by the ration of irreducible fractions (where $gcd(p,q) = 1$) to the total of fractions that can be represented. [6, 8].

5. Rational Approximations to Irrational Numbers

As already stated in the introduction it is a well-known fact from elemental arithmetic that every rational number can be expressed as a terminating or periodic fraction [6, 8]. Yet, pure period fractions such as 0.999... or mixed periodic fractions with a period of 9 such as 0.0999..., 0.1999..., 0.2999..., and the like cannot be generated by common fractions (rational) of the form p/q with $q \neq 0$.

However, it is possible to obtain approximations to each of these numbers as we desired. One such procedure, called the *Extended Euclidean Convergent Algorithm* (EECA) provides a sequence of convergent fractions p_i/q_i for $i = 0, 1, \dots, n$ where n the value of n is determined by the algorithm itself when a given condition is satisfied. The notion of convergent fractions is based on the definition of continued fractions which can be represented in standard abbreviated notation as $[a_0/a_1/a_2/\dots/a_n]$ where each $a_i \geq 0$ is an integer number called a partial quotient. As demonstrated in [7, 8] and indicated here without proof "Every rational number can be expressed by a finite simple continued fraction." Partial quotients can be obtained by application of the Euclidean Algorithm. As indicated in [6] and as a justification of the EECA algorithm, an approximation by rational numbers to any irrational number can be justified by Theorem 3 which will be stated here without a formal proof. The interested readers can refer to [6].

Theorem 3 "Given any irrational number λ and any positive integer k , there is a rational number p/q which denominator q does not exceed k such that

$$-1/nk < \lambda - p/q < 1/nk$$

In this work we will use an extension of the Euclidean Algorithm called the Extended Euclidean Convergent Algorithm [7, 8]. This algorithm is shown below in pseudocode and is applied to rational numbers of the form p/q with $q \neq 0$. The algorithm is called Extended because it incorporates the computations of the numerators and denominators of the convergent fractions denoted by p_i and q_i respectively. The assignment operator and the equality operator are indicated following the language R convention of "<-" and "==" . In this algorithm, *floor* stands for the function generally known in the mathematical literature as the greatest integer function. The EECA algorithm is presented here in pseudocode which can be easily translated and implemented in any modern programming language.

6. Extended Euclidean Convergent Algorithm (EECA)

Input: integers $p \geq 0, q > 0$

Output: sequence integer n and sequences $\{a_i\}, \{p_i/q_i\} i = 0, 1, \dots, n$

Initialization: $b_{-1} <- q; b_{-2} <- p; p_{-1} <- 1; p_{-2} <- 0; q_{-1} <- 0; q_{-2} <- 1$

$i <- 0$

repeat

$$a_i \leftarrow \text{floor}(b_{i-2}/b_{i-1}) \text{ \# quotient}$$

$$b_i \leftarrow b_{i-2} - a_i b_{i-1} \text{ \# remainder}$$

$$p_i \leftarrow a_i p_{i-1} + p_{i-2}$$

$$q_i \leftarrow a_i q_{i-1} + q_{i-2}$$

until $b_i == 0$

Example 1 An application of the EECA algorithm [7]

Let's consider the fraction $p/q = 173/55$. Table 1 shows the execution of the algorithm. The first two rows are the initial conditions of the algorithm for $i = -1$ and -2 .

i	a_i	b_i	p_i	q_i
-2		173	0	1
-1		55	1	0
0	2	8	3	1
1	6	7	19	6
2	1	1	22	7
3	7	0	173	55

Table 1

In this case, the convergent sequence is obtained by forming the fractions p_i/q_i for $i = 0 \dots 3$. Therefore, the convergent sequence is $p_0/q_0 = 3/1 = 3$; $p_1/q_1 = 19/6 \approx 1.6666\dots$; $p_2/q_2 = 22/7 \approx 3.1423\dots$; $p_4/q_4 = 173/55 \approx 3.1454\dots$. Notice also that the sequence is convergent because each $p_i/q_i < p_{i+1}/q_{i+1}$.

7. Concluding remarks

Whenever the real numbers are introduced via the irrational sets via Dedekind cuts there are always “convenient” numbers which are used without little or no justification. From a pedagogical point of view, these convenient numbers are generally a source of frustration to both students and professors. In this work, the authors have attempted to explain and justify some of the sticky points related to the convenience of these numbers, their nature, and the reason for being so using primarily the infinite ascent method. This method, although a very powerful proving mechanism is, in general, not widely used or at least not mentioned by this name. The authors wanted to illustrate an application of the method using Dedekind cuts. The EECA algorithm is presented to obtain rational approximations to any irrational number via the computer.

References

- [1] Rudin, Walter - *Principles of Mathematical Analysis*. McGraw-Hill, 3rd Ed. 1964.
- [2] Dedekind, Richard - *Essays on the Theory of Numbers*. Dover Publications, Inc. 1963. Reprint of the English translation first published by Open Court Publishing Company. 1901.
- [3] Havin, Julian. - *The Irrationals: a Story of the Numbers you Can't Count On*, Princeton University Press. 2012.
- [4] Suppes Patrick - *Introduction to Logic*. D. Van Nostrand Company, Inc. 1957.
- [5] Birkhoff G., MacLane S. - *A Survey of Modern Algebra*. 3rd Ed. The Macmillan Company. 1965.
- [6] Niven, I. - *Numbers: Rational and Irrational*. New Mathematical Library. Yale University. 1961.
- [7] Korerup P., Matula, D. W. – *Finite Precision Number Systems and Arithmetic*. Encyclopedia of Mathematics. Cambridge University Press. 2010.
- [8] Rosen, K. H. - *Elementary Number Theory and its Applications*. 4th Ed. Addison Wesley Longman.2000

DEALING WITH VAGUENESS IN AGENT-BASED MODELS: A PYTHON FUZZY LOGIC ABM FRAMEWORK

Andrei LUCHICI¹

Abstract

Complex systems are everywhere; countless examples of behaviors fall into the complex systems paradigm, from physical and natural sciences to social and economic sciences. Given the nature of these systems, where the whole is greater than the sum of its constituents, scientists must have adequate tools for investigating complex systems. Recently, Agent-Based Models (ABM) have become a de facto tool for creating idealized computer simulations to investigate pattern formation, perform root-cause analysis, or simulate alternative scenarios within the domain of complex systems. This paper introduces a miniature framework for developing and analyzing agent-based models where agents and the environment can follow vague rules. The proposed tool is applied to a sample simulation, providing a proof-of-concept example of how Fuzzy Logic and Fuzzy Inference can model complex systems with vague rules.

Keywords: complex systems, agent-based modeling, fuzzy logic, fuzzy inference, rule-based systems, rule-based simulation, simulation

JEL Classification: C63

1. Introduction

Simulations are increasingly becoming a de facto tool for understanding complex phenomena. Traditional approaches relied heavily on induction, i.e., generating theories based on collected data, or deduction, i.e., starting from first principles and creating a general theory. However, with the advent of computers and increasing processing power and data, researchers are starting to adopt a new way of doing research, namely, simulations or generative methods [9].

Simulations can replicate complex systems and processes as closely as possible. Using computer simulations allows researchers to analyze and evaluate the effects of different parameters and variables on a given system. By allowing users to experiment and test different scenarios, simulations can be a powerful tool for understanding and predicting the behavior of complex systems [3].

Computer simulations are helpful in various fields, such as physics, engineering, economics, and biology. For example, in economics, simulations can be used to analyze the effects of various policies on the market and the economy [5]. In biology, scientists use computer simulations to study organisms' behavior and environment [6].

¹ PhD Associate Lecturer, Romanian-American University, andrei.luchici@rau.ro

Moreover, social scientists are increasingly using computational tools and simulations to understand the effects of different variables on a particular population or system. For example, ABMs model the spread of an epidemic or the effects of a particular policy on a specific group of people. Simulations are becoming increasingly important in research and development as they allow researchers to quickly and accurately model complex systems [3].

Agent-based models (ABMs) are a type of computer simulation used in social sciences and economics research to analyze the collective behaviors of autonomous agents interacting with each other in a well-defined environment. Agent-based modeling combines individual-level behaviors, micro-macro dynamics, and emergent phenomena to explain observed societal patterns. ABMs are used to understand the collective behaviors of complex systems, such as the effects of different types of social networks, the behavior of markets, and the dynamics of economic growth. ABMs have been used to explore the effects of policy interventions, such as taxes, subsidies, and regulations, and to study the formation and evolution of social norms [9].

Presently there are several frameworks and tools available for building agent-based simulations². Java, C/C++, or Objective-C are the main programming languages used to build these tools. More recently, Kazil et al. proposed Mesa [10], a Python-based framework for developing ABMs. Another famous example is NetLogo created by Uri Wilensky³. This tool was used extensively to build ABMs for different physical, biological, and social sciences processes and problems. More recently, more tools emerged as complex systems research has gained momentum. However, most of the tools available only deal with binary logic and uncertainty, i.e., probabilities. In contrast, many of the theories available, especially in the social and biological sciences, rely on vague descriptions of the processes. Therefore, there is a real need for new tools that can work with vague terms and definitions and make computations using these vague concepts to evolve the state of the agents.

Lotfi Zadeh introduced fuzzy logic in 1965 to help computers represent vague concepts. Since then, scientists and engineers have used fuzzy logic in various applications, including decision-making algorithms, natural language processing systems, and robotics control systems [4]. Fuzzy logic can be used for many applications, including fuzzy control systems, decision-making algorithms, pattern recognition and classification systems, natural language processing systems, and robotics control systems. In fuzzy control systems, a set of rules written in terms of linguistic variables determine the system's output, unlike classical approaches, such as equation-based modeling. Through fuzzy logic, a digital computer can understand the real-world environment better and respond to changes more quickly than traditional control methods [4].

In decision-making algorithms, fuzzy logic provides a way to make decisions based on uncertain or incomplete information. For example, it could be used in an expert system that helps a doctor diagnose an illness where there may not be enough data available for a definitive diagnosis. In pattern recognition and classification systems, fuzzy logic can help computers recognize patterns more accurately than conventional methods. It also has

² A list of several ABM modeling software can be found here:
https://en.wikipedia.org/wiki/Comparison_of_agent-based_modeling_software

³ <https://ccl.northwestern.edu/netlogo/>

applications in natural language processing, where it can help computers interpret ambiguous sentences more effectively than traditional rule-based approaches. Finally, it has been applied successfully in various robotics control tasks where its ability to capture uncertainty makes it especially useful when dealing with a dynamic environment [4].

By coupling ABMs and Fuzzy Logic, one can obtain a framework for modeling complex behavior in the presence of imprecise information. In this framework, ABMs are used to model the dynamics of a system, and Fuzzy Logic is used to represent the imprecise information. Using Fuzzy Logic, we can help computers represent vague concepts difficult to describe using traditional mathematical equations.

This combination can be used to simulate various types of interactions between agents in a system and examine their effects on different outcomes. For example, it can be used to model how different policies or strategies might affect the behavior of an economic system or how specific environmental conditions might lead to changes in the population dynamics of a species. In recent years, it has become increasingly crucial for modeling complex behaviors in agent-based simulations due to its ability to capture uncertainty and provide more accurate simulations of real-world environments than traditional methods alone can provide. By combining these two powerful tools, researchers can gain valuable insight into the behavior of complex systems.

This paper proposes a new Fuzzy Logic framework for creating agent-based simulations. The framework combines fuzzy logic and ABMs to create an environment where agents can interact with one another and the environment. It then uses fuzzy logic to represent the imprecise information in real-world environments, allowing for more accurate simulations of complex behavior.

2. Fuzzy Logic and Inference

2.1 Fuzzy Logic

Our brains have evolved to make computations without requiring high precision. For us, concepts like tall, thin, short, wide, and close do not require a precise definition, i.e., an object is tall if its height is more than 1.52m. However, a digital computer will need help to solve this task because it requires a precise and objective definition of every concept. More, there are many situations where "tall" might mean 1.23m (think about toddlers versus children), or "wide" might mean 1 meter or 7 meters (think about a coffee table versus a highway lane). In other words, we, as humans, are used to doing computations with vague concepts, and we often attribute slightly different interpretations to them depending on the context. Vagueness is an issue when we want computers to perform human-like actions because they operate using a much more restrictive concept, binary logic, where something belongs to just one class or has just one meaning. Fuzzy logic helps solve these issues. It allows us to abandon the binary way of thinking about concepts and embrace vagueness where things can simultaneously belong to different classes, i.e., the glass can be both half full and half empty to some extent [4].

Linguistic variables represent the core of Fuzzy Logic. They are used to represent quantities of interest in the system under investigation. Linguistic variables allow us to define

concrete and vague concepts such as speed, distance, age, or danger. When we model a system, we usually capture the essential variables on which the system's behavior depends.

A linguistic variable is defined by its terms. Depending on the granularity we require, we can have any number of terms that define that variable. For example, think about a person's age. One can describe their age as "young" or "old". Similarly, one can describe a person as being a "child", "teenager", "young adult", "adult", or "senior". Both descriptions are valid depending on the context in which they are used. However, more than these descriptions are required for computations because a digital computer operates with crisp values to perform any computation.⁴Therefore a digital computer cannot perform any computations using terms like "young", making it very difficult to describe the behavior of a system using vague rules. Fuzzy logic proposed a mechanism for converting the linguistic description of a variable, object, or action into a numerical counterpart using membership functions to help the computer understand vague concepts [4].

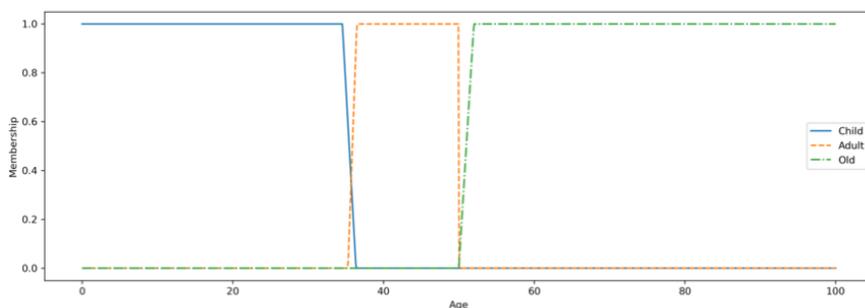


Figure 1. Sample membership functions describe the age of a person. Note that someone can be both a "child" and an "adult" with various degrees of membership.

Membership functions define the extent to which a value belongs to a given term. As mentioned before, classical logic has only two states. A variable can belong to one and only one set at a time. In fuzzy logic, membership functions define the degree of belongingness, ranging between 0 and 1, with 0 meaning that the object does not belong to that set and 1 representing a full membership. The membership function requires a universe of discourse, i.e., all the possible values that a variable can take. Returning to our example, Figure 1 contains a possible interpretation of the terms used to describe a person's age. In the example, the universe of discourse is [0,100], which are all the possible values for a person's age in years. Then, we defined five terms for this variable: child, adult (40-60), and old (60-100). As shown in the figure, each term has a corresponding membership function that defines how much each value belongs to that term. For example, if we take the value 39, it belongs more to "adult" than to "child" since its degree of membership is higher in the former case than in the latter one [4].

⁴ Crisp variables represent variables that have precise numerical values. They are used in contrast with fuzzy values that describe a vague concept.

2.2 Fuzzy Inference

Fuzzy inference represents a set of tools used for making decisions using imprecise information. Fuzzy inference systems are used in various applications, such as computer vision, robotics, and decision-making. In fuzzy inference systems, the system is given a set of input variables representing some feature or property of the system (e.g., temperature) and an output variable representing the desired response (e.g., turning on the air conditioner). Applying a set of fuzzy rules to the input variables computes a final output variable that can be converted to a crisp value or reused as input for evaluating more rules. Fuzzy rules are derived from knowledge about how specific inputs should affect specific outputs and often rely on expert opinion or historical data. The output from a fuzzy inference system can be used to control physical devices such as robots, or it can be used to make decisions in business settings such as finance or marketing analysis [4].

A Mamdani system is one of the most common Fuzzy Inference methods [1]. This system takes a set of inputs, applies fuzzy logic operators such as AND, OR, and NOT to them, and then produces an output. In practice, there are more alternatives for performing Fuzzy inference. One common alternative is the Sugeno approach [2].

The Mamdani system first determines a set of rules that will be used to evaluate the inputs. Each rule provides information regarding how each input should affect the output. After determining the rules, the system is given a set of values for each input variable and then uses these values to determine how each rule should be applied. A Mamdani system allows for decisions or actions to be taken based on imprecise information or data that may have yet to have definitive answers [1]. A schematic representation of a Mamdani system can be observed in Figure 2.

Fuzzy inference systems can also be used in medical diagnosis and expert systems, which help automate decision-making processes within complex problem domains. Fuzzy inference has been used in medical diagnosis systems where it helps doctors identify diseases more accurately than traditional methods based on symptoms alone [7]. In business applications, fuzzy inference has been used in financial forecasting models where it helps predict stock market movements more accurately than traditional models using technical analysis alone [8].

Overall, the fuzzy inference is an essential and valuable tool for making decisions when precise information is unavailable or difficult to obtain. It provides a powerful way of automating decision-making processes by considering many different inputs while still providing reliable outputs that can be used to make decisions, making fuzzy inference a valuable tool in many applications and problem domains [4].

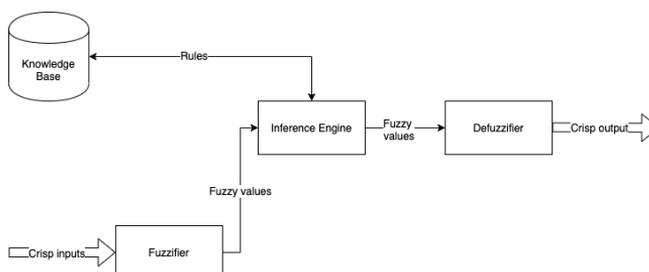


Figure 2. Overview of a generic Mamdani Fuzzy Inference System.

3. Framework Development

The tool described in this paper was designed as a modular framework that can easily be adapted to fit multiple scenarios. The tool's core is represented by two modules: the fuzzy module and the agent module. Additionally, a simulation module is required where the user can define special agents, provide the fuzzy rules governing their behavior, and set up the environment and other mechanics required to simulate the desired situation. Finally, figure 3 presents an overview of the tool and its main modules, which will be discussed in more detail in the subsections below.

3.1. The Fuzzy Module

The Fuzzy Module consists of five modules that provide the mechanism for defining linguistic variables and Fuzzy rules, creating, and instantiating membership functions, and performing Fuzzy inference.

The module defines a Vocabulary that represents a list of all available Linguistic Variables required for modeling the system. Each Linguistic Variable is composed of a set of Terms, with every term having a predefined Membership Function. When simulating a system, the user needs to specify the Vocabulary using a JSON configuration file. This configuration file describes the concepts available for defining the agents' behaviors (rules) and for evolving the simulation over space, time, or both. An example JSON configuration file for a vocabulary containing just one variable, SURVIVAL, that can model the survival probability of an agent based on a vague definition of survival can be found in figure 3.

Every Fuzzy variable is defined by a set of terms, for example, “low” and “high” in the example presented in Figure 3. These terms are characterized by a membership function that maps a crisp input to a corresponding membership degree (see Section 2 for more details). Finally, to complete the definition, a universe of discourse is provided.

```
[
  {
    "name": "survival",
    "terms": [
      {
        "name": "low",
        "membership": {
          "name": "left_trapezoidal",
          "parameters": {
            "x1": 0.25,
            "m1": -2,
            "b1": 1.5
          }
        }
      },
      {
        "name": "high",
        "membership": {
          "name": "right_trapezoidal",
          "parameters": {
            "x1": 0.75,
            "m1": 2,
            "b1": -0.5
          }
        }
      }
    ]
  },
  "universe": [0, 1]
]
```

Figure 3. Example JSON configuration defining a Linguistic Variable (“SURVIVAL”) with two terms, “LOW” and “HIGH”, and their associated membership functions.

The tool presented in this paper contains the most common membership functions already defined: uniform, linear, step, triangle, trapezoidal, and sigmoid functions. Additionally, the tool has a simple interface for defining custom membership functions if needed. Each membership function is implemented as a new class derived from a base class. To define a new membership, one has to implement the method *func()*, which takes an input, *x*, as an argument together with the predefined values of any parameter required to evaluate the function. The JSON configuration sets the values for all additional function parameters (as can be seen in the *parameters* key in Figure 3)

In addition to the Vocabulary and Linguistic Variables, the Fuzzy module also includes the functionality for defining and evaluating Fuzzy rules. Each rule is built from an antecedent (the IF part) and a consequent (the THEN part). If more terms are needed to define the antecedent, they can be combined using standard logical operators (AND, OR, and NOT). Moreover, in the current implementation, only simple, single-value consequents are supported.

Finally, the Fuzzy module implements a mechanism for performing Fuzzy inference. This mechanism fuzzifies a crisp value for one or multiple inputs. Their fuzzy values are combined, and finally, a crisp output is produced using the Center of Gravity defuzzification method [4]. At the end of each rule evaluation, a numerical output is obtained for every consequence of the evaluated fuzzy rules. The implementation follows a Mamdani inference system, as described in Section 2.2.

The current version of the package requires the domain expert to design the knowledge base (the behavior rules) and the Vocabulary (linguistic variables). Manual or expert-driven vocabulary and rule design can be difficult, especially if there is little theoretical or experimental knowledge about the system. Moreover, this approach can lead to biased results as the user has a particular belief when designing the knowledge base.

Future versions of the package will introduce machine learning algorithms that can learn from data and automatically generate the knowledge base and Vocabulary for a given problem. Adding machine learning to this tool would eliminate the need for manual rules design, making it easier for domain experts to build and use fuzzy logic systems quickly. Additionally, this approach reduces results bias using actual data rather than subjective assumptions.

3.2. The Agent Module

The Agent module serves as a basis for defining specific agents. This module helps the user quickly define agents that abide by a set of rules and perform inferences to update the agent's state according to specific Fuzzy rules. To define an agent, one needs to provide the agent with knowledge (Fuzzy rules describing the agent's behavior), an initial state, a vocabulary (used to reason about the world), and an Inference mechanism. The user also needs to implement a *next()* method for each agent type to describe how the agent's state is updated after all the rules are evaluated. Finally, it is essential to note that the Agent module cannot learn that only some agents can operate with classic rules or thresholds. This

implementation decision allowed agents to deal with fuzzy concepts first. Subsequently, other versions will expand the agent's capabilities to work with classic rules and thresholds.

3.3. The Simulation Module

To develop an agent-based simulation, one usually starts with a theory of behavior in a prescribed setting. Next, one can follow one of two paths, one led by domain experts or one by available data about the system.

The first approach relies heavily on experts to determine the linguistic variables required to describe the behavior, the agent types, and other parameters that might influence the system. Following the expert opinions, one proceeds to develop a set of Fuzzy rules and implement the simulation logic. One may be interested in creating a post-processing pipeline for analyzing and understanding the simulation results.

The second approach uses data about the system. One uses data collected about the system to discover the linguistic variables required to describe the system using a clustering or dimensionality reduction algorithm. Subsequently, one can also infer the membership functions for each linguistic term using the available data via another clustering procedure followed by a statistical modeling step whereby one tries to determine the probability of an instance (observation) belonging to a given linguistic term. Next, one can determine the Fuzzy rules driving the system and implement the simulation logic. Finally, a post-processing pipeline for analyzing and understanding the simulation results should be developed similarly to the previous approach.

Once the simulation is built and running, it is time to validate it against the initial theory of behavior to assess its accuracy. Once validated, one can start running experiments with different combinations of parameter values to observe their effect on the system's behavior or performance. Using fuzzy logic and agent-based simulation models can be an effective way to model complex systems. By leveraging the power of fuzzy rules and agents to represent parameters, behaviors, and interactions in a system, one can create a powerful tool for predicting population dynamics. Moreover, using data-driven approaches to determine the linguistic variables and membership functions allows one to develop practical simulations that accurately capture real-world behavior quickly.

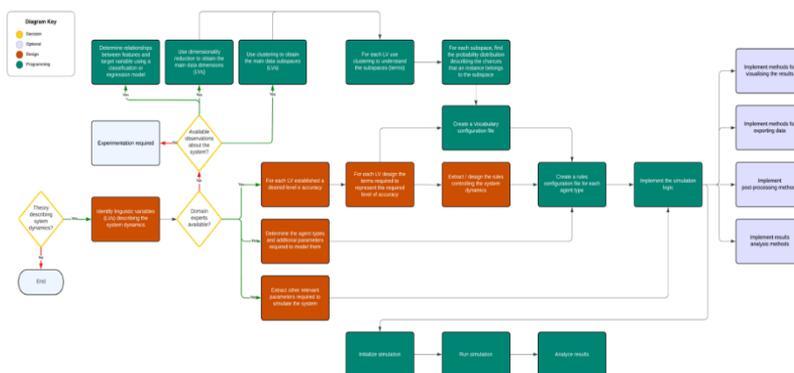


Figure 4. Diagram showcasing the process for developing an agent-based simulation.

The current implementation of the simulation module aims to help the user create an Environment for the agents, define the system's parameters under investigation, and prescribe additional rules for updating parameters because of the agent's behavior. In addition, the Simulation module also implements the methods required to visualize the system's evolution over time and/or space. It is important to note that the simulation module has two options for updating the states of the agents. First, one can set up the simulation to update the agent states in the order in which they were added (sequential update). Second, one can set up the simulation to update agent states randomly, picking one agent without replacement until all the agents update their states. Finally, one can select a simultaneous state update. Subsequent versions of the package will also support a simultaneous update mode, whereby all agents operate in parallel at every step. Finally, the current simulation module supports only time-based simulations, i.e., agents evolve from one simulation step to another without any knowledge of their position, proximity to other agents or environment objects, or connection to other agents (network). Different simulation versions will eliminate this restriction, allowing users to develop more comprehensive and realistic simulations.

4. Example Simulation: Population Dynamics

The current framework was used to simulate the dynamics of a simple population consisting of two classes of agents ("Conscious" and "Selfish"). Each agent class has two subtypes or gender. The main idea behind this sample simulation is to investigate the dynamics of two populations. The first population is conscious of the environment and guides its behavior depending on the available resources trying to prolong the population's lifespan for as long as possible. The second population is selfish about the environment and does not consider the available resources too much to update their behavior. Also, the selfish population contributes to replenishing the available resources.

Agents work with five concepts or linguistic variables: AGE, REPRODUCE, SURVIVAL, PRODUCE and CONSUME. The AGE variable determines the degree to which an agent belongs to three classes, CHILD, YOUNG, or OLD. This computation is done based on a crisp age value. Next, the REPRODUCE variable determines the chances (LOW or HIGH) of an agent reproducing during a given simulation time step. The agent class, available resources, and age influence an agent's reproduction chances.

Moreover, the SURVIVAL variable encodes an agent's chances (LOW or HIGH) to survive during a given iteration. The agent's type, available resources, and age also influence an agent's survival chances. Finally, the PRODUCE and CONSUME variables guide how many resources the agent will consume and produce based on the agent's class and age. It is essential to notice that although the agents belong to two gender classes (MALE and FEMALE), this information does not influence the agent's behavior. However, the agents will reproduce if at least two agents, one MALE and one FEMALE, have a reproduction change greater than 0.5. The simulation ends when no agents are left or when the agents consume all the available resources.

The agent's behavior is encoded using two sets of rules, one set defines the behavior of "Conscious" agents, and one defines the behavior of "Selfish" agents. The main differences between the two types of agents are that "Conscious" agents always produce many

resources and reproduce less if the available resources are "Low". The exact rules used to represent the agent's behavior can be found in the example simulation online⁵. Finally, it is essential to note that the membership functions for each term are all hypothetical at this stage as this work aims to develop a working framework, not to simulate population dynamics accurately. To make an accurate simulation, one needs to follow a systematic methodology for creating the Vocabulary, the Rules, and any other agent behavior, as presented in Section 3.

4.1. Results

The population dynamics simulation presented in this paper uses six linguistic variables described by two or three terms (see Section 3 for more details about the variables). Several membership functions describe the terms for every linguistic variable to highlight the framework's capabilities introduced in this work. The linguistic variables and their corresponding terms are shown in Figure 5. The membership functions that describe every linguistic variable are chosen to illustrate the framework's capabilities.

Three simulations were performed using the same setup (Vocabulary, knowledge base, environment) to investigate the survival rate of a population of 50 agents composed of selfish and conscious agents given different ratios of agents of each type. Based on the results of the simulations, a population where selfish agents are more prevalent than conscious agents do not manage to survive for a long time.

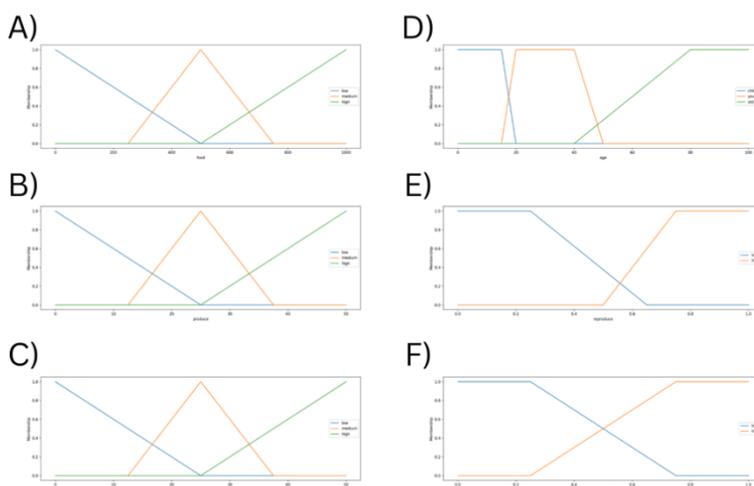


Figure 5. Definition of all linguistic variables used for the population dynamics simulation. A) Membership functions describing the food produced by each agent. The membership function has three levels, "low", "medium", and "high". B) Membership functions describing the available food quantity. The membership function has three levels, "low", "medium", and "high". C) Membership functions describing the food consumed by each agent. The membership function has three levels, "low", "medium", and "high". D) Membership functions describing the agent's age. The membership function has three levels, "child", "young", and "old". E) Membership functions

⁵ <https://github.com/aluchici/fuzzy-logic-framework>

describing the agent's reproduction rate. The membership function has two levels, "low" and "high". F) Membership functions describing the agent's survival rate. The membership function has two levels, "low" and "high"

In Figure 6, panels A) to C), a population where 75% of the agents were "selfish" survived for only three rounds, with the available resources declining rapidly. In contrast, when the proportion of selfish agents is less than that of the conscious agents, the population can survive for a more extended period. Panels D) to F), a population of 50% selfish and 50% conscious agents survived for the whole duration of the simulation. Moreover, the available resources have increased over time. It is interesting to note the apparent oscillatory behavior of the available resources as time evolves. More experiments need to be performed to investigate if this behavior is consistent for populations where the number of conscious and selfish agents is the same.

Furthermore, in panels G) to I), a population of 25% selfish agents also survived the simulation. It displayed a similar behavior as a population with an equal number of agents of each type. In this case, it is interesting to note that the number of agents varies, with the conscious agents increasing over time while the selfish agents appear to stabilize. However, to prove this observation, more experiments need to be conducted.

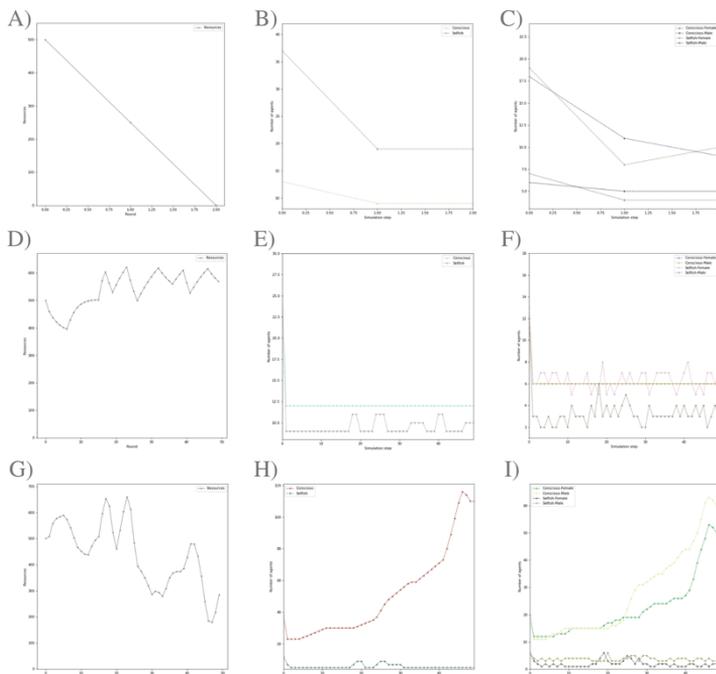


Figure 6. Three example simulations where agents are initialized with a random survival and reproduction rate for the first round of the simulation. A) – C) Evolution of the population of 50 agents. Initial resources are set to 500, representing 50% of the maximum amount. Agents are split into 25% Conscious and 75% Selfish, with a 50% ratio of Female agents for each agent type. D) – F) Evolution of the population of 50 agents. Initial resources are set to 500, representing 50% of the maximum amount. Agents are split into 50% Conscious and 75% Selfish, with a 50% ratio of Female agents for each

agent type. G) – I) Evolution of the population of 50 agents. Initial resources are set to 500, representing 50% of the maximum amount. More, agents are split into 75% Conscious and 25% Selfish, with a 50% ratio of Female agents for each agent type.

It is important to note that every simulation presented in Figure 6 initializes a new population of agents of different ages with random chances of survival and reproduction in the first round. It could be that 50% of the agents may disappear during the first round could explain the sharp decrease in the number of agents. Also, this can contribute significantly to the chances of survival. Therefore, additional simulations were performed.

More simulations were performed to explore the influence of random survival and reproduction rates in the first round of the simulation. For this batch, all agents survive the first round. The results of some of the simulations are presented in Figure 7. Panels A) to C) show different behavior compared to the case presented in Figure 6. Specifically, one can observe that more than a 50% ratio between Conscious and Selfish agents is needed to ensure the population's survival. Panels D) to F) and G) to I) show that when all agents survive the first round, the population does not survive for the whole simulation duration, even if 75% or 85% of the agents were Conscious.

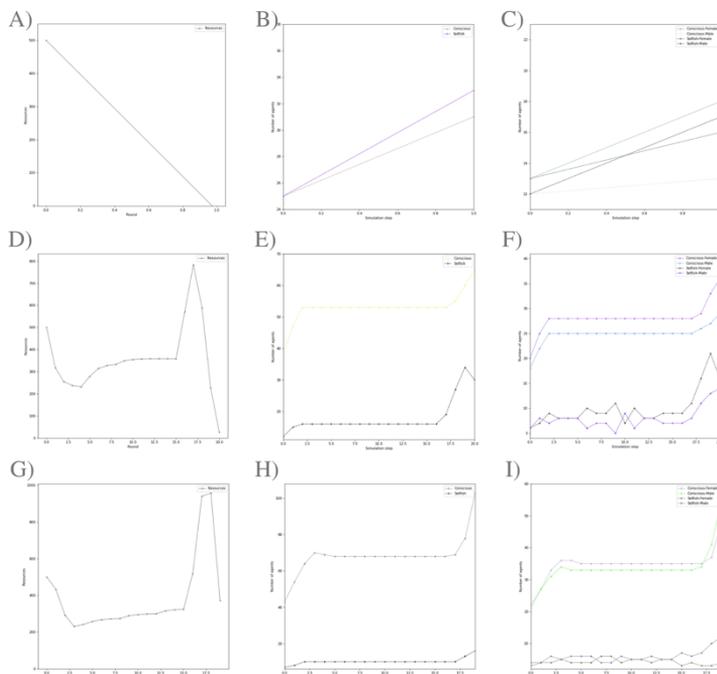


Figure 7. Three example simulations where agents are initialized with a guaranteed survival for and random reproduction rate for the first round of the simulation. A) – C) Evolution of the population of 50 agents. Initial resources are set to 500, representing 50% of the maximum amount. Agents are split into 50% Conscious and 50% Selfish, with a 50% ratio of Female agents for each agent type. D) – F) Evolution of the population of 50 agents. Initial resources are set to 500, representing 50% of the maximum amount. More, agents are split into 75% Conscious and 25% Selfish, with a 50% ratio of Female agents for each agent type. G) – I) Evolution of the population of 50 agents. Initial

resources are set to 500, representing 50% of the maximum amount. Agents are split into 85% Conscious and 15% Selfish, with a 50% ratio of Female agents for each agent type.

Furthermore, another batch of simulations was conducted. For this new batch, the survival rate was a random value between 0 and 1. The reproduction rate was fixed at 1 for the first round of the simulation. It can be observed that a population consisting of an even number of Conscious and Selfish agents can survive for the entire simulation duration. Moreover, a similar behavior as in Figure 6 is observed in panels A) to C). Surprisingly, when the ratio of Conscious agents increased to 75% or 85%, respectively, the population could not survive for the entire duration of the simulation. Instead, the population quickly disappeared as the number increased (see panels D) to F) or G) to I)).

From these simulations, several interesting behaviors emerge. First, in several simulations, for example, in Figures 7 and 8, panels D) and G), the population rapidly disappeared (all available resources were consumed) even if there were considerably more Conscious agents than Selfish agents. These results indicate a potential tipping point for the number of agents and/or the ratio between conscious and selfish agents.

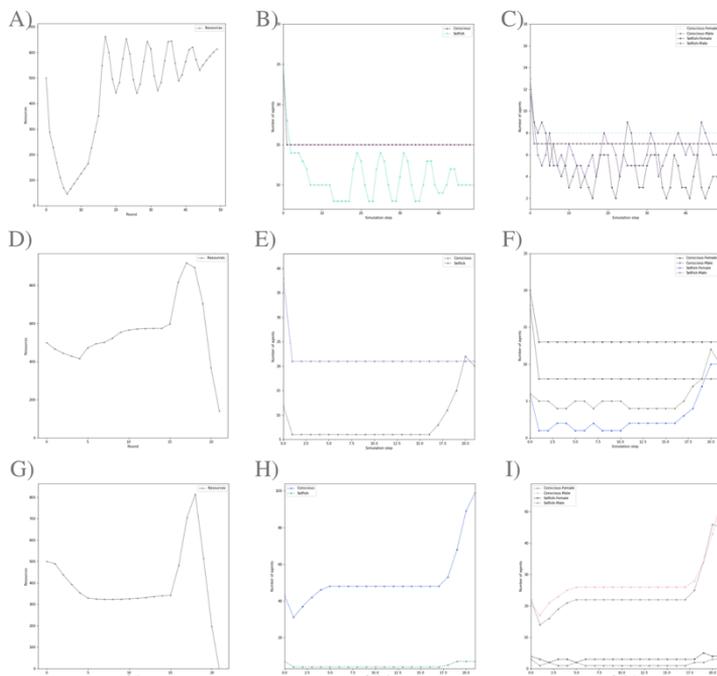


Figure 8. Three example simulations where agents are initialized with a guaranteed reproduction and random survival chance for the first round of the simulation. A) – C) Evolution of the population of 50 agents. Initial resources are set to 500, representing 50% of the maximum amount. Agents are split into 50% Conscious and 50% Selfish, with a 50% ratio of Female agents for each agent type. D) – F) Evolution of the population of 50 agents. Initial resources are set to 500, representing 50% of the maximum amount. More, agents are split into 75% Conscious and 25% Selfish, with a 50% ratio of Female agents for each agent type. G) – I) Evolution of the population of 50 agents. Initial

resources are set to 500, representing 50% of the maximum amount. Agents are split into 85% Conscious and 15% Selfish, with a 50% ratio of Female agents for each agent type.

5. Conclusions

This paper presented a Fuzzy Logic ABM framework implemented in Python to aid researchers in exploring complex systems. The framework builds upon established methods and extends them by implementing a Fuzzy Logic and Inference module. With the help of this module, vague concepts can be employed to create a set of rules guiding the agent's behavior, interactions, and environment evolution.

Moreover, a population dynamics simulation is presented to illustrate the proposed framework. This simple ABM consists of two agent types that consume, produce resources, reproduce, or die. A set of Fuzzy rules drives the agent's behavior and what the agent does depends solely on the available environmental resources. Although simple, the simulation yielded some exciting situations requiring closer investigation.

In conclusion, Fuzzy logic and inference represent a viable method for encoding an intelligent agent behavior and allowing machines to operate with vague definitions. However, this approach requires more testing and validation in various settings.

References

- [1] Ebrahim II MAMDANI, S ASSILIAN – *An Experiment in Linguistic Synthesis with a Fuzzy Logic Controller* – International Journal of Man-Machine Studies, volume 1 no. 1 page 1-13. ISSN 0020-7373. January 1975
- [2] Tomohiro TAKAGI, Michio SUGENO – *Fuzzy Identification of Systems and Its Applications to Modelling and Control* – IEEE Transactions on Systems, Man, and Cybernetics, volume SMC-15 no. 1 page 116-132. ISSN 0018-9472. January – February 1985
- [3] Nigel GILBERT – *Agent-Based Models* – Pages 1-47, 68-74. ISBN 978-1-4129-4964-4. Sage Publications, Inc. 2008
- [4] S. N. SIVANANDAM, S. N. DEEPA – *Principles of Soft Computing* – Pages 5-9, 251-264, 295-305, 311-320, 347-355, 356, 363-364. ISBN 978-81-265-2741-0. Wiley India Pvt. Ltd. 2011
- [5] W. Brian ARTHUR – *Foundations of Complexity Economics* – Nat Rev Phys, volume 3, pages 136-145. ISSN 25225820. January 2021
- [6] Jessica S. YU, Neda BAGHERI – *Agent-Based Models Predict Emergent Behavior of Heterogeneous Cell Populations in Dynamic Microenvironments* – Frontiers in Bioengineering and Biotechnology, volume 8:249 ISSN 2296-4185. June 2020
- [7] Hossein AHMADI, Marsa GHOLAMZADEH, Leila SHAHMORADI, Mehrbakhsh NILASHI, Pooria RASHVAND – *Diseases diagnosis using fuzzy logic methods: A*

systematic and meta-analysis review – Computer methods and programs in biomedicine, volume 161, Pages 145-173. ISSN 01692607. April 2018

[8] Yong ZHANG, Weilong LIU, Xingyu YANG – *An automatic trading system for fuzzy portfolio optimization problem with sell orders* – Expert Systems with Applications, volume 187. ISSN 0957-4174. January 2022

[9] Robert AXELROD – *The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration* – Pages 3-9, 40-68. ISBN 0-691-01567-8. Princeton University Press. 1997

[10] Jackie KAZIL, David MASAD, Andrew COOKS – *Utilizing Python for Agent-Based Modeling: The Mesa Framework* – Pages 308-317. ISBN 978-3-030-61255-9. Springer International Publishing. October 2020

Bibliography

von ALTROCK C., *Fuzzy Logic and NeuroFuzzy Applications in Business and Finance*. ISBN 0-13-591512-0. Prentice Hall Inc. 1997.

ARTHUR W. R., *Foundations of Complexity Economics*, Nat Rev Phys, volume 3, pages 136-145. ISSN 25225820. January 2021

AXELROD R. – *The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration* – ISBN 0-691-01567-8. Princeton University Press. 1997

CEDERMAN L.-E., *Emergent Actors In World Politics: How States and Nations Develop and Dissolve*, ISBN 0-691-02149-X. Princeton University Press. 1997

GILBERT N., *Agent-Based Models*, ISBN 978-1-4129-4964-4. Sage Publications, Inc. 2008

JANG J.-S. R., SUN C.-T., MIZUTANI E., *Neuro-Fuzzy and Soft Computing A Computational Approach to Learning and Machine Intelligence*. ISBN 0-13-261066-3. Prentice-Hall Inc. 1997.

KARRAY F. O., DE SILVA C., *Soft Computing and Intelligent Systems Design: Theory, Tools, and Applications*, ISBN 0-321-11617-8. Pearson Education Limited. 2004

KAZIL J., MASAD D., COOKS A., *Utilizing Python for Agent-Based Modeling: The Mesa Framework*, ISBN 978-3-030-61255-9. Springer International Publishing. October 2020

MAMDANI E., ASSILIAN S., *An Experiment in Linguistic Synthesis with a Fuzzy Logic Controller*. International Journal of Man-Machine Studies, volume 1 no. 1 page 1-13. ISSN 0020-7373. January 1975

SIVANANDAM S. N., DEEPA S. N., *Principles of Soft Computing*, ISBN 978-81-265-2741-0. Wiley India Pvt. Ltd. 2011

TAKAGI T., SUGENO M., *Fuzzy Identification of Systems and Its Applications to Modelling and Control*. IEEE Transactions on Systems, Man, and Cybernetics, volume SMC-15 no. 1 page 116-132. ISSN 0018-9472. January – February 1985

YU J. S., BAGHERI N., *Agent-Based Models Predict Emergent Behavior of Heterogeneous Cell Populations in Dynamic Microenvironments*. *Frontiers in Bioengineering and Biotechnology*, volume 8:249 ISSN 2296-4185. June 2020

SHOPPING BEHAVIOUR FOR ONLINE ENGLISH LANGUAGE COURSES AND DIGITAL LEARNING PRACTICES OF ROMANIAN STUDENTS

Gyongyver MĂDUȚA¹

Abstract

Based on the study of the specialized literature regarding the way in which students interact and use digital means to learn a foreign language, deficiencies and ambiguities were identified that want to be overcome by proposing, testing, and validating an integrated model of buying behavior and consumption specific to Romanian students who want to study English online. For a better understanding of the student's behavior regarding English language courses, a qualitative research was carried out in the field of exploratory nature, which, like any qualitative research of an exploratory type, serves to carry out an investigation that precedes the complex study, of a quantitative nature. The specialized literature offers a solid theoretical basis in terms of online purchasing behavior, but no reference has been made recently to Romanian online consumers, to their perceptions, motivations, satisfaction or attitudes towards using the Internet to learn a foreign language.

The results of the research indicate that the majority of those interviewed have both the resources and the knowledge and skills necessary to learn English online, perceive a high self-efficacy following online courses, and have a favorable attitude towards the idea of continuing to learn English exclusively online.

Keywords: online learning, digital teaching tools, online courses, consumer behavior, language learning, learning motivation, learning satisfaction.

JEL Classification: D83, P36, P46, Z11

1. Introduction

Endogenous or psychological influences can largely express the purchasing behavior of the consumer [1]. However, these variables cannot be directly observed and must be inferred. As per online purchasing behavior, various consumer perceptions of the factors with indirect or direct influence on the purchase intention or actual behavior were studied, the motivations, the motives that drive consumers to adopt the use of the Internet, respectively the website in order to learn, consumer attitudes towards using the Internet to buy, and not least stated purchase intentions and actual behavior, which consists of buying online services such as English language courses for personal use.

The Internet, like the e-commerce infrastructure, creates uncertainty about online transactions. On the one hand, it amplifies the risks related to the product through the lack of sensory experiences such as: taste, smell, tactile sense, through the impossibility of asking a question to the seller face-to-face, through the temporal separation between payment and taking possession of the service, separation that gives rise to uncertainties

¹ PhD Teaching Assistant, Romanian-American University, gyongyver.maduta@rau.ro

regarding delivery as well [2]. When buying online, the consumer is not given the chance to inspect or observe the seller directly, traditionally used assurance mechanisms. Service risk is associated with the product itself and represents the consumer's belief that the product purchased online will perform as expected [3]. This type of risk increases when the product or service is technologically complex or when the service satisfies ego-related needs, such as a foreign language course that requires personal interaction [4].

The concept of "trust" has been intensively studied due to its complexity and multi-dimensional nature, being considered a cornerstone for the adoption of electronic transactions by consumers [5] [6] The concept of trust and its dimensions have been studied from the perspective of several disciplines and filters: economic, social (institutional), behavioral (psychological), managerial (organizational) and technological, being considered essential in exchange relationships [3].

Ba and Pavlou [7] identify two dimensions of online trust: goodwill and credibility. Goodwill refers to the consumer's belief that the seller is genuinely interested in the consumer's welfare and has beneficial intentions and motives for the consumer. Credibility refers to the consumer's conviction that, in this case the trainer is honest, reliable and competent.

Online consumers learn from past positive experiences in the online purchasing process and thus build trust in the safety of commercial websites. Trust in the website was oriented towards aspects of private life (privacy of personal data) and security of online payments [3].

Thus, the characteristics of the website or platform used can influence: perceived financial risk (fear of suffering financial losses) and informational risk (fear that personal information will be exposed or misused) [8].

Recent studies have provided evidence regarding the existence of other elements that positively or negatively influence online trust: corporate reputation (Sun, 2009) and website design [5].

The individual accepts or rejects a new information technology based on perceived benefits. Perceived usefulness, a concept of the Technology Acceptance Model, represents the user's belief that the use of an information technology entails a series of benefits. Compatibility, a variable specific to the Diffusion of Innovation Theory, is defined as "the extent to which the innovation fits the existing values, past experience and current needs of the potential user" [9].

The Internet as a channel for selling goods and services is viewed as an innovation and the extent to which consumers will adopt or reject this innovation depends on perceived compatibility. In other words, individuals are more likely to accept the new way of shopping if they perceive it as compatible with their needs, previous experience and values.

Compatibility cannot be directly observed but inferred based on consumer perceptions. In the field of online purchasing behavior, the extent to which consumers perceive a higher or lower degree of compatibility between their needs, beliefs and lifestyle and the new way of shopping via the Internet has been studied.

Using the Internet to learn a foreign language requires certain specific skills and abilities. It is virtually impossible for a person who has no personal computer experience, or a person

who has no experience with the Internet, to not find the online shopping process complex or cumbersome. Self-efficacy has been defined as the individual's perceptions of their own abilities to behave in a certain way [10]. An individual will perceive a high level of personal efficacy when he is convinced that he has the necessary knowledge and skills to use the Internet to buy and feels confident in his own abilities to buy online [11]. Personal efficacy has also been measured by the individual's ability to navigate, order and pay without help from another person [12].

Particularly important in the study of purchasing behavior is the variable known as learning and defined as "the observable and unobservable change in the behavior of a consumer, due to the effects of experience, which leads to an increase in the probability that a behavioral act will be repeated" [1]. Closely related to learning is the concept of personality, defined as those "characteristics of a consumer that make him have a distinct buying and consumption behavior, compared to other consumers" [1].

Satisfaction can be studied not only in relation to a decision or transaction, but also in relation to a service. Satisfaction with a service, whether purchased online or traditionally, is defined as a consumer's judgment based on the difference between their initial expectations of the service's characteristics and its actual performance after purchase [13]. Churchill and Suprenant liken satisfaction to attitude because it can be interpreted as a sum of satisfactions on several attributes [14].

Online consumers choose to learn a foreign language through the Internet because of the perceived benefits. These benefits include: increased convenience, financial and time savings, a greater variety of courses and time slots available online [15].

Increased comfort or convenience is the main reason why consumers choose to shop via the Internet. The consumer does not have to physically travel to a center/classroom or schedule his shopping time according to the company/teacher schedule. [15].

Service quality in Ahn et al.'s [16] model is measured by responsiveness (the ability of the website to anticipate and promptly respond to user requests), creditworthiness (the ability to deliver on promises made), empathy (the ability to understand and adapt to the specific needs of the user), trust (ability to establish trust among users and reduce uncertainty), competence (ability to have a professional and competent image), follow-up (ability to provide follow-up to users).

2. Methods

2.1 Purpose and objectives

Based on the economic reality that characterizes Romania at the moment and due to the lack of specialized studies based on a sample of Romanian online consumers, there is a need to carry out an exploratory research on the use of digital media to learn English, before moving on to a quantitative research on a wider scale. We thus state the purpose of the qualitative research as forming an overview of the online purchase behavior of English language courses by exploring the perceptions, motivations, satisfaction and attitude of Romanian online consumers towards using the Internet to buy English language courses.

To highlight the purpose of this research, we aimed to:

- Remove possible errors that could have intervened in the formulation of the problem to be investigated in the framework of the quantitative study that follows this research;
- Better identify the working hypotheses of a quantitative study that follows this research;
- Adjust the number of variables that determine the buying behavior of foreign language courses in the online environment.

It is also necessary to mention the limits of an exploratory research that derive precisely from its purpose, which is a better knowledge of the investigated phenomenon.

The present exploratory study has three main objectives:

1. Identifying the habits of using the Internet and the habits of buying English courses through the Internet, among Romanian online consumers;
2. Identifying the factors influencing online learning behavior among Romanian online consumers;
3. The classification or grouping of these factors according to the importance that Romanian online consumers attribute to them.

2.2 Methodology

Considering the nature, purpose and objectives of the research, I chose to conduct a semi-structured interview. The application of such an interview is based on open questions, which oblige the interviewees to provide answers regarding the investigated phenomenon [1].

In the case of the semi-structured interview, the interviewer has a series of questions in mind, usually no more than 10, questions that he addresses to the respondents, but which do not necessarily have a certain predetermined order [17].

The advantage of this type of interview is that it offers flexibility, unlike the fully structured interview, but allows, at the same time, to cover all the proposed topics. Moreover, the results of this interview can be compared, reversed or even converted into statistics.

Initially, the target population was defined as all Internet users in Romania, who bought goods or services online for personal use, in the last 3 months. The chosen sample was intended to reflect the structure of the researched community. In order to achieve this approach, the stratified sampling approach was used. The sampling base (Table 1) included people from Bucharest, both female and male, aged between 18-59 years, with low, medium and above average income, people with and without higher education.

Layer	Gender	Age	Education	Income	Average	Sample
1	f	18-23	pri/med	<1000	2.78	1
2	f	18-23	pri/med	1000-2000	1.835	1
3	f	18-23	pri/med	>2000	1.30	0
4	f	18-23	sup	<1000	4.74	2

5	f	18-23	sup	1000-2000	3.12	1
6	f	18-23	sup	>2000	2.22	0
7	f	24-39	pri/med	<1000	3.48	1
8	f	24-39	pri/med	1000-2000	2.29	1
9	f	24-39	pri/med	>2000	1.63	0
10	f	24-39	sup	<1000	5.92	0
11	f	24-39	sup	1000-2000	3.91	2
12	f	24-39	sup	>2000	2.77	2
13	f	40-59	pri/med	<1000	1.57	0
14	f	40-59	pri/med	1000-2000	1.03	0
15	f	40-59	pri/med	>2000	0.73	0
16	f	40-59	sup	<1000	2.66	0
17	f	40-59	sup	1000-2000	1.76	1
18	f	40-59	sup	>2000	1.25	1
19	m	18-23	pri/med	<1000	2.78	1
20	m	18-23	pri/med	1000-2000	1.835	0
21	m	18-23	pri/med	>2000	1.30	0
22	m	18-23	sup	<1000	4.74	3
23	m	18-23	sup	1000-2000	3.12	1
24	m	18-23	sup	>2000	2.22	0
25	m	24-39	pri/med	<1000	3.48	1
26	m	24-39	pri/med	1000-2000	2.29	1
27	m	24-39	pri/med	>2000	1.63	1
28	m	24-39	sup	<1000	5.92	0
29	m	24-39	sup	1000-2000	3.91	2
30	m	24-39	sup	>2000	2.77	2
31	m	40-59	pri/med	<1000	1.57	0
32	m	40-59	pri/med	1000-2000	1.03	0
33	m	40-59	pri/med	>2000	0.73	0
34	m	40-59	sup	<1000	2.66	0
35	m	40-59	sup	1000-2000	1.76	1

36	m	40-59	sup	>2000	1.25	0
----	---	-------	-----	-------	------	---

Table 1. Sample structure and size

Individual semi-structured interview participants were recruited through telephone interviews in which recruitment criteria were verified and interview attendance confirmed.

The recruitment criteria discussed both by telephone and face to face, allowed the selection of those individuals who correspond to the criteria established in the sampling process.

The interviews took place between July 27 and August 14, 2022 based on the interview guide (conversation guide). Eight topics were covered during the discussion:

- The purposes of using the Internet and the most frequent activities carried out online
- Buying habits for online foreign language courses
- Consumers' motivation to buy foreign language courses online
- The risk associated with online courses
- Confidence in merchants and the online environment in learning a foreign language
- Consumer satisfaction with online English courses
- Social influence from reference groups
- Behavioral intentions.

3. Results and discussion

The analysis of the information obtained following the conduct of the interview in order to formulate conclusions was based on the review of the interviews. It was necessary for the data obtained from the interviews to be reviewed through recordings and field notes. Each topic is treated separately.

3.1. Internet usage habits

All respondents selected for the interview use the Internet regularly, which is a necessary characteristic of the investigated population. The activities carried out through the Internet are numerous, from recreational activities to the use of the Internet for professional and educational purposes.

"The moment I turn on the computer I connect to the Internet. My [instant chat] programs start automatically (...) If I am 'offline', I answer. If not, I'll check my email"

The majority of respondents use the Internet to get information or to socialize, these two activities being indicated in the top of the most frequent activities carried out online. There are also situational uses of the Internet: looking for a job or paying bills before they are due.

"First of all, I use the Internet to always be close to my friends (...) even if face-to-face we may only see each other once a week or even less often"

The use of the Internet to buy goods and services for personal use is among the activities carried out online, this being a necessary characteristic of the investigated population. I have not come across any cases where the "first thought that comes to mind" is related to online shopping.

"There were periods when I subscribed to the latest offers from discount sites. I received dozens of offers by e-mail every day. I bought a lot of them"

3.2. Online shopping habits

Romanian internet users buy online very rarely and in particular, certain categories of products, among which are IT products and discount coupons representing various beauty services, tourist stays, restaurant meals, theater tickets and various shows, etc.

"I really don't know why I don't shop online more often. I never thought. The products I usually need, food, (...) I buy them from the hypermarket, or from the kiosk in the staircase of the block"

"I don't leave Bucharest so often that I look for and buy a tourist offer every week"

Asked if they think there are certain product categories they avoid buying online, most respondents mentioned food and clothing and footwear.

"I avoid buying everything perishable: crockery, food... (pause) I remember now. Everything I can't touch, test, sample: clothes, new perfumes, clothing (...) I buy perfumes online, but perfumes that I've used before and know how they smell"

"I have never bought vegetables online. I don't even think there is an 'online grocery' in Romania (laughs). But I would be willing to try!"

When asked what would motivate them to shop more often, most respondents pointed to price cuts.

"The deals! I can't resist a discount of over 50%. Even if I don't necessarily need [that] product. I feel like I'm doing a good deal"

"I don't know (...) Maybe if merchants would constantly renew their offers, if they would always bring new products or if they would offer added value to the service"

"An instant delivery. I know this is not possible. But how do restaurants with home delivery manage to deliver in 30 minutes?"

3.3 The motivations to buy online

Respondents buy online because of the perceived advantages or because sometimes buying online is the only solution.

"There are no physical collective discount stores. There are outlets (..) but there is no store where I can find both products and service offers, with discounts of up to 90%, in one place"

"I frequently buy digital products: pictures, especially (...) or licenses for [editing programs]. These can only be bought online"

The relative advantages of online shopping are perceived differently by respondents. If for some, the level of prices or the existence of online bargains are the reasons why they choose this alternative to buy, for others, convenience is the main motivation.

"Definitely, the price! Even brick-and-mortar stores like [Domo] offer discounts for online or phone orders"

"Whenever I shopped online, I saved some money. We always chose the best offer as a price. If [online stores] don't have the prices listed, I send them an email with a request. And they send the same message to multiple providers. They [traders] see that too, and that's how they get the best deal without haggling too much."

"On the Internet you have a choice. There are many suppliers and there is competition between them. From here I have to gain"

"I use to buy online because it's more efficient. I can place the order at any time, I know I will be called the very next day for confirmation and delivery"

"I put in minimal effort. All I have to do is type some characters and make some clicks. I don't get dressed, I don't get on the bus, I don't bring the products home"

For other respondents, access to a multitude of information, products, brands and suppliers gives them greater power of selection and the possibility to make an informed choice.

"I have access to several products, which I can compare in a very short time. I can also compare the prices [of these products]. There are also sites that compare prices [price aggregators] but they don't always show all the offers that I find by searching on [Google]"

"On the Internet you have a choice. If the seller doesn't suit me, I can find another a few clicks away"

3.4. The risk associated with online shopping

There are a number of risks associated with online shopping, but consumers perceive the importance of these risks differently. Based on the 26 responses, the most frequently cited fears are: the possibility of credit card fraud, the possibility that the service does not have the specified attributes or does not work at normal parameters, and the possibility that personal data is stolen and made public, or distributed to third parties without their permission.

Respondents' biggest fear is the possibility of losing money due to credit card fraud. The fear is born due to the articles in the newspapers or the televised news about the existence of these causes, intensively mediatized.

"I read about real cases when groups of hackers took money out of people's accounts or emptied them completely. I admit that I'm afraid it won't happen to me too"

Online consumers reluctant to pay online have developed methods to lessen the risk or even avoid it.

"(...) I made a special card for the Internet. I don't keep a lot of money on this card. Always transfer as much as necessary"

"I don't pay by card. There are many other ways to pay. I choose [to pay] on delivery, or through [Qivi terminals]"

Consumers fear that commercial websites are not sufficiently secure and in the absence of seals/marks certifying the safety of the payment, they refuse to pay online.

"I need to be sure that the payment is secure. I'm looking for Truste or VeriSign seals"

"[Online retailers] are popping up like mushrooms after the rain. I would not enter my credit card details on an unknown seller's website. On the other hand, when it comes to a well-known company, like [eMag], I have no such reservations"

Fear that the ordered products will not have the mentioned attributes or will not perform at normal parameters is again among the most frequently mentioned fears related to online shopping. This risk is closely related to the impossibility of testing a service before buying it, the impossibility of touching it, smelling it, tasting it, etc.

"(...) I don't understand how other people, and I know cases in my group of friends, buy services online. I personally need to have feedback on a service from a friend before I buy a service (...)"

"I have reservations, yes. Until I see the product at home in perfect working order I wonder... But I haven't had such problems. I am also very careful where I buy from".

Most consumers fear that their personal data will be used for purposes other than those for which it was collected: invoicing and delivering a service ordered online. Consumers fear the existence of the possibility of an informational attack through which the databases end up in the hands of malicious persons. Consumers also fear that certain merchants will willingly alienate databases to third parties in exchange for sums of money. They are aware of the existence of these practices and fear the consequences.

"I am not willing to give out more personal information than is necessary. And then I do it with reservations. When I buy from the store [the saleswoman] doesn't ask me for my personal code"

"I can only hope that [the personal data] will not become public. Everyone would know my phone number and address, leaving me exposed to many dangers"

"I'm sure many online merchants are alienating or selling their databases! How else can you explain that I get n spams [unsolicited messages]?"

Dissatisfaction or fears also arise in the case of delivery of services ordered online. This time there is the issue of delivery quality. Respondents' opinions about trust in online merchants are divided and often expressed within opinions about the risk associated with online shopping. Consumers do not trust all online merchants, only those with a good reputation.

Consumers are selective and cautious when shopping online. They have learned to guard themselves from opportunists and possible electronic fraud.

3.5. Consumer satisfaction with online language courses

The vast majority of respondents say they are "quite satisfied" or "very satisfied" with their decision to buy online. However, there are restraints that prevent them from being fully satisfied with their online shopping experience.

There are respondents who want a better quality of information on commercial websites. Other respondents want better organization of information on the page, good navigation, lack of pop-ups, etc.

"I wish companies would constantly update their website. Or have the courses listed clearly, not available to order"

"I am disturbed by the lack of transparency in the case of some services and products. Instead of displaying the price on the website, I replace it with a request for quote form. It does not seem fair"

"I often don't realize what the service looks like. More images, possibly video recordings, demonstrations would be useful"

Other respondents indicated lack of alternative payment methods or lack of a company headquarters as the main dissatisfaction.

"You can't force the customer to pay only by card or Paypal (...) All sellers should offer the option of payment on delivery"

There have also been customers who have complained about the lack of seriousness or professionalism of online sellers, or the poor quality of the service sold online.

"Lack of seriousness. There are a number of established companies (...) But the rest... Some don't even answer e-mails or phone calls"

"I am disappointed that there are no consumer protection laws. If there were, how would it allow so many replicas to exist? And the bottom line is that many of these ghost language centres also occupy the top search positions or have also appeared on discount sites."

Opinions about using the Internet to buy online language courses from consumer reference groups are divided. Opinions also differ between reference group members who shop online and those who do not.

"(...) My parents, for example, are very reserved about online school. They think you're taking a free risk when you make that choice."

"My husband has the most vehement position. Everything he knows [about online shopping] comes from TV. He can't wait for me to be wrong so he can tell me he was right"

"My friends generally shop and study online. Some [of them] complained but that didn't stop them from buying again"

3.6. Behavioral intentions of online consumers

There was not a single respondent who said they would not consider buying language learning services online again. But the intensity with which this intention manifests differs among them.

"Even though I don't specifically set out to do this, I will definitely buy again"

"I receive offers daily. It's impossible to refrain [from shopping online]"

Moreover, there are consumers who recommend online language courses to members of their reference groups.

"I always recommend the offers [of collective discounts] that I propose to buy"

"My friends and family members know that I take online classes. I know my position and I don't necessarily need to recommend anything to them. They realize it too".

4. Conclusions

The technique of the structured interview conducted on the basis of an interview guide was used among 26 consumers. The sample used is a stratified one according to the characteristics of Romanian online consumers. The interview followed eight main themes on which conclusions were formulated. In order to better highlight the way in which Romanian online consumers think, certain statements have been cited.

All selected respondents are regular Internet users and they use the Internet to shop online. Respondents use the Internet mainly for recreational purposes: socializing, watching movies, music, games, etc. But there are consumers who use the Internet in particular to get information, but not necessarily about goods and services. When asked how often they shop online, most respondents said they don't shop often enough and focus only on certain product or service categories.

Asked what would motivate them to buy more often, most respondents avoided answering this question, ending up stating that promotional techniques are what would lead them to increase the frequency of online shopping. However, both the diversification of the range of services through the import of new and innovative courses were indicated.

It seems that the price level in the online market and the existence of price discounts and advantageous offers motivates consumers to buy online. Collective discount sites were often referred to, indicating price as a relative advantage of online shopping. Other consumers cited the convenience associated with saving time with online classes. Moreover, the use of the Internet in the information stage allows consumers to compare offers and suppliers in a very short time, resulting in an informed decision.

Along with the benefits, there is also a risk associated with online shopping for English language courses. Many of the respondents are afraid of online payments due to the possibility of credit card fraud. In this regard, many have developed defense mechanisms. Of equal importance there is the risk associated with the loss of personal data, the fear that they may not become public or be alienated by online sellers. Fears also arise about the attributes or the quality of the service ordered online. These fears are born due to the deprivation of certain sensory processes. As they perceive a high level of risk associated with online shopping, respondents have learned to become selective in choosing an online seller and cautious about making an online payment on any unsecured e-commerce site.

There is a good level of satisfaction with online shopping, but dissatisfactions arise with regard to the quality of information, navigation in e-commerce sites, the lack of price transparency in the case of some categories of services, the cluttering of the Internet with ghost language schools.

Members of consumer reference groups are divided on the new way of shopping. There are both reluctant people and people who encourage the use of the Internet to study online. It is necessary to emphasize the fact that the people reluctant to online learning are usually older people, parents or life partners.

Most importantly, not a single respondent stated that they do not intend to shop online again in the future. But they are not sure how often they will do it. The use of the Internet in the buying process becomes a necessity, when it is not possible to buy otherwise, a need to learn more in the case of services with a high value or an opportunity, when faced with an added value.

The results of the qualitative research confirm the already existing theory on buying behavior in the online environment. Motivations. Consumers choose to buy online mainly due to the increased convenience or comfort and due to the existence of a variety of products, brands, manufacturers, retailers that allow a greater power of selection. Low prices, price reductions, wealth of information are other reasons why consumers choose to buy online.

Barriers. The main barriers to not buying online are primarily given by the perceived risk in the online environment. Consumers fear for the security of their financial and personal data. They are afraid of a possible attack through which unauthorized persons could gain possession of the data on the card. Some consumers expressed reservations about the disclosure of personal data due to their belief that certain online sellers will sell their databases to third parties and they will receive unsolicited commercial messages. Consumers do not trust all online sellers and tend to buy online from those who already have a reputation and reputation both online and offline. Consumers complain about the existence of so-called "ghost" sellers. Consumers fear that the product bought online will not be the one ordered in terms of the promised characteristics, attributes and performance. Most consumers would prefer to be able to test or try the product before buying it. Consumers perceive delivery as another impediment. First of all, it is necessary to wait at least 24 hours before taking possession of the desired product. Second, they worry about delivery: Will the product be delivered on time? To the indicated destination? Without suffering damage due to handling and transport? If they are not satisfied with the product, they perceive the return process as difficult and time-consuming.

Expectations. Consumers form certain expectations in the three stages of the buying process. In the pre-purchase stage, consumers expect to easily reach the desired information, with as few clicks as possible. Consumers expect the information from e-commerce web platforms to be complete, detailed, accurate, updated and arranged in an appropriate format to allow them to make comparisons between prices, features, functionalities of the products. In the buying phase, consumers expect to place the order without difficulty and without errors and for it to be confirmed by the seller both by phone and instantly, generated by the e-commerce web platform. Regarding payment, consumers expect the online seller to offer them several payment methods, not only online card payment. In order to pay online with the card, consumers need an assurance regarding the security of the e-commerce web platform. They pay by card only if the e-commerce platform and the seller inspire them with confidence. In the post-purchase stage, consumers expect to be able to contact the seller at any time to find out about the status of the order. Also, they expect the delivery to be on time.

Perceptions. Studying consumers' perceptions regarding behavioral control in the case of buying goods and services on the Internet, most of those interviewed have both the resources and the knowledge and skills necessary to buy online. They stated that they can order and pay online without any help from another person, moreover, they are able to explain and teach other people to buy online. All those interviewed frequently use the Internet, for various purposes, which is why they perceive a high self-efficacy. Studying consumers' perceptions regarding the compatibility between their needs, values and lifestyle and how to buy online, opinions are divided. There are those consumers who are always in crisis, for whom going physically to the store is a burden and for convenience they prefer to buy online. There are also those price-sensitive consumers whose financial savings they can make online attract them to this way of buying. These two categories of consumers perceive a high level of compatibility with the new way of buying online. There is another category of consumers who prefer to buy traditionally due to the experience that the traditional store offers them. These consumers make shopping a pleasant, often social activity. The lack of socialization in the online environment causes them to perceive a reduced compatibility with the new way of shopping. There are also those risk-averse consumers who prefer to inspect the product, test it, sample it. They also perceive a low compatibility with the new way of shopping.

Attitude. Most of the people interviewed have a favorable attitude towards the idea of buying language courses online. Even if they don't use the Internet to buy everyday products such as food and drinks, they don't reject the idea of learning a language online, or at least getting information on the Internet, in the case of other categories of training services. The majority of those interviewed would recommend buying language services via the Internet.

References

- [1] Iacob CĂTOIU, Nicolae TEODORESCU – *Comportamentul consumatorului*, ISBN: 973-9021-80-8. Published by Editura Uranus, July 2004
- [2] Said S. AL-GAHTANI – *Modeling the electronic transactions acceptance using an extended technology acceptance model*, Applied Computing and Informatics, Vol. 9, pp. 47-77, ISSN: 2210-8327, 2011
- [3] Kim SOJUNG, Michael S. EASTIN – *Hedonic tendencies and the online consumer: An investigation of the online shopping process*, Journal of Internet Commerce, Vol. 10, pg. 68-90, ISSN: 1533-2861, 2011
- [4] Sandra FORSYTHE, Chuanlan LIU, David SHANNON, Liu-Chun GARDNER – *Development of a scale to measure the perceived benefits and risks of online shopping*, Journal of Interactive Marketing, Vol. 20, No. 2, pp. 55-75, 2006.
- [5] Glen L. URBAN, Cinda AMYX, Antonio LORENZON – *Online trust: State of art, new frontiers and research potential*, Journal of Interactive Marketing, Vol. 23, pp. 179-190, ISSN: 1094-9968, 2009

- [6] Dan J. KIM, Donald L. FERRIN, Ronald H. RAO – *A trust-based consumer decision-making model in electronic commerce: The role of trust, perceived risk and their antecedents*, Decision Support Systems, Vol. 44, pg. 544-564, ISSN: 0167-9236, 2008
- [7] Sulin BA, Paul A. PAVLOU – *Evidence of the effect of trust building technology in the electronic markets: Price premiums and Buyer Behavior*, MIS Quarterly, Vol. 26, Nr. 3, pg. 243-268, ISSN: 0276-7783, 2002
- [8] Constantinides EFTHYMOS – *Influencing the online consumer's behavior: the Web experience*, Internet Research, Vol. 14, Nr. 2, 2004, pg.111-126, ISSN: 1066-2243
- [9] Shirley TAYLOR, Peter A. TODD – *Understanding Information Technology Usage: A Test of Competing Models*, Information Systems Research, Vol. 6, Nr. 2, pg. 144-176, ISSN: 1047-7047, 1995
- [10] Deborah R. COMPEAU, Christopher A. HIGGINS – *Computer self-efficacy: Development of a measure and initial test*, MIS Quarterly, Vol. 19, Nr.2, pp. 189-211, ISSN: 0276-7783, 1995
- [11] Herrero Angel CRESPO, Rodriguez DEL BOSQUE – *Explaining B2C e-commerce acceptance: An integrative model based on the framework by Gatignon and Robertson*, Interacting with Computers, Vol. 20. Nr. 2, pg. 212-224, ISSN: 0953-5438, 2008
- [12] Aron O'CASS, Tino FENECH – *Web retailing adoption: exploring the nature of internet users Web retailing behavior*, Journal of Retailing and Consumer Services, Vol. 10, 2003, pp. 81-94, ISSN: 0022-4359
- [13] Ralph L. DAY – *Modeling choices among alternative responses to dissatisfaction*, Advances in Consumer Research, Vol. 11, pp. 496-499, ISSN: 0098-9258, 1984
- [14] Gilbert A. CHURCHILL Jr., Carol SURPRENANT – *An Investigation into the Determinants of Customer Satisfaction*, Journal of Marketing Research, Vol. 19, November 1982, pg. 491-504, ISSN: 0022-2437, 1982
- [15] Lynn MARGHERI. – *The Emerging Digital Economy, U.S. Department of Commerce*, Washington, D.C., 1998, ISBN: 978-189-2209-16-0, available online at <http://govinfo.library.unt.edu/ecommerce/EDEREprt.pdf>
- [16] Tony AHN T., Ryu SEEWON, Ingoo HAN - *The impact of the online and offline features on the user acceptance of Internet shopping malls*, Electronic Commerce Research and Applications, Vol. 3, Nr. 4, 2004, pg. 405-420, ISSN: 1567-4223
- [17] Jonathan GRIX – *Demystifying Postgraduate Research: From MA to PhD*, University of Birgmingham Press, Uk, ISBN: 1-902459-35-0, 2001

ANALYSIS OF THE BEST FIT PRE-TRAIN DEEP LEARNING MODEL (DLMS) THAT CAN INTEGRATE BLOCKCHAIN TECHNOLOGY IN THE HEALTH SECTORS USING NATURAL LANGUAGE PROCESSING (NLP) AS THE MAIN SOURCE OF DATA CLUSTERING

Pascal Muam MAH¹

Iwona SKALNA²

Tomasz PEŁECH-PILICHOWSKI³

Abstract

Blockchain technology is a secure digital platform that allows the creation, sharing, and storing of innovative solutions for various datasets within sectors including healthcare. Blockchain technology can be used in the healthcare sector to securely manage and exchange laboratory diagnoses. Advance developments in technology have pushed healthcare sectors into remote care and management systems. Until today, there's no concise and preferred system globally accepted by health sectors due to the unavailable remote systems, and skepticism amongst customers and patients concerning remote healthcare monitoring and surgeries. This paper aims to introduce a pre-train prototype deep learning model (DLMS) based on blockchain technology using natural language processing (NLP) as the main source of data from healthcare. Text content related to healthcare issues was classified into various language structures. A systematic influence of blockchain technology was calculated based on the dataset cluster. The sample texts represent NLP classified into input layers, hidden layers, and output layers of DLMS. The parts of speech used in the study help to explain a possible system integration of Blockchain technology with deep learning based on clustering algorithm pre-determined features of blockchain technology. A “behavior-oriented driven and influential functions” of blockchain was used to measure the influence on healthcare applied NLP. On a scale 1-5 grade, 3.88 was recorded as a predetermine value of blockchain on healthcare applied NLP.

Keywords: Deep learning models, Natural language processing, Data clustering, Blockchain

JEL Classification: C8

1. Introduction

Blockchain technology is moving away from just being a cryptocurrency platform into a smart contract system, healthcare preferred embodiment center for proper delivery and

¹ AGH University of Science and Technology, Krakow, Poland, mahpascal01@gmail.com / mah@agh.edu.pl

² AGH University of Science and Technology, Krakow, Poland

³ AGH University of Science and Technology, Krakow, Poland

safeguarding of customer's data. Blockchain allows users to store, verify, execute and share codes on a blockchain [1],[2],[3],[4],[5],[6],[7],[8]. Natural language processing (NLP) is system software that enables interactions between humans and computers using text or speech [9],[10],[11],[12]. Deep learning models (DLMs) is computer systems of artificial intelligence that build frames using texts, figure, pictures, and objects to represent human thoughts called neurons [13],[14],[15],[16]. Healthcare Blockchain is the future foundation of hope, maturity, security, reliability, transparency, innovativeness, and growth in healthcare systems [17],[18],[19]. Communications within systems administration are in healthcare or financial are very secure with end-end access to Blockchain technology. Natural language processing with the capability to transform linguistics appraisal into human computers with the support of artificial intelligence can be much more secure with Blockchain technology.

In today's world, cyber-attacks are forcing millions to turn their backs on social media platforms that could be much-more friendly. To give hope to most users, it's really necessary to implement Blockchain technology within social media platforms. Research shows social media platforms play a leading role in the minds of users [21],[22],[20]. The increase in privacy breaches, system hackers, and extensive volume of data within healthcare have necessitated the need for Blockchain technology as one of the most secure and fastest platforms. Securing the platforms enable a balanced society with fewer psychological associated challenges for healthcare providers [23]. Research has indicated that most rich people are less engaged on social media platforms due to their insecure nature [31],[32],[33]. The insecurity within healthcare sectors enables a platform flooded by youths and less of the aging population [25]. To fully engage the whole world at large, there's a need for a secure chain to prevent counterfeiting information and Communication attacks²⁴. It is also alert that most entertainment services are moving to most of these social media platforms [27],[28],[29],[30],[26]. There's a need for a speedy system and secure platforms that will engage both the young and aging population. This can be only achieved with the help of Blockchain technology that enables a secure digital platform and market where privacy breaches are less often. Two types of Blockchain exist: Public Blockchain technology and Private Blockchain technology.

2. Related Work

Blockchain technology applications allow the recording of sensitive information relating to medical records, legal contracts, educational institutions, and other industries. The state of the art introduced here is to help healthcare providers easily make decisions based on text guarder from patients or customers. The public blockchain is an open access chain that does not require any special kind of authorization to join. The general public is allowed to participate without authorization because it is of a decentralized nature and is not controlled by anyone [51],[52]. The public blockchain allows all branches of the chain to be created and validate data for data storage and sharing and it's well encrypted.

The private blockchain is a type of blockchain that allows only one organization to have access to the entire network [53],[54]. This type of Blockchain is very important to the healthcare industry. The private Blockchain is the opposite of a public blockchain because it's not an open network to which anybody has access. The private blockchain is the best solution for organizations. Data is accessible to whom can be trusted with it. One of the

reasons blockchain is so popular is because Blockchain technology provides a safe means for individuals and enterprises to interact with one another without involving third parties. Blockchain technology is a type of database that keeps information in a systematic platform making it easier for users to access. Blockchain technology's main challenge despite some communities pushing for standards and collaboration delay and forces holding the technology back from mainstream global adoption.

Three types of deep learning models recognize as important elements of Deep learning that can adopt Blockchain technology. Recurrent neural networks (RNNs), Classic neural networks and Convolutional neural networks (CNN).

Recurrent neural networks (RNNs). It is a type of neural network that applied an artificial neural network system used in speech recognition and natural language processing [46],[47],[48]. The study uses recurrent neural networks in this study to identify the need for data security, faster acquisition of patient information by healthcare, and encrypted dataset systems incorporation into the healthcare industry. Blockchain technology in artificial neural networks can be created by interconnecting data processing components closely designed to respond to all parts of speech tied to function like the human brain. Classic neural networks or Multilayer perception supervised deep learning Model. It is a type of feedforward Artificial Neural Network that has a training purpose as the technique used to supervise learning known as backpropagation [49]. Convolutional neural networks (CNN). It is an exhibited superior performing type of classification and prediction tasks with a low interpretability level. It is an operation where one function modifies the shape of another [50].

Blockchain systems boost performance, transparency, and security in the exchange and sharing of medical reports and results. Blockchain systems also prevent the fabrication and duplication of medical results. Blockchain systems have a centralized ledger and public ledger that help record, and secure information and prevent unevenly sharing and republicans of medical results. Unlike other applications where they are stored in a dataset, Blockchain systems are stored within networks. Meaning information within Blockchain systems is very secure with end-end access only to those with access. Information retrieval has remained a top challenge within healthcare. The development of natural language processing is to cope with the duplication of data. Blockchain technology helps in retrieving data in crowded databases. Health care systems can benefit from Blockchain in that, it helps create a secure medical buffet zone for medical reports and results. With Blockchain, medical records will enjoy a series of confidentiality benefits of fast updating patient data across multiple entities in no time. One of the most challenging situations within healthcare today is the availability of false content. The world is growing with the increasing quantity of information. There's a need for a secure system that can help process information faster.

Blockchain system technology has its fundamental quality to improve the distributed network of telecommunication of the modern world by computing applications like NLP which allows storing transaction history through text and documenting in the time stamping. Blockchain systems have nodes. Within each Blockchain node in the distribution network processes lies a secure verification ledger that helps record each data input.

Advancing mental safety and positive perception. Within healthcare, it is very important for a patient's psychology. Blockchain technology within healthcare sectors increases overall safety in the health treatment of patients. The mental health of an establishment has

a very great role to play in healthcare in addressing medication validity and drug traceability issues. Good healthcare with a safe environment attracts good and professional workers. The technology behind Blockchain isn't all about financial security and systems security but it also enables fast data acquisition of patients. Any system software that allows for safe interoperability is very important for humanity. The Blockchain technology helps prevent counterfeiting of drugs and manufacturing by bringing real drugs data into the market faster through its security system which is better than dataset systems

Blockchain provides the fastest data transformation in a timely and less costly road. These factors alone secure a well-defined system to handle the lump sum data available within healthcare sectors. Today, most companies are spending money to buy 5G services that can help analyze data generated within their various systems. Blockchain technology helps in mobilizing innovative new, creative, industrialized, and synchronized initiatives that provide a secure means for health practitioners to obtain information and apply it. Blockchain reduces redundant expenses and enables the flow of correct health records [43],[44],[45]. Since Blockchain systems are securely built, they help the system avoid duplicated information. In many instances, due to large datasets and pressure from patients, many mistakes usually occur. Blockchain technology consists of blocks, data, nonce, and hash.

- **Blocks:** They are made up of many blocks where each block has three basic elements which are data
- **Data.** This can be text or symbols or figures.
- **Nonce.** This is a 32-bit whole number. It generates randomly in a block and also causes the generation of block header
- **Hash.** This is a 256-bit number that is very small and is connected to the nonce.

When a chain a block is created nonce generates a hash which is assigned and tied with the data in the block. Mining of the data from the block makes the nonce and hash be untied with the data. The ability for systems to leverage the energy within artificial intelligence (AI) and natural language processing (NLP) to simplify decision-making for their users and subscribers lies within Blockchain technology. Natural language processing, a system that summarizes textual content in a much easier form is very important for healthcare providers. Blockchain and NLP ensure a lot of trust and confidence in healthcare when it comes to the need for trusted and tamper-proof usable insights. Blockchain systems incorporated with natural language processing will provide a friendly ecosystem environment which will go a long way to enacting a healthy environment.

Advantages of Blockchain for healthcare

- Secure data across blocks
- Cross-border data transfer
- Real-time operating system
- The Supply system constantly monitor
- Encrypted dataset exchange
- Personal identity security

Blockchain technology helps to store accurate data that cannot be altered and is permanent while Machine learning can utilize this data to discover patterns, give accurate predictions and notify the users.

3. Results

In this section, we provide details on how text or speech content can be classified into different parts of the speech based on data obtained via NLP means that help in decision making. Data clustering here helps health practitioners to make proper decisions.

We called this behavior-oriented drive and influential functions. Based on some selective ratings, we offer each a score of one up to five ratings. The rating is based on the author's choice. The Key Benefits are based on the Metrics Score range obtained from the text content. The key benefits score rate is classified into poor, fair, good, very good, and excellent. The behavior score defined the gradient of the key benefits from the summation statistic retrieve from cluster data.

In this study push, factors of blockchain are characteristic of blockchain technology that influences the health sector to obtain vital information from patients or customers to achieve better management. The push factors of blockchain provide healthcare sectors with solutions to enhance and produce good services to customers or users in their daily activities. This Push factors of blockchain will depend on some unique items referred to in this study as dependent parameters. In the study, dependent parameters are (Enabling business activities more efficient, enabling social reasoning more effective, and enabling education in a most reliable, informed, and accessible). The metrics range is made up of MR of (*nouns, adjectives, verbs, adverbs, interjections, prepositions, conjunctions, pronouns, determiners, and numerals*) and MR^s Is made up of (*nouns, adjectives, verbs, adverbs, interjections, numerals, and prepositions*) measure with a sequence of numbers from (1, 2, 3, 4, 5) that help extract vital information within a speech. The Behavior Score is a unique level determined in the Metrics Range and is made up of words in a sentence classified into parts of speech. Multiple words representing a single part of speech is allowed for each Metrics Range, but one same sentence cannot represent two different parts of speech. The Benefits score rate is a grade allocated for each result defined as a behavior score. The answer from every summation will determine the key benefit score.

Formulae

*The influence is symbolized as $BIF = F(D)$ which is said "f of d" equal to. $Eq = \int(D) \sum_{MR}^{MR^S} \times BS$ MR are related such that for every MR, there is a unique part of the speech of MR. That is, $F(D)$ cannot have more than one value for the same d in MR. MR is up of (*nouns, adjectives, verbs, adverbs, interjections, prepositions, conjunctions, pronouns, determiners, and numerals*). Is made up of (*nouns, adjectives, verbs, adverbs, interjections, numerals, and prepositions*) The said theory used function related in an element d as defined by MR to an influence $F(D)$ to determine the influence behavior score.*

BIF=Behavior oriented drive and influential function

F=push factors of Blockchain

D=Dependent parameters

MR=Metrics Range

MR^S= Metrics Range Substitute

BS=Behavior Score

KBS=key benefits score

$$Eq = \int (D) \sum_{MR}^{MR^S} \times BS$$

<i>Metrics Range</i>	<i>Nouns</i>	<i>Adjectives</i>	<i>Adverbs</i>	<i>Verbs</i>	<i>Prepositions</i>	<i>Pronouns</i>	<i>Conjunctions</i>	<i>Interjections</i>	<i>Determiners</i>	<i>Numerals</i>
<i>Metrics Range Substitute</i>	<i>Nouns</i>	<i>Adjectives</i>	<i>Adverbs</i>	<i>Verbs</i>	<i>Prepositions</i>	<i>Interjections</i>	<i>Numerals</i>			

Table 1. Metric range. Source: Owner

Table 1 above represents elements of the part of speech that the study uses to evaluate the influence of blockchain technology application with a deep learning model using natural language processing. The classification is following the English language standard.

Table 1 above also represents substituted elements of the part of speech that the study uses to evaluate the influence of blockchain technology application with a deep learning model using natural language processing. This selection is based on its close look as compared to others that directly explain human situations, actions, and express feelings. The classification is per the English language standard.

key benefits score grades	Poor	Fair	Good	Very good	Excellent
Behavior Score	1	2	3	4	5

Table 2. Key benefits score rate. Source: Owner

Table 2 represent arrange of selected score that the study uses to measure the level of influence of blockchain on applied deep learning model using natural language processing. The score grade is determined after each summation and data clustering. The answer obtains from the solution after clustering determines each of the score grades above.

Push Factors of Blockchain	Dependent Parameter
Consensus for decision making	Enabling business activities more efficient
	Enabling social reasoning more effective
	Enabling education in a most reliable, inform and accessibility.
Security & Unanimity	Enabling business activities more efficient
	Enabling social reasoning more effective
	Enabling education in a most reliable, inform and accessibility.
Encrypted dataset exchange	Enabling business activities more efficient
	Enabling social reasoning more effective
	Enabling education in a most reliable, inform and accessibility.
Faster data integration & analysis	Enabling business activities more efficient
	Enabling social reasoning more effective
	Enabling education in a most reliable, inform and accessibility.
Faster data acquisition and ease in settlements	Enabling business activities more efficient
	Enabling social reasoning more effective
	Enabling education in a most reliable, inform and accessibility.

Table 3. Behavior oriented drive and influential function of Blockchain on healthcare.
Source: Owner

Table 3 above represents the characteristics of blockchain that push healthcare services and centers willing to accept blockchain technology. According to the study each factor is measured with a specific list of determiners. The determiners are areas of interest on the side of healthcare unites that depend on the characteristics of blockchain refer to in this study as push factors of blockchain.

Determination of Behavior oriented drive and influential function of Blockchain on healthcare

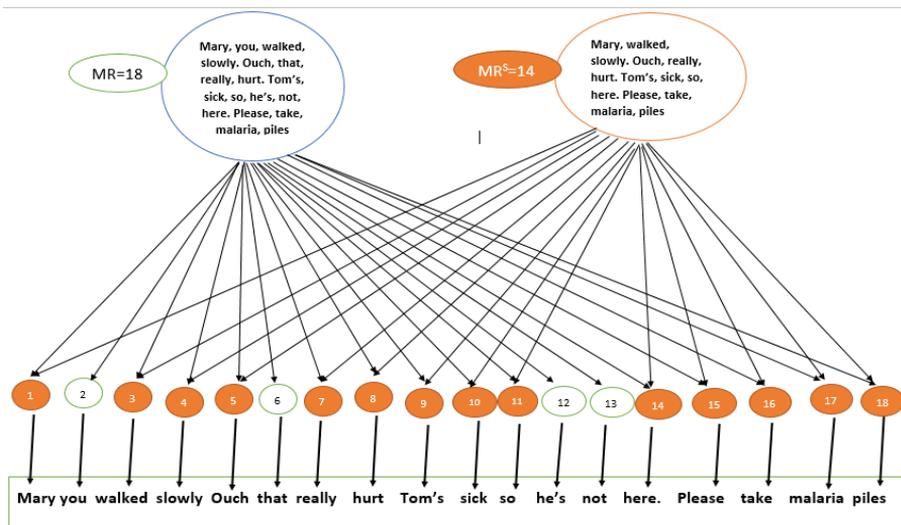


Figure 1. metric range and metric range substitute. Source: Owner

Above figure 1, provide data classified into different groups. The group mark with red is metric range substitute while the whole list both in red and while blocks is metric range. To obtain influence rate, metric range substitute is divided by sum of metric range then multiple by behavior score. The text annotation in red consists of matric range substitute while white consist of metric range. $MR = 18$ and $MR^S = 14$

BIF=Behavior oriented drive and influential function

F=push factors of Blockchain

D=Dependent parameters

MR=Metrics Range

MR^S= Metrics Range Substitute

BS=Behavior Score

KBS=key benefits score

$$Eq = \int(D) \frac{MR^S}{\sum MR} \times BS$$

$$\implies \int(D) = \frac{14}{18} \times 5$$

$$\implies \int(D) = 3.88$$

The statistics above detailed how relevant blockchain technology is to the healthcare. From the statistics we can say that the influence score is grade “Good” as per classification. The

score 3.88 is the influential function determining the need and desire of blockchain technology in this study as determined by the classification according to the author.

4. Method and Discussion

The increased demand for computing power from the business world, pharmacological entities, agricultural industries, and scientific communities to classify huge applications and process huge data is on the rise. One of the biggest challenges in achieving this is the time constraint [37],[38],[39]. Present-day applications take a lot of time to process the available data. Sometimes it goes for days and weeks to provide the much-needed data to reach a decision. The pharmaceutical industry, agricultural industries, educational institutions, and business processes require to be completed at a significantly fastest time scale than before.

The Blockchain distributed ledger for data clustering underlines the need and reason to achieve real-time execution of tasks and overcome the lag caused by the delay in integrating such a technology [40],[41],[42]. Incentivizing resource sharing is one of the centralized model's reasons to adopt Blockchain technology to help keep the information era secure and safe from fraudulent activity and hackers. The need for data security and fast transactions necessitated the coming to life of this article. To better understand how important Blockchain technology is to healthcare, the following figures below explore the areas, methods of implementation, and stages required to achieve Blockchain technology in deep learning models using natural language processing as a source of data.

4.1 Stages of data clustering

Blockchain technology layers focus on what they can do individually and that gives provable large-scale storage with long track records and good accountability and transaction support. The study lays out the following stages to properly develop and adopt Blockchain technology in deep learning models using a natural language processing approach.

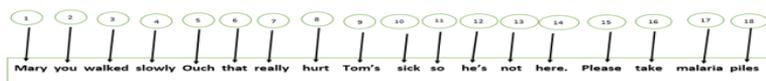


Figure 2a General identification of parts of speech

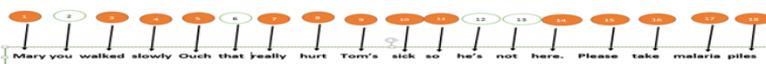


Figure 2b Classification into metric range substitute (MR^S) and metric range (MR)

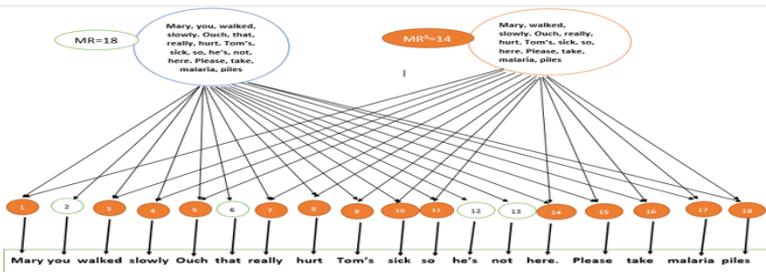


Figure 2c Metric range and Metric range Substitute Data Cluster

Figure 2a represents how data should be first of all identified according to the parts of speech then label according to sentence flow. Figure 2a indicated a sentence made up of 18 words. The 18 words each belong to a part of speech. The following texts are classified following Standard English language parts of speech. The general identifications of parts of speech are according to the author's view and knowledge of the English language. The study however understands that the English language is broad and also different languages have their standard structures.

Figure 2b represents the classification into metric range and metric range substitutes. The metric range according to the study is made up of all the parts of speech. Both the words Mark with red and white are of metric range. Metric range substitutes are selected parts of speech. The author observed that the parts of speech recognize in the study as metric range substitutes are closely related to human aspects of life that can help others easily feel the pain or happiness other people go through Just by observing their text.

Figure 2c represents the metric range and metric range substitutes after classification referred to in this paper data cluster. Figure 2c presents a total of 18 parts of speech in total. The 18 parts of speech. On the other hand, metric range substitutes consist of 14 parts of speech. The total parts of speech allocated to metric range substitutes. Figure 2a, 2b, and 2c present the invention of the modern start of arts in data clustering that follows strict rules of Blockchain technology. Blockchain technology characteristics are very exciting and present a very secure system that is difficult to break through. The author exploited this system and introduced deep learning models.

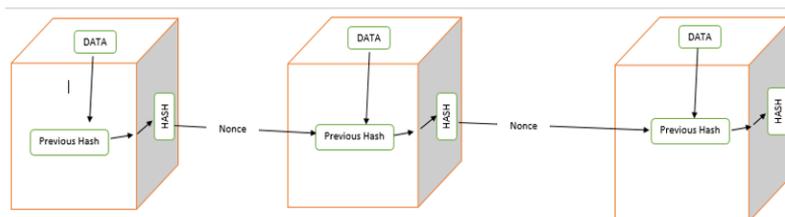


Figure 3a Blockchain technology

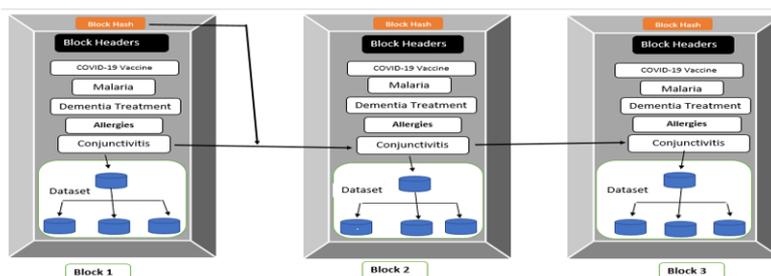


Figure 3b Blockchain technology

Figure 3a presents elements that make up a Blockchain technological system. The elements that make up the Blockchain technology are Data, mining, Data. It is the type of information stored in a Blockchain system. The type of data stored in a block is different based on the

blockchain type and purpose. All data registered in a Blockchain consist of the sender, receiver, and transaction amount. Mining. The systematic process of adding blocks to the blockchain. Hash. A hash is the fingerprint structure of a Blockchain that identifies, records, and stores a unique level of data belonging to a unique user. Whenever a block is created a hash is computed. Whenever something changes within the block, the hash will change as well. That is why hashing helps in detecting changes in a blockchain.

Previous hash. A previous hash block is the first piece in a blockchain. The hash of a preceding block helps in the creation of chains. As a result, chains in a blockchain are extremely secure to trust and use.

Figure 3b presents a Blockchain technology system where information is stored in a Blockchain. The information contained type, sender, receiver, and network. Figure 3b presents a perfect distribution within 3 blocks used block chain named conjunctivitis. The flow within the Blockchain from block 1 through block 2 to block 3, maintains the Blockchain identity called conjunctivitis.

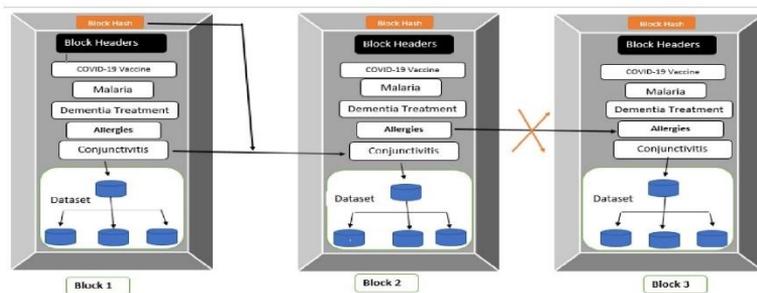


Figure 4a Blockchain technology rules of block change applied in deep learning model of hidden layers

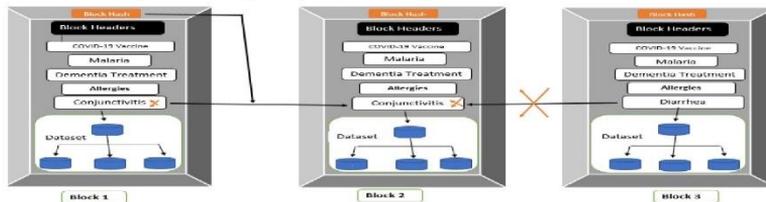


Figure 4b Blockchain technology rule of Data change applied in deep learning model of hidden layers

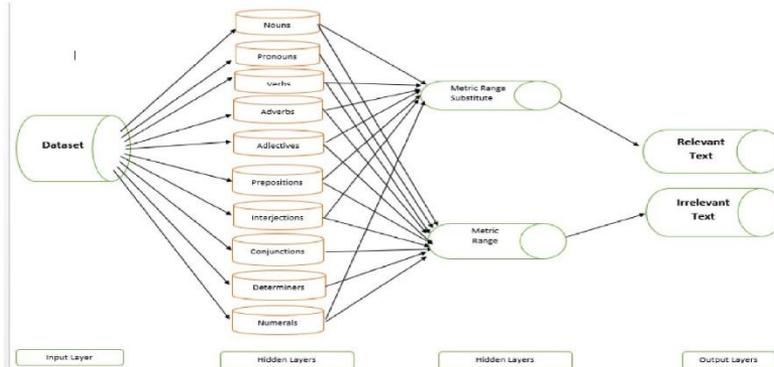


Figure 4c Blockchain technology rule and deep learning model of Recurrent Neural Network Data Classification

Figure 4a Blockchain technology rules of block change applies in deep learning models of hidden layers. Figure 4a explains that blockchain is a system that provides a powerful method of storing data in such a way that it is difficult and impossible to edit, hack, or trick the system. Blockchain system technology is essential for modern-day digital ledgers for transactions that can be copied and distributed across the blockchain's wide network of computer systems. Figure 4a presents a Blockchain where data is distributed to three blocks. From block 1 to block 2, the data was very fine until in block 3 when the direction of information changed. From figure 4a we can see a rejection that shows a well-defined system that can't be tampered with.

Figure 4b presents a similar situation where data has been changed in one of the blocks. From block 1 to block 2 and a reverse action is observed in block 3 as data is altered. Figure 4a presents a situation where the network line changes in block 3 and the whole system was disrupted. From block 1 Nonce was in conjunctivitis to block 2 and in block 3 it changes to allergies and the system Blockchain technology was rejected.

Figure 4b, if any further action is needed there must be changes made in block 1 and block 2 to reflect the changes in block 3. Figure 4b shows a change of data name conjunctivitis in block 3 to diarrhea. To ensure a smooth system flow, changes are required to start from block 1 through block 2 to reflect the changes in block 3.

Figure 4c presents Blockchain technology rules application in the deep learning model of recurrent neural networks data classification. Figure 4c presents the input layer, hidden layers, and output layer skeleton of a deep learning model that will classify data strictly based on 10 parts of speech. The 10 parts of speech are divided into metric range and metric range substitutes.

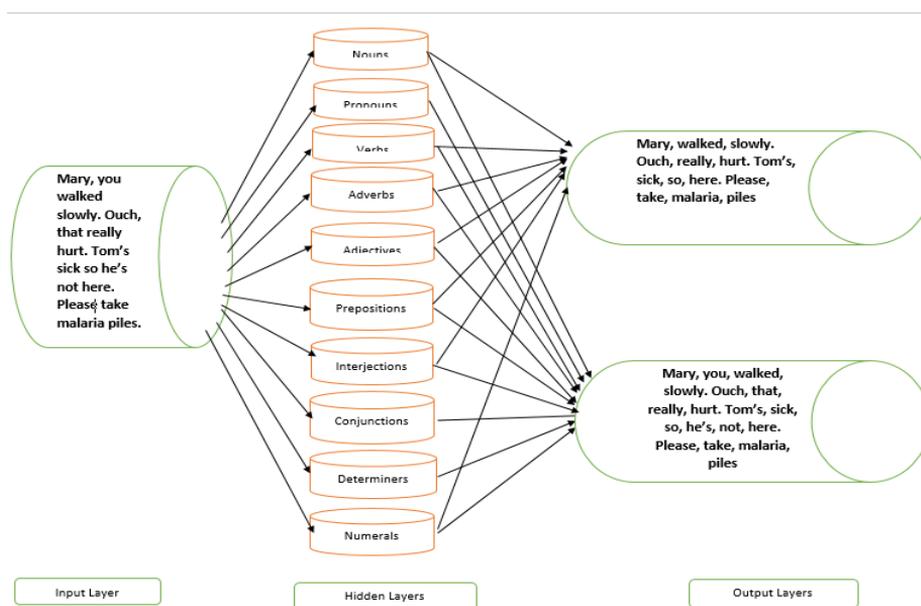


Figure 5 metric range and metric range substitutes adopted Blockchain into recurrent neural networks data classification. The figure is based on the principle of immutable and

distributed fundamentals of blockchain technology properties. The principles of the immutability of the ledger mean you can always trust it to be accurate. Once distributed protects the blockchain from the network. The modern virtual documentary system requires a system of Blockchain technology for a secure free environment. Figure 5 indicates that the transactions recorded on the Blockchain ledger are stored in a block. The information contained in a block of a Blockchain is dependent on a link to the information in a previous block and over some time forms a chain of transactions. Unlike spoken words, they depend on various parts of speech. There's no way a text can be out of the scope of language structure. If such a situation occurred, then a new dictionary of the English language is required.

The use of a peer-to-peer distributed network by Blockchain system directly reflects a neural networks system used in deep learning models [34],[35],[36]. The use of neural networks in deep learning models ensures the decentralized nature of the technology, unlike Blockchain systems technology. We all know that every device that connects to the network is considered a node. In Blockchain technology there exist nodes unlike in deep learning models. The difference is that in the deep learning model nodes represent the human brain while in Blockchain nodes represent data network systems. That is why this study exploited the advantage to introduce text data clustering to ensure smooth data acquisition and retention for decision making.

5. Conclusion

Blockchain technology is a secure digital platform that will enable the creation, sharing, and storing of innovative solutions for various datasets within sectors including healthcare. Blockchain technology will be used in the healthcare sector to securely manage and exchange laboratory diagnoses. Advance developments in technology have pushed health sectors into remote care and management systems is indeed a positive push for the modern society. Three deep leaning models show excellent integration with blockchain technology. The best fit deep learning model that matches blockchain technology according to the study is recurrent neural network model of deep learning.

To safeguard the much-needed issues related to data access and safekeeping, we need to apply blockchain technology in healthcare. Security concerns about data safety for transactions in healthcare system are much safer with blockchain technology. Blockchain system architects has the potential to improve and advanced security in healthcare through remote patient monitoring using system automated delivery with encrypted end-to-end data exchange. The art of clustering introduce in this study indicates that healthcare sectors can do better and delivery fast results ever to patients. Blockchain technology is not just fast but it very secure.

Declaration Conflict of Interest

We certify that we have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials

discussed in this manuscript. We have no financial or proprietary interests in any material discussed in this article.

Declaration of material used

All data underlying the results are available as part of the article and no additional source data are required or reserved somewhere.

References

- [1]. Griggs, K. N., Ossipova, O., Kohlios, C. P., Baccharini, A. N., Howson, E. A., & Hayajneh, T. (2018). Healthcare blockchain system using smart contracts for secure automated remote patient monitoring. *Journal of medical systems*, 42(7), 1-7.
- [2]. Novikov, S. P., Kazakov, O. D., Kulagina, N. A., & Azarenko, N. Y. (2018, September). Blockchain and smart contracts in a decentralized health infrastructure. In *2018 IEEE International Conference "Quality Management, Transport and Information Security, Information Technologies"(IT&QM&IS)* (pp. 697-703). IEEE.
- [3]. Amir Latif, R. M., Hussain, K., Jhanjhi, N. Z., Nayyar, A., & Rizwan, O. (2020). A remix IDE: smart contract-based framework for the healthcare sector by using Blockchain technology. *Multimedia tools and applications*, 1-24.
- [4]. Vyas, J. D., Han, M., Li, L., Pouriye, S., & He, J. S. (2020, April). Integrating blockchain technology into healthcare. In *Proceedings of the 2020 ACM Southeast Conference* (pp. 197-203).
- [5]. Khatoon, A. (2020). A blockchain-based smart contract system for healthcare management. *Electronics*, 9(1), 94.
- [6]. Sharma, A., Tomar, R., Chilamkurti, N., & Kim, B. G. (2020). Blockchain based smart contracts for internet of medical things in e-healthcare. *Electronics*, 9(10), 1609.
- [7]. Fiaidhi, J., Mohammed, S., & Mohammed, S. (2018). EDI with blockchain as an enabler for extreme automation. *IT Professional*, 20(4), 66-72.
- [8]. Hu, Y., Liyanage, M., Mansoor, A., Thilakarathna, K., Jourjon, G., & Seneviratne, A. (2018). Blockchain-based smart contracts-applications and challenges. *arXiv preprint arXiv:1810.04699*.
- [9]. Kang, Y., Cai, Z., Tan, C. W., Huang, Q., & Liu, H. (2020). Natural language processing (NLP) in management research: A literature review. *Journal of Management Analytics*, 7(2), 139-172.
- [10]. Nadkarni, P. M., Ohno-Machado, L., & Chapman, W. W. (2011). Natural language processing: an introduction. *Journal of the American Medical Informatics Association*, 18(5), 544-551.

- [11]. Liddy, E. D. (2001). Natural language processing.
- [12]. Chowdhary, K. (2020). Natural language processing. *Fundamentals of artificial intelligence*, 603-649.
- [13]. Dorafshan, S., & Azari, H. (2020). Deep learning models for bridge deck evaluation using impact echo. *Construction and Building Materials*, 263, 120109.
- [14]. Sedik, A., Ilyasu, A. M., El-Rahiem, A., Abdel Samea, M. E., Abdel-Raheem, A., Hammad, M., ... & Ahmed, A. (2020). Deploying machine and deep learning models for efficient data-augmented detection of COVID-19 infections. *Viruses*, 12(7), 769.
- [15]. Yang, C., Wang, Y., Lan, S., Wang, L., Shen, W., & Huang, G. Q. (2022). Cloud-edge-device collaboration mechanisms of deep learning models for smart robots in mass personalization. *Robotics and Computer-Integrated Manufacturing*, 77, 102351.
- [16]. Chang, J., Lee, J., Ha, A., Han, Y. S., Bak, E., Choi, S., ... & Park, S. M. (2021). Explaining the rationale of deep learning glaucoma decisions with adversarial examples. *Ophthalmology*, 128(1), 78-88.
- [17]. Bali, S., Bali, V., Mohanty, R. P., & Gaur, D. (2022). Analysis of critical success factors for blockchain technology implementation in healthcare sector. *Benchmarking: An International Journal*, (ahead-of-print).
- [18]. Khosla, A., Vashist, S., & Nijhawan, G. (2022). Blockchain Technology in Healthcare. In *Blockchain, Artificial Intelligence, and the Internet of Things* (pp. 163-185). Springer, Cham.
- [19]. Sunny, F. A., Hajek, P., Munk, M., Abedin, M. Z., Satu, M. S., Efat, M. I. A., & Islam, M. J. (2022). A Systematic Review of Blockchain Applications. *IEEE Access*.
- [20]. Varkaris, E., & Neuhofer, B. (2017). The influence of social media on the consumers' hotel decision journey. *Journal of Hospitality and Tourism Technology*.
- [21]. Ramanathan, U., Subramanian, N., & Parrott, G. (2017). Role of social media in retail network operations and marketing to enhance customer satisfaction. *International Journal of Operations & Production Management*.
- [22]. Unni, M. V. (2020). Does digital and social media marketing play a major role in consumer behaviour. *International Journal of Research in Engineering, Science and Management*, 3(4), 272-278.
- [23]. Santana, M. J., Manalili, K., Jolley, R. J., Zelinsky, S., Quan, H., & Lu, M. (2018). How to practice person-centred care: A conceptual framework. *Health Expectations*, 21(2), 429-440.
- [24]. Al-Saqaf, W., & Seidler, N. (2017). Blockchain technology for social impact: opportunities and challenges ahead. *Journal of Cyber Policy*, 2(3), 338-354.
- [25]. Correa, T. (2016). Acquiring a new technology at home: A parent-child study about youths' influence on digital media adoption in a family. *Journal of Broadcasting & Electronic Media*, 60(1), 123-139.

- [26]. Liao, D. Y., & Wang, X. (2018, November). Applications of blockchain technology to logistics management in integrated casinos and entertainment. In *Informatics* (Vol. 5, No. 4, p. 44). MDPI.
- [27]. Chou, H. C. (2021, August). A Blockchain-based Framework Proposal for Online Entertainment Ecosystem. In *2021 IEEE Region 10 Symposium (TENSymp)* (pp. 1-5). IEEE.
- [28]. Xu, B., Agbele, T., & Jiang, R. (2020). Biometric blockchain: a secure solution for intelligent vehicle data sharing. In *Deep Biometrics* (pp. 245-256). Springer, Cham.
- [29]. Wang, S., Xiao, P., Chai, H., Tu, X., Sun, Q., Cai, H., & Wang, F. Y. (2021, October). Framework of the Tourism Comprehensive Service Platform Based on Blockchain Technology. In *2021 China Automation Congress (CAC)* (pp. 2433-2436). IEEE.
- [30]. Benz, D., Hamzah, M., Ghazali, M. F., & Asli, M. F. (2021, April). Bringing Blockchain Technology in Innovating Industries: A Systematic Review. In *International Conference on Emerging Technologies and Intelligent Systems* (pp. 391-416). Springer, Cham.
- [31]. Ferrara, E. (2015). "Manipulation and abuse on social media" by Emilio Ferrara with Ching-man Au Yeung as coordinator. *ACM SIGWEB Newsletter*, (Spring), 1-9.
- [32]. Naeem, M. (2021). Do social media platforms develop consumer panic buying during the fear of Covid-19 pandemic. *Journal of Retailing and Consumer Services*, 58, 102226.
- [33]. ZHANG, Y., LI, S., & YU, G. (2021). The relationship between social media use and fear of missing out: A meta-analysis. *Acta Psychologica Sinica*, 53(3), 273.
- [34]. Angrish, A., Craver, B., Hasan, M., & Starly, B. (2018). A case study for Blockchain in manufacturing: "FabRec": A prototype for peer-to-peer network of manufacturing nodes. *Procedia Manufacturing*, 26, 1180-1192.
- [35]. Shi, M., Hoffmann, A., Wagner, A., Huyeng, T., Thiele, C. D., & Ruppel, U. (2020, August). Using blockchain technology to implement Peer-to-Peer network in construction industry. In *International Conference on Computing in Civil and Building Engineering* (pp. 839-849). Springer, Cham.
- [36]. Stoykov, L., Zhang, K., & Jacobsen, H. A. (2017, December). Vibes: fast blockchain simulations for large-scale peer-to-peer networks. In *Proceedings of the 18th ACM/IFIP/USENIX Middleware Conference: Posters and Demos* (pp. 19-20).
- [37]. Iakushkin, O., Malevanniy, D., Sedova, O., Degtyarev, A., & Korkhov, V. (2019). Exploring applications and opportunities of remote virtual supercomputer. In *27th Symposium on Nuclear Electronics and Computing, NEC 2019* (pp. 326-330).
- [38]. Al-Mamun, A., Li, T., Sadoghi, M., Jiang, L., Shen, H., & Zhao, D. (2019, November). Hpchain: An mpi-based blockchain framework for data fidelity in high-performance computing systems. In *Proceedings of the International*

Conference for High Performance Computing, Networking, Storage and Analysis (SC'19), Denver, CO, USA (pp. 17-19).

- [39]. Vangipuram, S. L., Mohanty, S. P., & Kougianos, E. (2021). CoviChain: a blockchain based framework for nonrepudiable contact tracing in healthcare cyber-physical systems during pandemic outbreaks. *SN Computer Science*, 2(5), 1-16.
- [40]. Nguyen, D. C., Ding, M., Pham, Q. V., Pathirana, P. N., Le, L. B., Seneviratne, A., ... & Poor, H. V. (2021). Federated learning meets blockchain in edge computing: Opportunities and challenges. *IEEE Internet of Things Journal*, 8(16), 12806-12825.
- [41]. Gadekallu, T. R., Pham, Q. V., Nguyen, D. C., Maddikunta, P. K. R., Deepa, N., Prabadevi, B., ... & Hwang, W. J. (2021). Blockchain for edge of things: applications, opportunities, and challenges. *IEEE Internet of Things Journal*, 9(2), 964-988.
- [42]. Zhaofeng, M., Xiaochang, W., Jain, D. K., Khan, H., Hongmin, G., & Zhen, W. (2019). A blockchain-based trusted data management scheme in edge computing. *IEEE Transactions on Industrial Informatics*, 16(3), 2013-2021.
- [43]. Jia, D., Xin, J., Wang, Z., Guo, W., & Wang, G. (2018, July). ElasticChain: Support very large blockchain by reducing data redundancy. In *Asia-Pacific Web (APWeb) and Web-Age Information Management (WAIM) Joint International Conference on Web and Big Data* (pp. 440-454). Springer, Cham.
- [44]. Li, G., He, B., Wang, Z., Cheng, X., & Chen, J. (2021). Blockchain-enhanced spatiotemporal data aggregation for UAV-assisted wireless sensor networks. *IEEE Transactions on Industrial Informatics*, 18(7), 4520-4530.
- [45]. Ren, W., Wan, X., & Gan, P. (2021). A double-blockchain solution for agricultural sampled data security in Internet of Things network. *Future Generation Computer Systems*, 117, 453-461.
- [46]. Biesner, D., Ramamurthy, R., Stenzel, R., Lübbering, M., Hillebrand, L., Ladi, A., ... & Sifa, R. (2022). Anonymization of German financial documents using neural network-based language models with contextual word representations. *International Journal of Data Science and Analytics*, 13(2), 151-161.
- [47]. Borkowski, L., Sorini, C., & Chattopadhyay, A. (2022). Recurrent neural network-based multiaxial plasticity model with regularization for physics-informed constraints. *Computers & Structures*, 258, 106678.
- [48]. Priyadarshi, A., & Saha, S. K. (2022). A study on the performance of Recurrent Neural Network based models in Maithili Part of Speech Tagging. *Transactions on Asian and Low-Resource Language Information Processing*.
- [49]. Van Gerven, M., & Bohte, S. (2017). Artificial neural networks as models of neural information processing. *Frontiers in Computational Neuroscience*, 11, 114.
- [50]. Jia, W., Gao, J., Xia, W., Zhao, Y., Min, H., & Lu, J. T. (2021). A performance evaluation of classic convolutional neural networks for 2D and 3D palmprint and

palm vein recognition. *International Journal of Automation and Computing*, 18(1), 18-44.

- [51]. Guegan, D. (2017). Public blockchain versus private blockchain.
- [52]. Benhamouda, F., Gentry, C., Gorbunov, S., Halevi, S., Krawczyk, H., Lin, C., ... & Reyzin, L. (2020, November). Can a public blockchain keep a secret? in *Theory of Cryptography Conference* (pp. 260-290). Springer, Cham.
- [53]. Yang, R., Wakefield, R., Lyu, S., Jayasuriya, S., Han, F., Yi, X., ... & Chen, S. (2020). Public and private blockchain in construction business process and information integration. *Automation in construction*, 118, 103276.
- [54]. Pahlajani, S., Kshirsagar, A., & Pachghare, V. (2019, April). Survey on private blockchain consensus algorithms. In *2019 1st International Conference on Innovations in Information and Communication Technology (ICIICT)* (pp. 1-6). IEEE.

BLENDING REMOTE/HYBRID WORK AND HYBRID ACADEMIC EDUCATION

Alexandra MĂRGINEAN¹

Abstract

This study is trying to metaphorically get the pulse of a segment of senior students who are involved in either a remote or hybrid work scenario, as far as, first, the perception of the two employment models among members of the young generation who are also computer-literate, then, to get a feel of which model they would choose for academic education, and, last but not least, to see what scenario is considered to be the best when one tries to blend the roles of a student and an employee simultaneously. For this, a set of seven questions has been drawn up, both choice and open-ended. The paper has been structured into three middle sections, besides the Introduction and the Conclusions, which focus on: fears and their remedies related to remote and hybrid work; the combination of hybrid work and hybrid education; the prospects for hybridity in both education and one's professional life. Twenty third-year, computer science students have been solicited to provide answers, on the logic that they have the understanding of all the "experimental" times that we have gone through: of pandemic online exclusiveness, being back in face-to-face encounters, and then plunged into a hybrid model.

Keywords: remote/hybrid work, remote/hybrid education, young adults, survey

JEL Classification: H5, Z10

1. Introduction

The pandemic times have opened our eyes to a new reality of off-site work, which has triggered a new set of rearrangements and rethinking of various aspects of our existences, in terms of how we prioritize our personal and professional lives, time management, renegotiation of boundaries of all kinds and of work arrangements.

Initially, this situation involved a decentralized approach to locations and space, towards where one could actually be while unfolding his/her professional duties, challenging the very idea of co-presence, which was somehow ingrained and at the very core of what we conceived to be the performance of our tasks and of doing our jobs. Linguistically and conceptually, the notions of "going to work" or "workplace" needed rethinking, as there was no longer a particular site or space or place where one had to be in order to carry out one's responsibilities. The concept of space as associated intrinsically with a particular job simply disappeared, which came along with a certain amount of bafflement for every person.

After having learned how to cope, or get better at using technology, and adapting lifestyles to the new reality, the pandemic was over – or was it? – and novel readjustments needed to

¹ Associate Professor, Romanian-American University, alexandra.roxana.marginean@rau.ro

be made. People craved socializing again, talked about it, looked forward to it and enjoyed it when they were able to interact normally and achieve the lost co-presence again. However, some of the sometimes painfully acquired readjustments left a toll or put their imprint on our awareness, which, along with the ongoing problems related to a virus that keeps producing new variants and seems not quite extinguished yet, have determined people to look for an in-between, a middle way of approaching their work life. Human nature decided that it was perhaps better to have the best of both worlds, and people found themselves craving to preserve in their current realities some of the flexibility that they have come to miss since back in the pandemic and remote work times. Hence, the concept of remote work has emerged and is still being forged in our minds as of recently.

This paper sets out to analyze the realities of remote work and hybrid work, as they are perceived among students who also have to handle their academic education simultaneously with being employed in one of these two forms or arrangements. In comparing remote and hybrid work, we are looking at some differences in their perception by young adults/students, trying to ascertain aspects related to fears and remedies to those fears inspired by these two models of employment. We are further inspecting the meaning of hybrid work, which is taking various shapes and sizes in our minds these days. Then, last but not least, we mean to throw a glance at students' expectations for the future in terms of getting involved in hybrid work (and study) arrangements.

We are using a quantitative and qualitative analysis and are preponderantly interested in the impressions left by the proposed forms of interaction, as most of the reactions and thoughts related to how one should cope with them are subjective, whether we realize it or not, which shall be made evident in what we discuss. In other words, the way we assess both contexts is a matter of perception, is about what we choose to focus on and how we choose to interpret them, of positive thinking and approach more than about definite, factual factors. In the age of advanced technology, and once technological aspects are solved and put aside, the psychology of the individual is what stays decisive in the way in which (s)he is prepared to deal with a particular context, and the aspect individuals need to mostly work upon at all levels, be they management or subordinate. It is not necessarily about what can or cannot be done concretely, as these are matters that can be solved at some point, but about being comfortable, trusting and at ease in a certain environment, about learning how to become metaphorically "equipped" on the inside in order to be able to do that. It is related to "which thinking patterns, behavior patterns, and emotions are appropriate for a given role" [1].

2. Remote and hybrid work – fears and remedies

2.1 Prep phase and focus group

I have selected for the study a number of twenty third-year computer science students as respondents to the questions. I wanted to have the same age segment, of more mature students who have already been through the pandemic in an online education system, being accustomed to its specificity, but have also experienced the comeback times, of return to face-to-face academic activity.

The focus group consisted of ten students who are employed in a remote work system and ten who are employed in a hybrid work arrangement, for the sake of comparing notes and

answers given from within the respective situation. All twenty students are part of a full-time studies program, thus struggling to attend courses and seminars simultaneously with fulfilling the duties for their job in the respective form of employment. Besides having adjusted to the requirements of their job, they have to also accommodate the newly found form of hybrid education, which in our case, at the Romanian-American University, entails carrying out a part of the semestrial activity online, the equivalent of thirty percent, i.e. a few courses and seminars, while attending the rest, including tests and final examinations, face-to-face.

Conducting the research among representatives of the young generation eliminates, to a reasonable extent, the problem of handling technology, i.e. of being literate, astute or even proficient in this area. The interviewees do not display issues related to fear of being able to cope with technology, as they are young (i.e. proverbially more flexible and adroit in this sphere), as well as, moreover, students of computer science, which minimizes the impact of stress brought about by using technology down to almost null, hence making their answers, from a psychological point of view and given the absence of this pressure factor that might have induced additional fear reverberating on their perception of the situation, all the more relevant. It is worth mentioning, however, that a certain effort of dealing with new technology has to be made by them as well, as adjustment to certain platforms, software, applications, customized intranet and workflow was required from their part, but we may consider that the effort was less significant or came in handy, coming from overall technology-literate young people.

2.2 Fears

The respondents had to pick one of the four possible answers to Question 1, “What is your greatest fear among the ones enumerated below, related to the system of employment you are part of (remote or hybrid work)?”. The options provided were:

- a) loneliness and missing socializing
- b) the integration of the corporate culture and identification of colleagues (putting a face to a name or avatar)
- c) being visible to the management, being acknowledged
- d) coping with new technology (applications, platforms etc.)

Statistics rank the loneliness and isolation factor as taking precedence over others in the area of distancing oneself from the office on-site interactions. Loneliness is picked up as the greatest struggle by twenty percent of the respondents of a poll conducted by Insights Manager Erin Eatough, next to collaboration and communication (holding an equal percentage), which goes to show how significant this factor is [2]. Buffer's 2019 annual report on the State of Remote Work ranks loneliness the second most significant struggle, holding nineteen percent of the first choices, right after “unplugging after work”'s 22% [3]. In the updated, 2022 version of the same statistics, in which respondents could choose all those that apply from a preset of options, loneliness still appears in the top, with twenty-four percent allotted to it, after the same inability to unplug holding twenty-five percent, so very close, while thirty-one percent of the interviewed stated that they no longer have any struggles [4]. Most of Kojic's nineteen members of the focus group she has conducted her

study on, consisting of CEOs, freelancers, marketing specialists or entrepreneurs, refer to loneliness and isolation as among their most significant problems in working remotely (in an enumeration of two or three each), either directly, using these specific terms, or indirectly, by mentioning improper routines, lack of or poor communication and coordination, less excitement or absent inclusiveness [5].

Corporate culture is a relevant aspect in many articles written on work that is trying to encompass distance from the workplace in various forms. Martine Haas signals the need for remote workers to understand the “company’s norms, values, and expectations” at the same level and quality as people working on-site, within a hybrid work scenario, and to “integrate them into the company’s culture” [6].

Below, there is a table that synthesizes the answers given by the two sets of students and the number of students that have chosen each answer.

REMOTE WORK EMPLOYEES	HYBRID WORK EMPLOYEES
integration of the corporate culture and peer identification (4)	loneliness and missing socializing (4)
loneliness and missing socializing (3)	visibility to management and being acknowledged (3)
coping with new technology (2)	integration of the corporate culture and peer identification (2)
visibility to management and being acknowledged (1)	coping with new technology (1)

Table 1. Answers to Question 1 – What is your greatest fear among the ones enumerated below, related to the system of employment you are part of (remote or hybrid work)?

I have decided on the formulation of the options provided for Question 1 subsequent to the consultation of the relevant literature that I have read on the challenges posed by remote and hybrid work, detaching the most relevant and frequent occurrences. Also, every one of the four answers is paired with a certain aspect/need that I consider the answer to represent, as follows. The ideas of socializing and avoidance of loneliness send to the satisfaction of an emotional need, symbolizing an *emotive* component. Getting acquainted with one’s colleagues, knowing enough things about them to be able to draw a more or less satisfactory picture as far as their unique personalities and ways of interaction, which are detailed enough to separate them from a crowd in one’s mind and make their uniqueness known, along with knowing and comprehending thoroughly the mission, objectives and identity of the company as a whole satisfy a need that we shall call *cognitive* in the specific environment of the company or workplace. Being acknowledged by, and visible to the management, being respected and valued and detaching oneself as an individuality from the others in the eyes of those representing the superior hierarchical levels have to do with one’s *prospects for reward*, promotions and not missing out on other opportunities and bonuses made available in the work environment. Not making one’s contributions known may entail, at the opposite pole, potential material and face loss disadvantages. It ultimately means not obtaining maximum yield or benefits from a situation, not capitalizing on

maximum potential gain. Finally, having enough *know-how* to handle technology is a practical need and at the same time a *sine qua non* condition to be able to carry out one's activity. What needs to be stipulated in connection with these pairings is that any given answer from the four may contain a plurality of ingredient-aspects: a feeling component, a practical one, as well as identity and building image-of-self needs etc., i.e., at some point, the lines as to the type of sphere that each of these choices reflects become blurred, as any given option reunites more types of needs. However, I have tried to detach what I have considered to be the most relevant, weighty or primary need fulfilled by the actions mentioned in the option in each case. The second table shows the way in which these needs have been prioritized by the two categories of students-employees.

REMOTE WORK EMPLOYEES	HYBRID WORK EMPLOYEES
<i>cognitive</i> (4)	<i>emotive</i> (4)
<i>emotive</i> (3)	<i>prospects for reward</i> (4)
<i>(technological) know-how</i> (2)	<i>cognitive</i> (2)
<i>prospects for reward</i> (1)	<i>(technological) know-how</i> (0)

Table 2. Prioritizing of needs among remote and hybrid student-employees

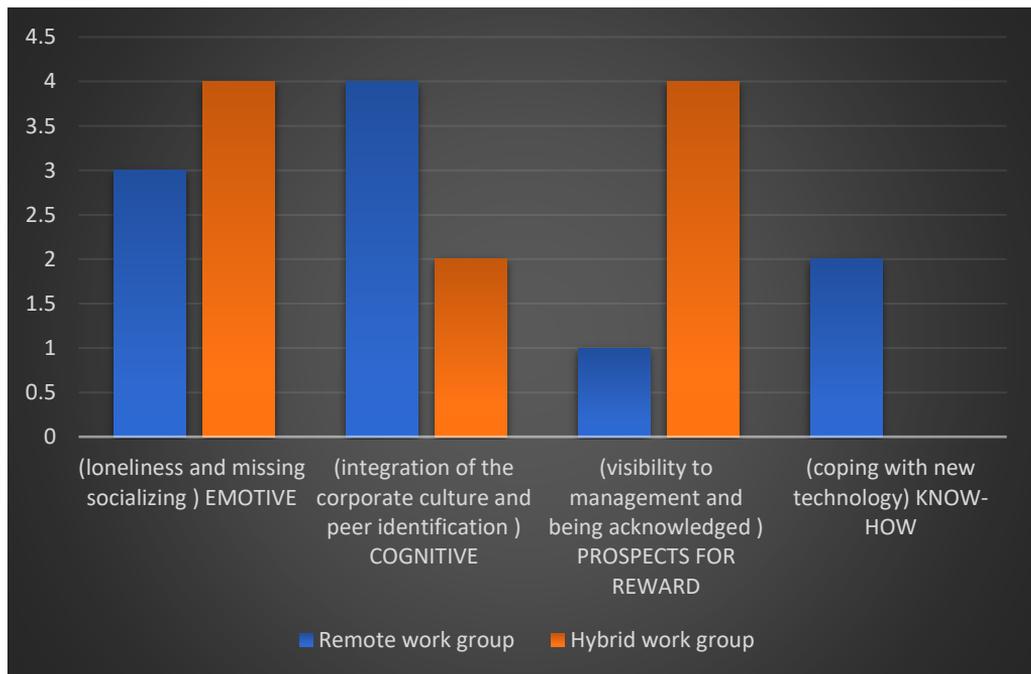


Chart 1. Question 1 – What is your greatest fear among the ones enumerated below, related to the system of employment you are part of (remote or hybrid work)?

There are some observations that we can make based on the information in the tables and chart above. To start with, the insecurities related to manipulating technology and being in

the know in this respect, keeping up with the times, surprisingly still represent an issue, even though we are dealing with students in IT and we are far from the incipient stages of the pandemic, when this reality hit hard a lot of people. This happens in the remote work scenario, where the employees have no direct access to the headquarters, at least not as part of an official, structured timetable. The issue is no longer present in hybrid work contexts, where intermittent access to on-site people and equipment should presumably put employees at ease completely, a theory that is actually proven by the data. This shows that pandemic online exclusiveness has managed to at least give people enhanced technological know-how, helping them learn more about technology and improving their computer operation skills.

Students interviewed in the remote work employees subgroup had not known their colleagues previous to the hiring, having, from the very beginning, from their day one of work, made their entrance in the company directly into this scheme of remote interaction. This is the reason why familiarization with the company in terms of corporate culture and identity as well as co-worker identity is ranked first. The main worry for remote work staff is cognitive. What we may further explain here is that informal discussions, chance or side comments, or details from the changing scenery and individuals' interaction with it help familiarization with peers and corporate identity much better and quicker than formal introductions or video meetings that represent constraining contexts by their nature, in which people do not express themselves fully freely. Someone's particularities, personality traits and individuality may be caught much more rapidly and significantly from less controlled, less regulated and more relaxed interactions. We can also add the huge weight borne by the *unmediated* access to the non-verbal component which exists in hybrid environments, as opposed to remote ones.

Probably the most obviously predominant element, the one that holds the most weight and highest relevance in work environments that contain a remote feature is the emotive one. In both subgroups, it occupies either the second or, respectively, the first position among the answers; in the first subgroup, the equivalent of thirty percent of respondents chose it, and, in the second, forty percent, i.e. if we consider the respondents' answers together, the first percentage among the four options, i.e. thirty-five percent goes to this emotive ingredient, transforming it into the most relevant fear-need for both work scenarios that involve distancing. We have a chart below with the percentages by answers of the two subgroups reunited.

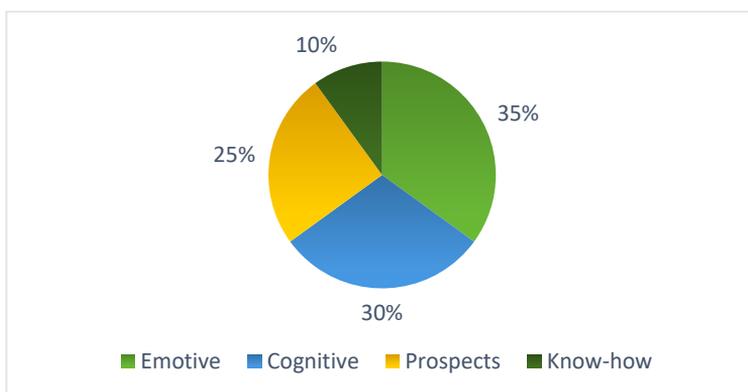


Chart 2. Ranking of the four fears/needs as per the twenty respondents

The students were asked to list some possible remedies to eliminate or help with their fears. This qualitative part of the study, therefore, consisted of an open-ended question, requiring their input in enumerating solutions and motivating their choices, explaining exactly how these are meant to diminish the negative impact of the fears above.

When referring to the manner in which the actual work activity unfolds, video time was mentioned among the preferred method of interaction in meetings, as opposed to merely audio input from the peers and managers. The reasons given were the following. One was a better control of who provides input and how often, and thus avoiding both stealing the spotlight and inability to break in the more vocal colleagues' conversations, so a more balanced discussion from the point of view of participation of all those engaged in it overall. Somehow, once the people can actually be viewed on a screen rather than present as names in a list, this increases their visibility. Then, visual access to the others during the presentation of input helps with aspects like getting the feeling that one is being listened to, understood and integrated. A lot of this feeling is thanks to the presence of the non-verbal component of communication, which is overwhelmingly important (as theory portends). What is specifically gained through it occurs due to regulators – the nods and micro expressions that regulate the taking of turns in exchanges – and the ability, by following the facial expressions, to get a kind of immediate feedback for what one puts forth. The downside would be that image quality and potential lags diminish the accuracy of this feedback, as well as the above-mentioned aspect of the non-verbal being somehow also constrained by the formality of the context, whereas non-verbal communication in physical co-presence is much richer and allows for more forms of expression.

As far as side activities are concerned, all the respondents enumerate attending company-organized events such as team buildings, outings, parties, going out for food and drinks, and thematic gatherings. A marked preference is expressed for these events bearing a specific topic, distinctive feature, a unique trait. A desirable characteristic of these specific get-togethers would be the element of surprise, for them to be unexpected – both in terms of timing/scheduling and content – and preferably humorous. The expressed predilection for these forms of congregating rather than the regular restaurant reunions is overwhelming. The reason provided is that they are much funnier and fun than the latter, neutral category, and thus manage to break routine better, bring excitement in the attendants' lives and illustrate character of participants better, helping with the manifestation of, and familiarization with peer identities.

3. Hybrid work and hybrid education

This part of the study blends questions that require subjective, creative answers with choice ones. The students were asked to define hybrid work, by answering the open-ended Question 3, "What is hybrid work?" I wanted to check the perception of this concept, given the amount of confusion signaled in literature that deals with, first and foremost, what it means, which seems to be yet unclear, let alone the way it is configured and implemented. In other words, based on the opinions expressed by the focus group, we may conclude indeed that "What exactly hybrid work will look like for each organization is just beginning to take shape" [7].

Let us look at what we mean by unclear ideas of hybrid work among the interviewed students. Most of them perceive the notion of hybrid work as entailing a work arrangement that presupposes on-site time combined with remote work. The ten students in the second subgroup were all able to provide definitions along this line. By contrast, students in the exclusively remote work subgroup were more confused as to what a hybrid environment would mean. They mentioned as potential features of this hybrid structure not necessarily the alternation of time chunks or days inside and outside of the office or company location for the same employee, but also other scenarios. For instance, there was the notion of flexible work hours in terms of daily variations of the beginning and end-time of the work day, i.e. an employee could start the workday at eight o'clock and leave at four or start at twelve or even one o'clock in the afternoon and leave at eight or, respectively, nine o'clock at night, and that these variations can be made of one's own accord, during the same week, without previous notice to the manager; this basically meant a flexible schedule for a certain individual that needs not be agreed upon in advance and could vary from one day to another, depending on one's mood. Other students defined hybrid structure as a part of the company employees being completely remote, while others are always in, which is also actually the case when an employee joined in the pandemic time and works exclusively remotely, being the "newbie", while others have the experience of office time together from before the changes brought about by the virus occurred [8].

If defining hybrid work seems easier to the subgroup of students who are employed in this work model, whose answers are consistent with the basic feature assigned to this concept, both subgroups of students were having difficulty agreeing on what hybrid work conditions should actually look like concretely and specifically, and who holds the right to define them. Some say that the management is supposed or expected to come up with the structure, and the employee has a passive role, being at liberty to accept or pass on the job, while others see it as a process of negotiation between parties, and, what is more, as an ongoing bargain, being not only fully personalized, but subject to renegotiation even subsequent to the hiring. This more collaborative and fluid approach is embraced by more than three quarters of the respondents. Most of them agree that hybrid work should not mean that the company has certain time intervals – weeks and even months of alternation between work from the office and remote work – set in stone from the beginning for all employees, but that the alternations should be personalized and negotiated with every individual. Some statistics show this tendency favoring more autonomy, to even reach full autonomy in deciding the hybrid work scenario; a survey of "more than 140,000 U.S. employees" showed that "About four in 10 employees say they want full autonomy to come and go as they wish, and six in 10 want more structure", with the mention that the six nevertheless "don't agree on 'how' to coordinate" [9]. The students' answers also reflect this trend towards an extreme variability. What we may conclude based on this is that the fluidity that this concept of hybridity may reach in the future is maximum, and miles away from the early attempts that we are experiencing with these days.

As far as their studies are concerned, for the time being students seem pleased with the scenario of one third of the studies being online. They welcome this flexibility for their studies. To Question 4, "Do you feel that the hybrid education scenario at your university is currently a welcome adjustment?", they answered "yes" in a proportion of ninety percent (eighteen positive answers out of twenty), and what is worth mentioning is that the two respondents who did not choose to answer affirmatively chose the option "I am not sure",

as there were three options given: “Yes”, “No” and “I am not sure”. Question 5, “Do you think that the online part of your studies should be increased or decreased?”, for which the potential answers were “Increased”, “Decreased” and “I am not sure”, there are still two students who seem in doubt, whereas the other eighteen are more or less uniformly divided, as eight answered in the direction of having less time online, whereas ten voted for more. The conclusion here would be that almost all think that a mixed scenario for their studies is a good idea, but they do not agree on how long the online proportion should be.

4. Hybridity – prospects for the future

In this part of the survey, students were required to answer two choice questions. Question 6, “What kind of scenario would you prefer while simultaneously being an employee and pursuing your academic education (including master studies)?”, provided the following possible answers (and I have mentioned in brackets, for every scenario, the number of respondents who picked it):

- a) online education and remote work (0)
- b) online education and hybrid work (0)
- c) face-to-face education and remote work (2)
- d) face-to-face education and hybrid work (3)
- e) hybrid education and remote work (3)
- f) hybrid education and hybrid work (12)

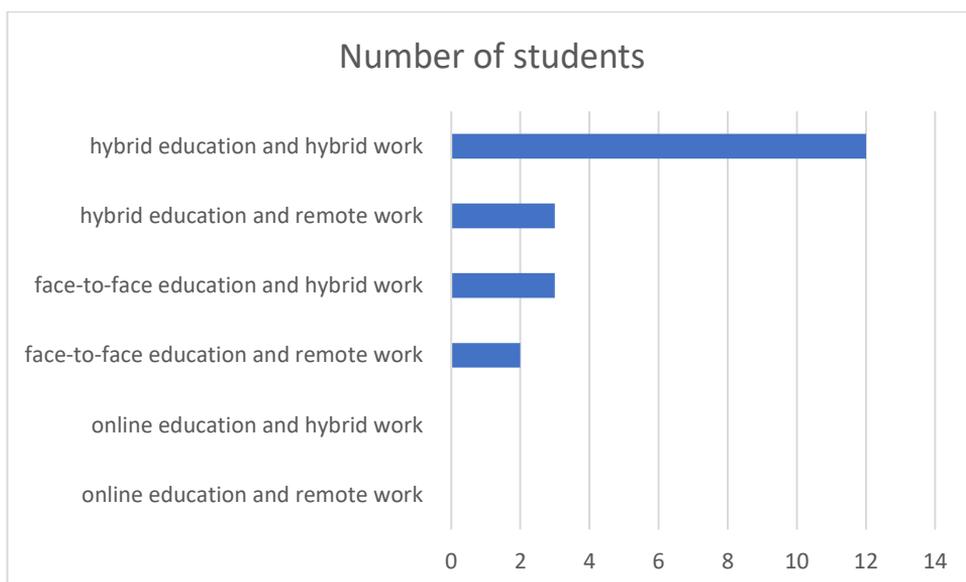


Chart 3. Question 6 – What kind of scenario would you prefer while simultaneously being an employee and pursuing your academic education (including master studies)?

Some aspects are worth a few comments. For one, no student believes that education should be fully online after having experienced this scenario during the pandemic; they do not want it repeated, and nobody thinks that academic education that unfolds exclusively online is a good idea, which is why for the first two answers the number of respondents is zero. Hybridity is favored in both education and one's professional life, more than half of the students choosing the last option. What we interestingly notice is that a great number from the students currently caught in a remote work scenario – half of them, five out of ten – migrated towards the hybrid model. Also, the two undecided students from the previous questions, when no longer given the option of undecidedness, went towards a mixed concept model for both their studies and work, choosing the last option. The students who chose face-to-face education for the future might have nevertheless agreed on the appropriateness of a hybrid studies scenario in the previous question temporarily, based on the still uncertain health situation globally, in the hope that it might get less risky for one's life or wellbeing to be fully onsite in the times to come. The results are displayed in the chart above.

Question 7 probed into how the students see their future lives in terms of favorite work models, asking them “What work model would you choose after graduation – remote, hybrid or fully on-site?”. The chart below sums up their selections, making it more than plain that the return to a fully on-site model, after the times that we have lived involving the remoteness factor to some degree, is seen, at least at this moment, as a virtual impossibility, as highly unlikely.

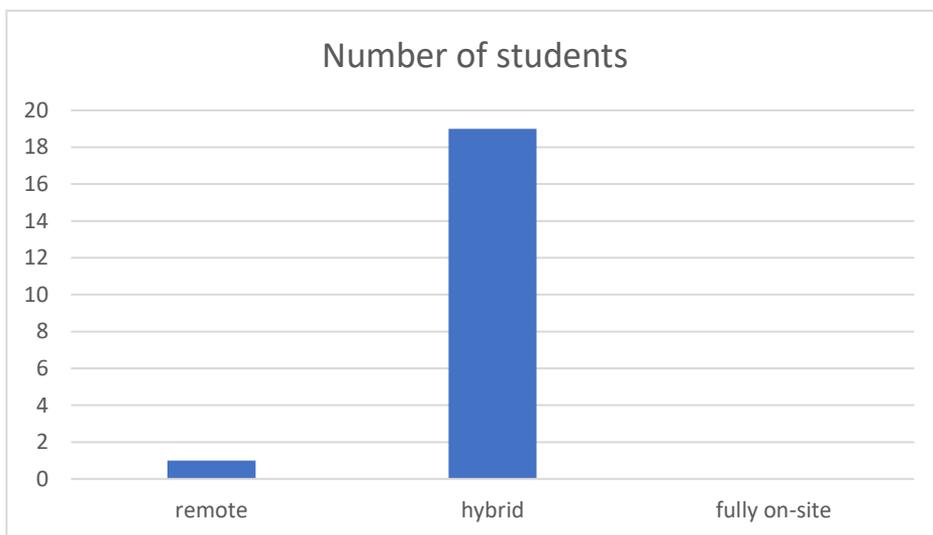


Chart 4. Question 7 – What work model would you choose after graduation – remote, hybrid or fully on-site?

5. Conclusions

The quantitative-qualitative analysis above reveals a few aspects related to the perception of remote and hybrid work and studies at the moment of the questionnaire. Firstly, notably, it is obvious that there is an emotional component related to socialization, loneliness and isolation that still represents a concern for all categories of respondents, i.e. for the young

generation overall, irrespective of their preferences for future work and education models. This only goes to show that the pandemic distancing and seclusion times have left their mark on the psychology of the young adult, who finds it a reason for concern, stress, with it even bearing the potential to trigger anxiety. The first two questions in the study reveal not only the fact that the emotive ingredient is relevant and draws attention to it, but that its importance is extremely high. Moreover, this occurs among students of IT, who are proverbially and perhaps stereotypically non people persons, displaying lower communication skills and, according to some, needs. The way they rank the emotive factor seems to be contradicting this outlook.

Then, we may conclude that young people have also learned how to value their freedom and wellbeing – perhaps another consequence of how the potential jeopardy raised to one’s health and life has determined a rethinking of one’s priorities and has perhaps changed the way the professional life has been automatically put first by some. The future, therefore, needs to be flexible, even highly or fully so, and negotiation and fluid boundaries appear to be the next norm. Both companies and future employees need to adapt to this new environment if they want to keep going. Technology will be part of our lives to a great extent, which entails in itself endless returns made on it by companies having this profile, and, from the perspective of the consumer of technology, befriending it and allotting significant amounts of money for its purchase.

Fully online education does also not seem an option. Despite the ability to adjust to the fully online system during the pandemic, the experience is perhaps found flawed, since it is not chosen by any of the young adults.

Most of the times, once the logistics is out of the way, the hybrid models of either education or work have a lot to do with how one decides to wrap her/his mind around the concept, as there are, objectively speaking, pros and cons involved in both staying remote and being there. As a last conclusion, we could say that the reconsideration of psychological boundaries and growing an inner psychological balanced profile that readjusts mindset are necessary and the key to successfully adapt to this new world ahead.

References

- [1] Greer, Tomika W., Payne, Stephanie C. (2014). “Overcoming Telework Challenges: Outcomes of Successful Telework Strategies” in *The Psychologist-Manager Journal*, 17(2), pp. 87–111
- [2] Eatough, Erin (2021, May 17). “Smarter Ways to Work from Home: 12 Challenges and How to Overcome Them”. On *BetterUp*. Retrieved November 30, 2022, 1:10 p.m., from <https://www.betterup.com/blog/challenges-of-working-from-home>
- [3] State of Remote Work 2019. On *Buffer*. Retrieved November 30, 2022, 1:20 p.m., from <https://buffer.com/state-of-remote-work/2019>
- [4] 2022 State of Remote Work. On *Buffer*. Retrieved November 30, 2022, 1:27 p.m., from <https://buffer.com/state-of-remote-work/2022>

- [5] Kojic, Marija (2022, September 21). “Remote Workers Share their Biggest Challenges”. On *Clockify*. Retrieved November 30, 2022, 1:42 p.m., from <https://clockify.me/blog/remote-work/challenges-remote-work/>
- [6] Haas, Martine (2022, February 15). “5 Challenges of Hybrid Work — and How to Overcome Them”. On *Harvard Business Review*. Retrieved November 30, 2022, 1:35 p.m., from <https://hbr.org/2022/02/5-challenges-of-hybrid-work-and-how-to-overcome-them>
- [7] Wigert, Ben (2022, March 15). “The Future of Hybrid Work: 5 Key Questions Answered with Data”. On *Gallup*. Retrieved December 1, 2022, 10:56 a.m., from <https://www.gallup.com/workplace/390632/future-hybrid-work-key-questions-answered-data.aspx>
- [8], [9] Horsley, Jonny (2021, August 31). “Five Employee Biases That Can Make or Break Your Hybrid Working Model”. On *DOCHANGERIGHT.com*. Retrieved December 1, 2022, 11:31 a.m., from https://dochangeright.com/five-employee-biases-that-can-make-or-break-your-hybrid-working-model/?gclid=EAIaIQobChMIzOro_IvY-wIVF9Z3Ch1TaQpCEAMYAAEgLOfvD_BwE

Bibliography

- ARRUDA, William (2022, July 19). “Six Serious Challenges of Hybrid Work and How to Overcome Them”. On *Forbes*. Retrieved November 29, 2022, 10:15 a.m., from <https://www.forbes.com/sites/williamarruda/2022/07/19/six-serious-challenges-of-hybrid-work-and-how-to-overcome-them/?sh=55c86f2018f3>
- BRECHSEIN, Jeremie, TRUSCOTT-SMITH, Anna, WIGERT Ben (2022, March 31). “The Four Essential Dynamics of Hybrid Work”. On *Gallup*. Retrieved December 1, 2022, 9:16 a.m., from <https://www.gallup.com/workplace/390632/future-hybrid-work-key-questions-answered-data.aspx>
- CHAMORRO-PREMUZIC, Tomas (2022, January 26). “The Challenges of Hybrid Work”. On *Forbes*. Retrieved November 29, 2022, 12:10 p.m., from <https://www.forbes.com/sites/tomaspremuzic/2022/01/26/the-challenges-of-hybrid-work/?sh=6c2cd0337286>
- EATOUGH, Erin (2021, May 17). “Smarter Ways to Work from Home: 12 Challenges and How to Overcome Them”. On *BetterUp*. Retrieved November 30, 2022, 1:10 p.m., from <https://www.betterup.com/blog/challenges-of-working-from-home>
- GREER, Tomika W., PAYNE, Stephanie C. (2014). “Overcoming Telework Challenges: Outcomes of Successful Telework Strategies” in *The Psychologist-Manager Journal*, 17(2), pp. 87–111
- JOSEPH, Ethan Danish (2022, July 28). “5 Challenges of Hybrid Work – How to Overcome Them”. On *Apty*. Retrieved November 29, 2022, 1:05 p.m., from <https://www.apty.io/blog/challenges-of-hybrid-work>

HAAS, Martine (2022, February 15). “5 Challenges of Hybrid Work — and How to Overcome Them”. On *Harvard Business Review*. Retrieved November 30, 2022, 1:35 p.m., from <https://hbr.org/2022/02/5-challenges-of-hybrid-work-and-how-to-overcome-them>

HICKMAN, Adam, WIGERT, Ben (2020, June 15). “Lead Your Remote Team Away from Burnout, not toward It”. On *Gallup*. Retrieved November 30, 2022, 18:22 p.m., from <https://www.gallup.com/workplace/390632/future-hybrid-work-key-questions-answered-data.aspx>

HORSLEY, Jonny (2021, August 31). “Five Employee Biases That Can Make or Break Your Hybrid Working Model”. On *DOCHANGERIGHT.com*. Retrieved December 1, 2022, 11:31 a.m., from https://dochangeright.com/five-employee-biases-that-can-make-or-break-your-hybrid-working-model/?gclid=EAIaIQobChMIzOro_IvY-wIVF9Z3Ch1TaQpCEAMYAyAAEgLOfvD_BwE

KOJIC, Marija (2022, September 21). “Remote Workers Share their Biggest Challenges”. On *Clockify*. Retrieved November 30, 2022, 1:42 p.m., from <https://clockify.me/blog/remote-work/challenges-remote-work/>

ROBISON, Jennifer (2021, June 28). “Communicate Better with Employees, Regardless of Where They Work”. On *Gallup*. Retrieved December 1, 2022, 11:22 a.m., from <https://www.gallup.com/workplace/390632/future-hybrid-work-key-questions-answered-data.aspx>

WIGERT, Ben (2022, March 15). “The Future of Hybrid Work: 5 Key Questions Answered with Data”. On *Gallup*. Retrieved December 1, 2022, 10:56 a.m., from <https://www.gallup.com/workplace/390632/future-hybrid-work-key-questions-answered-data.aspx>

WIGERT, Ben, WHITE, Jessica (2022, September 14). “The Advantages and Challenges of Hybrid Work”. On *Gallup*. Retrieved December 1, 2022, 8:56 a.m., from <https://www.gallup.com/workplace/390632/future-hybrid-work-key-questions-answered-data.aspx>.

2022 State of Remote Work. On *Buffer*. Retrieved November 30, 2022, 1:27 p.m., from <https://buffer.com/state-of-remote-work/2022>

State of Remote Work 2019. On *Buffer*. Retrieved November 30, 2022, 1:20 p.m., from <https://buffer.com/state-of-remote-work/2019>

“The 3 Biggest Challenges of Hybrid Working (and How to Overcome Them)”. On *Timely*. Retrieved November 29, 2022, 10:15 a.m., from <https://timelyapp.com/blog/challenges-of-hybrid-working>

NON-FUNGIBLE TOKEN (NFT): OVERVIEW, OPPORTUNITIES AND CHALLENGES

Cezar Octavian MIHĂLCESCU¹

Beatrice SION²

Ionel IACOB³

Abstract

Most people still believe that playing the stock exchange is “a ruse” for the naive, or that investing in stock market is very complicated or requires extremely advanced financial know-how. In reality, investments in stock market have been and still are a very important source of wealth, for everyman included.

Not everybody has the funds, the skills, and the right disposition to create a successful business. The failure rate here is approximately ninety percent. Also, real estate investments require significant amounts of money to be invested, as well as a lot of time.

Not everyone has the time, the knowledge and resilience to invest in individual stocks profitably. The good news is that anyone can passively invest in an ETF portfolio (exchange-traded funds, funds that trade on exchanges). An ETF is practically a bundle of stocks in various percentages given by the indexes that this ETF tracks.

Keywords: ETF, passive income, investments, financial security

JEL Classification: I2

1. Introduction

In Romania there are few people who own the majority of their wealth at national level.

Successful people do not allow themselves to be blinded by smokescreens; they go into detail, to get as close to reality as possible. It is only when we have factual data anchored in the present, that we manage to make the best decisions and excel. For instance, there are ETFs that replicate the S&P 500 Index which reunites the most important 500 companies listed in the U.S.A market. At the moment, the most relevant companies in the S&P 500 Index are Apple, Microsoft, Google, Tesla, Amazon and Facebook. In the past one hundred years, the S&P 500 Index has displayed an annual average return of approximately 10%. Anybody can learn how to draw up an efficient and smart ETF portfolio and acquire the discipline of making two or three transactions a month. In terms of time input, it will take

¹ Professor PhD, Romanian-American University, Bucharest, cezar.mihalcescu@rau.ro

² Lecturer PhD, Romanian-American University, Bucharest, beatrice.sion@rau.ro

³ Lecturer PhD, Romanian-American University, Bucharest, ionel.iacob@rau.ro

you only as little as fifteen minutes per month and, what is more, you can surprisingly have better results than over ninety percent of the other investors.

Net worth versus median wealth and the concentration of wealth in Romania

To understand more easily, according to Credit Suisse, the average net worth of a Romanian is approximately 176.000 RON, whereas the median net worth is 80.300 RON.

This kind of difference, which is more than double, between the average and the median, could make one think immediately of the concentration of wealth in Romania. If one stopped here, one might think that indeed a handful of people own most of the wealth in Romania. And this is how one ends up making the wrong decisions based on incomplete data, believing that this is real.

However, if one gets into details, one may notice, from a report drawn up by Boston Consulting Group (BCG), exactly how the Romanians' wealth is divided by segments.

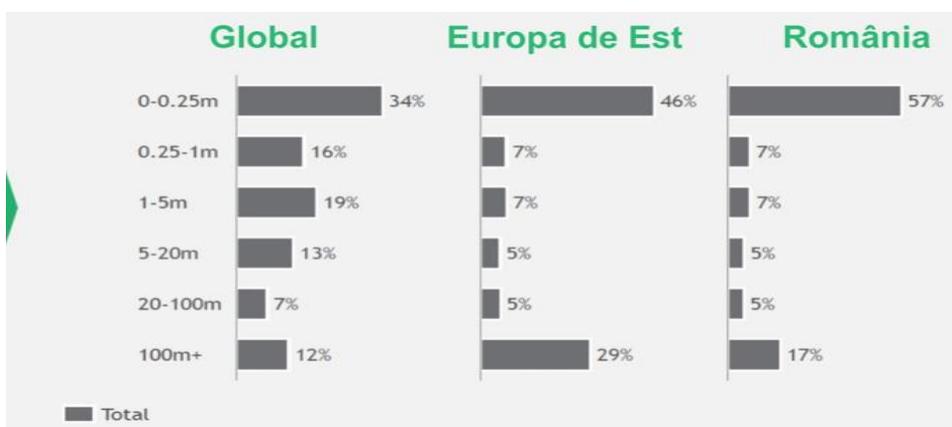


Chart 1: Comparison between wealth segments in 2019

Thus, we find out that, in fact, those pertaining to the segment with the smallest worth (0 – 0.25m USD) hold the highest percentage from the total wealth of Romania: 57%.

Moreover, comparing the same wealth segment with what happens at a global level, we notice an enormous difference: 34% versus 57%. In comparison with the regional level (Eastern Europe), there is a great difference as well, of over 11% in our favor.

At the other extreme, for the 100m+ segment, we notice the same thing. In relation with the region (Eastern Europe), the people with a 100m+ worth in Romania hold a much lower percentage from the total wealth of Romania: 17% versus 29% Eastern Europe. It is a fabulous difference of 12%.

We therefore see how the premises of the equation change radically, as there is no question of concentration of wealth in the case of Romania.

On top of that, we shall have a look at how the economic environment in Romania provides us with an unique opportunity. It is still Boston Consulting Group (BCG) that presents us the estimation of the wealth growth rate by segments.



Chart 2: Wealth segments in Romania

We may notice how it is estimated that those in the 0 – 0,25m segment, respectively 0.25 – 1m segment will experience the most rapid growth, with a CAGR of 6.9%, respectively 7.3%.

As we can see, it is only in Romania that the concentration of wealth is much lower than in the region, respectively globally, but also that the smallest two wealth segments will increase the most rapidly.

The aim should be to increase wealth quicker, and this is possible through efficient investments. Unfortunately, nevertheless, a lot of people invest without previous analysis, discovering too late, or never, that the returns of their investment could have been much higher.

If one tracks the evolution of a 12.000 RON investment annually (or 1000 RON per month) for thirty years, at an annualized average return of 5%, we witness how every 0.1% increment “lost” on taxes/commissions/inefficient allocation etc. “eats up” over 15.000 RON from the portfolio.

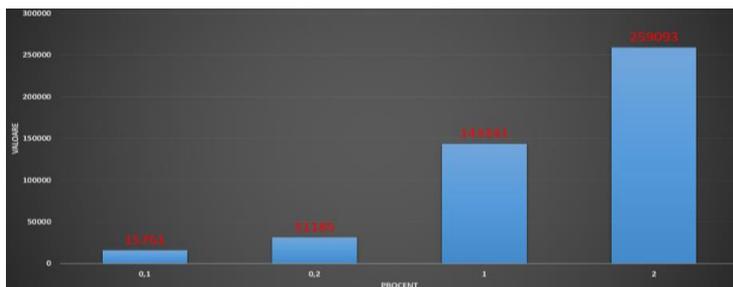


Chart 3: Portfolio increase/decrease per 0.1%

It is clear how every 0.1% return is extremely important, making all the difference between success and failure.

Depending on the savings rate, respectively the yield of the portfolio, we can calculate how many years the road to financial independence will take.

Practically speaking, for a savings rate of 35%, having a return of 5%, what results is a road of 24.6 years.



Chart 4: Retirement age/pension – scenario no. 1

Of course, this amount of time can be shortened by increasing the savings rate, but what if there were another way to increase quality of life?

For instance, by generating premium, i.e., greater returns. If, in the same math, we introduce a yield of 7% per year, at the same savings rate, one can gain 3.2 years of one’s life, reaching financial independence in 21.4 years, instead of 24.6.



Chart 5: Retirement age/pension – scenario no. 2

This is not all, there is another element that can shorten the road to financial independence: the safety withdraw rate (SWR). With a portfolio that has a SWR that is greater by 0.5%, one gains another 1.3 years.



Chart 5: Retirement age/pension – scenario no. 3

We shall introduce here exactly this: a strategy to minimize the number of years that are necessary to reach financial education through efficient investments that generate premium yield.

2. WHAT IS AN NFT?

NFT means nonfungible token. Simply put, it is a digital token existing on blockchain.

A real example in this sense would be the next one. A dollar is a dollar; it is fungible. A plane ticket, on the other hand, is nonfungible. Every plane ticket has different information and characteristics and cannot be exchanged with another. NFTs can be anything digital. Literally, anything can be an NFT, including an X-ray of your teeth, one of your Tweets or a two-second video of you.

Because digital assets can be copied and duplicated easily, NFTs, or non-fungible tokens, were created to provide proof of ownership over a digital asset. Again, think of it as a piece of artwork, although many prints can be created, often the original piece is most valuable. The benefit of owning an NFT is you can sell it to others and potentially make a profit.⁴ [1]

2.1 WHAT IS A TOKEN?

Technically speaking, a “token” is just another word for “cryptocurrency” or “cryptoassets”, but it has increasingly acquired more specific meanings, depending on the context.

The first is all cryptocurrency, except Bitcoin and Ethereum (even though, technically, these are tokens as well).

The second is to describe certain digital assets that roll over the blockchain of other cryptocurrencies, the way a lot of decentralized finance tokens (or DeFi) do.

Tokens have a large array of potential functions, from enabling decentralized exchanges to rare item sale in video games.

Nevertheless, all of them can be transacted or held as any other cryptocurrency.

2.2 WHAT IS A BLOCKCHAIN?

A blockchain is a “distributed database [...] shared among the nodes of a computer network. As a database, a blockchain stores information electronically in digital format.” (Hayes, Brown, Kvilhaug, <https://www.investopedia.com/terms/b/blockchain.asp>)⁵ [2]

⁴ Hayden, Marissa (2022, February 17). “What does it mean to mint an NFT?”, On *Canstar*. Retrieved November 25, 2022, 1:20 p.m., from <https://www.canstar.com.au/cryptocurrency/mint-nft/>

⁵ Hayes, Brown, Kvilhaug, <https://www.investopedia.com/terms/b/blockchain.asp>

Blockchains are best known for their crucial role in cryptocurrency systems, such as Bitcoin, for helping maintain a secure decentralized track of transactions.

Innovation brought by a blockchain is that it guarantees the accuracy and security of a data record and generates trust eliminating the need for a trustworthy third party.

How can one create an NFT?

One needs a crypto wallet with cryptocurrency in it to create an NFT.

An NFT can be created through the minting process of your digital asset (irrespective of its nature) on a blockchain.

Decryption defines minting as a computerized process of information validation, the creation of a new block and the registration of that information on blockchain. In short, if you want to create an NFT with one of your digital works of art (known as NFT art and CryptoArt), then you will need to use one of the CryptoArt platforms and mint the work of art through a smart contract. This is easy to do once you have connected your crypto wallet to a website.

Ethereum is the most popular blockchain for CryptoArt. In any case, there are other blockchains such as: Elrond eGold WAX, Flow Cosmos Tezos, EOS, Tron, Binance Smart Chain.

The value of an NFT may be a topic of discussion, these NFTs allowing proof of property in the digital world.

Due to blockchain technology and NFTs, the “scarcity” principle now exists in the digital world as well.

An NFT trading card is created on blockchain. Although they are not tangible (which means one cannot have them in physical form), the owner of the NFT holds, in a sense, the document of the digital transaction card. If it is appreciated in terms of value, the NFT owner can sell it for profit.

Perhaps the simplest method to make money from NFT purchase is to become an investor, more precisely to invest in the project as early as the private sale or pre-sale stage. Any serious NFT project should have three rounds, namely:

Private sale

It usually takes place before the pre-sale and the public sale. At this stage access is limited, most of the times only the greater investors of investment groups being able to obtain a ticket.

The biggest advantage is that, in the private sale, the NFT or the token (if it is about cryptocurrency) has a smaller price, and, most often, through its simple purchase at this stage, one can make double profit upon the official release.

For instance, a Richest NFT can be purchased at 0.5 EGLD in private sale, whereas in public sale the minimum acquisition price will be 1 EGLD, which means doubling the investment in just a couple of days.

Presale

It represents another round of investments. What we need to highlight here, though, is that not all projects have a pre-sale stage. At this point, investors who have not managed to buy in private sale can do that now.

Just as in the private sale, prices are lower than in the public sale, but the chances to acquire an NFT or token will be dim if the project aims for success, if it targets long-term results, as, in this period, like in the previous one, the number of NFTs that are released is not great either.

In order to give the possibility to as many people as possible to invest in good projects as early as the private sale or the pre-sale period, Richest sets for itself the goal to provide for the owners of at least 2 Richest NFTs the opportunity of membership in our community of investors upon releasing its NFT collection, a community where experts evaluate projects and negotiate the acquisition of a more valuable ticket that will be shared among those who invest in the respective project.

In this way, anybody who owns two Richest NFTs can obtain allotment from either the private sale or the pre-sale stages, in projects that are programmed for release. Thus, they can automatically increase their investment a few times.

Public sale

It is the official launch of the project. At this stage, most of the NFTs or tokens are released, and anyone who has in their wallets the equivalent sum of the listed price can buy.

This stage represents another auspicious moment for purchase, as, after the NFTs or tokens are finished, those who have not managed to buy yet and consider the project to be a good one shall buy at an even bigger price.

There have been NFT projects that have sold out in a few minutes from the release time, and those who have managed to buy in these three stages in the first week have made more than one hundred times profit, more precisely they have purchased an NFT for \$100 and then they have sold it for \$10.000.

3. What should one check first when one buys NFTs?

DESIGN

If at the beginning NFTs were considered “digital paintings”, things are different now, and the role of NFTs has come to be understood better. Just as a normal painting, NFTs have been bought according to taste and the creator behind them, namely had an NFT been created by a famous designer, then it would have definitely sold for a great sum of money.⁶[3]

Although currently behind any serious NFT project there is a smart contract, design continues to represent an important factor in the NFT purchase decision, for two reasons:

1. It is as if one drew a tree, and the drawing were put on sale in the form of an NFT for a price of 1 million dollars, claiming that through that NFT the buyer will obtain access to a journey to Mars.

⁶ Michael D. Murray, NFTs and the Art World -What's Real, and What's Not, 2022

The example may be inappropriate, but what one needs to understand by it is that one cannot target the creation of a great project without working out every detail.

2. The second reason is the psychological factor, as, nevertheless, NFTs are, before taking into account their utility, benefits and objectives, images, and if one does not like the image, the chances to sell NFTs for profit are slimmer, as currently there are still people who make the decision to buy an NFT based on the image. Although an NFT represents an “access ticket/pass” to the utility one aims to get, design keeps representing a significant factor in the purchase decision.

UTILITY AND BENEFITS

NFTs are used as a means to sell exclusive items in the online environment and have the potential to be used in order to check anything that might hold value in proving property, including digital works of art, tickets to events, limited editions of certain clothes, skins in a virtual game – and the list may continue.

Hence, the utility of an NFT consists in what one can do with that NFT, such as gain access to a private event.

One may ask why it is so important to know the utility and benefits that an NFT provides before buying it. We are interested in finding this out before the purchase, as in this way we can assess its value or the value that it may reach.

Through the purchase of a nonfungible token, one may gain access to a private event where a lot of influential people or business people will be present, each of whom may charge hundreds of euro for an hour of one to one consultancy. As a result of having bought the NFT, you have access to all of them at the same time for a few hours.

Through its utility, an NFT represents the right to property over a certain commodity, so, before buying it, it is crucial to be aware of its usefulness.

At the same time, one must not overlook the benefits that an NFT project also provides. An NFT project should be regarded more as a company, better said a start-up, as one can get subsequent to the NFT purchase the right to be part of the decision-making process behind the project, which is similar to holding shares in a company.

Imagine how it would be like to have a reserved seat for the general assembly of one of the great companies at the stock exchange. One can experience this feeling through the simple purchase of an NFT, and this is a reason why it is important to know the benefits of the project beforehand.

There are also projects that provide the NFT owners with the possibility to acquire passive income through staking. In other words, this means that one can receive dividends through the margins that the project has achieved after having fulfilled its final objective.

Once one finishes reading this e-book, it is enough to remember the idea that utility is perhaps the most relevant element to check before buying an NFT. As we have mentioned, NFTs are no longer just a JPEG, they provide the right to property over a merchandise.

The roadmap should comprise the project objectives, the manner in which they will be implemented and the time to do so. This makes it easier for investors to know when they

can benefit from the utility of an NFT that they have purchased or when it is most likely for it to gain value and offer them returns.

All this being said, why are we interested in tracking the roadmap if we intend to purchase an NFT?

THE TEAM

The moment we buy an NFT we wish to know who the creator of the project is and what recommends her/him to be able to develop what (s)he wants. We find a lot of NFT projects that want to accomplish great things, but behind them there are individuals who do not have enough experience for the respective goal.

Imagine Elon Musk would launch a collection of NFTs and that he would invest all the money in the creation of a flying car, while you would receive dividends from the sale of these cars. For sure, you would do your best to be among the owners of an NFT. How about if the project were launched by your second-floor neighbor? In order to have the certainty that we acquire an NFT whose value will increase, the assessment of the team should not be taken lightly.

In order to find out who is behind the project, one should check the official website of the respective project, where a presentation of the team would normally appear. As a side comment, if one does not find anything about the team or creator, it is a sure sign that one should no longer consider buying that NFT. Then, one should search for information on every member on social media channels, Google, LinkedIn, Instagram, Facebook or any other environment where something relevant can be found.

THE COMMUNITY

The community is another important aspect. Without a community, no project can fulfil its objectives, it is not a secret that any project needs endorsement in order to be able to develop. Therefore, before buying an NFT, it would be a good idea to check on its community. This can be done quite easily. By accessing the official website, one should be able to see on display links to Instagram, Discord, Twitter, Telegram, and a conclusion should not be difficult to draw based on this information.

HOW DOES ONE DECIDE IF A COLLECTION IS PROFITABLE?

Before explaining how we assess an NFT collection in terms of its profitability, it is important to mention that 98% of the NFTs will not be inspired long-term investments.

Perhaps this comment is scary, but one should realize that the same thing is valid for cryptocurrency projects. The percentage is similar even in traditional businesses, as nine out of ten go bankrupt in the first two years.

In order to minimize the risk to invest in an unprofitable project, it is first necessary to analyze the utility brought by the NFT one wishes to purchase.

Most NFTs do not provide utility based only on hype, which means that, for profit to be made, one needs to speculate the market, more exactly to predict when the interest in that NFT will rise and sell it then.

The problem is that most of the times the interest for an NFT that does not provide utility is low, just as the chance to make profit from it.

In the other category, there are the NFTs that provide long-term utility. One should think about what buying an NFT that grants access to an event or course with a limited number of attendants could mean.

In this case, one can generate profit twofold: for starters, one can go through the course, after which one can sell the NFT at a bigger price to someone who has not managed to buy from the beginning, and in this way both enjoy the benefits provided by the NFT and make some profit.

Another important aspect based on which we may conclude whether an NFT project can generate profit for the buyer is represented by the objectives established around it and the problems that it solves at the same time.

Along this line, in order to understand the final purpose of that project, one must follow the roadmap, which usually details every stage that is about to ensue.

In the case of an NFT project that pursues, for instance, the creation of an education platform, where access is granted solely based on NFTs, and the places available are limited by the number of the NFTs, the price of an NFT will automatically rise the moment the platform is launched.

The scarcity and desirability of the project are the next factors that determine the profitability of an NFT project. One should ascertain whether the project has only yet another opportunistic creator behind it, who produces mass JPEGs, or the individual NFTs have specific characteristics that make them rare and desirable.

Projects that issue a series of NFTs will usually set a limit for the project. For instance, in the Richest NFT project, there are only 3333 items.

Every NFT from that series shall be unique and program-generated at the moment of the minting, in order to incorporate a bundle of characteristics and features that point to its uniqueness.

Some features will be exceptionally rare, which entails that the NFTs which display them are more attractive and hence more valuable. Therefore, if in a collection we find a lot of NFTs with similar features, this leads us to believe that there has not been that much effort put in to make it, which would mean that the project does not have a long-term objective either.

To briefly conclude, in order to be able to make profit with an NFT, we should find a competent team behind the project, which has allotted enough time to outline the objectives, to create the design and to think of a strategy as a result of which the NFT owner can gain something long-term.

WHAT IS A SMART CONTRACT?

A “smart contract can be defined as a “computerized transaction protocol which automatically executes the terms of a contract when certain conditions are met” (“What is

a smart contract?” (n.d.), On *capital.com*, <https://capital.com/smart-contracts-definition>. [4]

Placed on a blockchain such as Elrond, smart contracts allow the execution of a contract without intermediaries or human intervention, reducing to a minimum losses through fraud, taxes, commissions and minimizing intentional and accidental foul play or exceptions.

Where can smart contracts be used?

Given their dependance on blockchain technology, the concept of a smart contract is familiar to those from the blockchain industry. Supporters of blockchain projects, such as Ethereum, often discuss possible use of smart contracts in everyday life, such as data storage, peer-to-peer transactions (from one person to another), the verification of someone’s identity and the facilitation of insurance applications.

How do smart contracts function?

They function in a similar way to regular contracts – they are simply faster, more secure, more efficient from the perspective of the costs involved, and they do not depend on third parties.

What is the minting process?

Minting “generally means something that is produced for the first time or made official, like minting a coin”; as Hayden points out, as far as the crypto and NFT world is concerned, the meaning stays the same, but the process is a bit different (Hayden, 2022). Hayden defines minting in the area of NFTs as “the process of taking a digital asset and converting the digital file into a digital asset stored on the blockchain”, “making it officially a commodity that can be bought and sold.” (*ibidem*) It may look complicated at a first glance, so let us take every stage step by step in order to make it easier to understand, which Hayden does for us. A digital asset “refers to any file that is created electronically”, i.e. “an image, article, video etc.”; its conversion into an NFT, namely the minting “is where the digital asset is added to a blockchain”; the blockchain is a “decentralised, digital ledger and once an asset is added to it, it cannot be modified, edited or deleted. Once the asset is minted and officially an NFT it can be sold at an NFT marketplace”, such as TRUST Market (*ibidem*).

E-commerce may be analyzed from four perspectives, as follows: from the point of view of communications, business processes, perspectives of services and real time (online) accessibility. {5}

Here is a guide on how to transform your work into an NFT, comprising of a few steps:

1. The creation of a digital wallet (Metamask)
2. Connecting the wallet to the market (TRUST Market)
3. Creating your own NFT
4. Listing the NFT for sale.

4. Conclusions

We have all been programmed from childhood to learn well, find a well-paid job and work to our retirement time. We have heard this hundreds or thousands of times. You have probably wondered yourself, thinking that there is nothing wrong with this thinking – it is honorable to learn well, find a good job and have a pension. The great problem with this situation is the depreciation of the real value of your economies, and the way it leads to the impossibility to retire at a decent standard.

The population of Europe is aging from one year to another. In Romania, an employee has come to support 1.3 pensioners already. In the current conditions, the situation is not looking up, it does not seem to improve at all.

Moreover, according to research of the Romanian Private Pensions Managers Association (APAPR), in the next fifteen years, Romania will be facing a crisis without a solution: an employee will be supporting 2.5 pensioners.

Under these circumstances, what pension may one expect to have after a lifetime of work? The probability that one should be able to lead a decent life from one's pension money is the same as for the rat on the treadmill to finish running and stop the continuously turning wheel.

Those who remain captive on the treadmill choose to run all their lives, to sell their time in exchange for money. Whereas those who escape the trap choose to put their money to work in order to gain time and to become independent. The latter are the people who end up living the life that they have always wanted. They manage to have a prosperous life, a decent pension and a peaceful retirement. As I like to put it, these are the ones who succeed in living “perfect, endless summer days”.

References

1. Hayden, Marissa, “What does it mean to mint an NFT?”, On *Canstar*. Retrieved November 25, 2022, from <https://www.canstar.com.au/cryptocurrency/mint-nft/>.
2. Hayes, Brown, Kvilhaug, [shttps://www.investopedia.com/terms/b/blockchain.asp](https://www.investopedia.com/terms/b/blockchain.asp)
3. Michael D. Murray, NFTs and the Art World -What's Real, and What's Not, 2022, https://www.researchgate.net/publication/359931627_NFTs_and_the_Art_World_-_What's_Real_and_What's_Not
4. Sophocles Theodorou, Nicolas Sklavos, in *Smart Cities Cybersecurity and Privacy*, 2019, *Blockchain-Based Security and Privacy in Smart Cities*, <https://www.sciencedirect.com/topics/computer-science/smart-contract>

Cezar MIHĂLCESCU, Beatrice SION, *Ionel IACOB*, *Essential Elements an electronic commerce strategy at company level*, *Journal of Information Systems & Operations Management*, may, 2018, pp. 58-70, ISSN 1843-4711

HOW TELEMEDICINE CAN SUSTAIN THE ROMANIAN TRANSFORMATIONAL REFORM

Larisa MIHOREANU¹

Elena Iuliana PAȘCU GABĂRĂ²

Daniel Gabriel DINU³

Andreea STOIAN KARADELI⁴

Liliana STANCIU⁵

Abstract

The healthcare sector faces the last years' crises have long-run unexpected consequences that put the light on the need to strengthen by modernization and quality increase of the medical services. The recent diseases have also challenged the working systems and the remote interaction via audio-video transmission operating systems comes as a social benefit for all actors involved. This paper analysis the role of telemedicine within the teleworking health reform, based on innovative transformational hints. The authors identified the advantages and limits of practicing the medical profession within pandemics, extrapolating the medical services practice through applicative operational structures under a legal frame validated at European level. The results of a survey are analyzed here using a research survey. The study confirms that telemedicine has high potential; its use helps improving the medical act quality through effective operational activities, relieve hospitals by rapid filtering and prioritize patients to get optimal treatments for their better satisfaction. It represents both an opportunity and a requirement in the process to give the healthcare system a hint to shape and use holistically and efficiently the organizational innovation and the administrative drive. The approach opens new horizons to research, from the beneficiary of telemedicine's perspective to e-health services' future to optimize results, improve satisfaction and strengthen excellence. The research could also facilitate the decision on how telemedicine practice and governing can play for all parties' benefit.

Keywords: COVID-19, eHealth, Mobile Health, Health Security, Pandemics, Public Policy, Telehealth, Telemedicine

JEL Classification: I15, I18, I28, O33, O35, O38

¹ Faculty of Administration and Public Management, Bucharest University of Economic Studies, Romania, e-mail: larisa.mihoreanu@amp.ase.ro

² Doctoral School of Business Administration, Bucharest University of Economic Studies, Romania, e-mail: pascuelenaiuliana@gmail.com

³ The Bucharest University of Economic Studies, Romania, e-mail: daniel.dinu90@gmail.com

⁴ Department of Public Affairs & Security Studies, University of Texas Rio Grande Valley

⁵ Faculty of Medicine, 'Ovidius' University of Constanta, Romania, e-mail: lilianastanciu77@yahoo.com

1. Introduction

During the COVID-19 pandemic our societies witnessed the crisis of an overwhelmed healthcare system challenged by a rising number of patients, logistic non-conformities, shortage and exhaustion of medical staffs, inappropriate public management, and inefficient crisis related public policies. The current data reflecting the evolution of the pandemic and the response of several different sectors of activity provide us the opportunity to assess the management of the crisis and understand the weaknesses of our public system. While further research is expected on emergent data, this paper argues that innovative transformation should start with developing a smarter design of the public policies that would allow the formation of resilient human resources backed by technological development.

The COVID-19 pandemic surprised all operational actors of the medical and healthcare sector. The consequences proved to be dramatic. While the health system represented the first target, other branches of our societies were eventually hit by the results of the pandemic. International events have been cancelled, travelling was reduced, and a high number of industries were affected. The world economy, fragile under the health crisis, still suffers from the pandemic aftermath, and continues to be challenged by geo-strategic, political, and social events.

The health sector, overwhelmed by the avalanche of requests for health services, is constantly mobilizing and innovating in the use of existing resources, beyond the borders of the rational, to save as many lives as possible and diminish the economic losses.

The COVID-19 era has brought many challenges based on high alerts and full resources use by the health emergency while the coordination and proper functioning of all health systems has become a strategic international concern for the coverage and accelerated settlement of the demand for medical services. Such atypical crises called for abrupt change witnessed in different contexts: the pattern and times of operation, the rank of services provided, the way of delivering the medical care to cope with the pandemic and its consequences. Today, healthcare administration and patients feel wiser in handling the COVID-19 combat; however, their targets remain linked to reduce the disastrous effects and provide the population with higher quality services. The main solution provided by this paper is telemedicine (TM), arguing that it can represent part of the sustainable health reform.

2. Literature Review

Evidence shows that the pandemic amplified the existing factors that plagued the healthcare system over time: inefficacy of over repetitive routine, frustration rooted in the highly bureaucratic administration, ineffective workflows that prevent the good care for patients and destroy the fulfilling relations between medical staffs and patients. Reforming the health field means transferring the burden of tedious manual work from humans to technology. In this regard, telemedicine (TM) can represent part of the solution for a sustainable health reform.

Institutionally, TM refers to the “remote exchange of medical information and/or services between patient and clinician using electronic technology, via communication of

information” [1]. The last years, TM has become more of a complementary structure in the practice of medicine than a special, separate practice of the classical one. As some authors underline [2], the health authorities' interest in TM grows and it mainly refers to the operational and technological infrastructure, safety, security, legal framework including the circumstances in which this practice can be put in use to improve accessibility and quality of healthcare on behalf of the most precious of the societal assets - highly qualified human capital, time to react, logistics and finances.

The literature mentions over 100 definitions for TM [3]; it also suggests its affiliation with contemporary sciences [4], presenting it as a dynamic development, a versatile evolution and innovative application of the smartest technology and medical practices encountering the growing demand for health services and customize the diverse context of modern societies [5]. The TM concept differs from the “telehealth”. The single provider of medical services relies in the medical doctor hands, unlike the telehealth which is served by any other categories of healthcare professionals - nurses, midwives, pharmacists. For a better understanding of things, both concepts are used in the paper.

WHO defines the concept of TM through three of its essential elements [5]: a) purpose - providing clinical support, b) mission - improving health outcomes by overcoming geographical barriers and connecting with users who are not in the same physical location, c) medical support instruments used with patients to make operational the technology of information and communication (ICT). TM uses new technologies; therefore, complements classical medicine and allows the provision of remote clinical services, in any critical situation where patients are isolated as a necessity, due to a disease, or suffer physical or geographical unavailability [6]. The pandemic challenges the society had to face, defines the precise moment of opportunity to develop and improve ICT tools in any of the healthcare activities. The TM practice will neither replace the medical clinical examination nor the medical investigation; as a fact, it can effectively help reducing the spread of infection and prevent visits from patients with non-emergencies medical conditions in overcrowded or in crisis health facilities.

Despite the successful evidence of TM practice abroad, its use in Romania has been limited [7] by methodological, financial, praxeological and regulatory obstacles:

- liability for malpractice,
- forensic issues related to reimbursement of the medical service provider,
- technological challenges,
- training the patient on the use of some devices,
- patient access to technology.

Meanwhile, the health authorities advance and facilitate the e-healthcare implementation, temporarily removing the technological or forensic barriers to expansion. The new institutional and regulatory framework provides a unique opportunity for the widespread use of TM services to meet the growing demand for medical care for patients in solitary confinement at home or away from the healthcare unit to which they are referred to.

Both in the academic circles and in business practice it has become increasingly clear that scientific and technological developments bring to the forefront the potential of using TM in healthcare, increasing the accessibility and the quality of healthcare while improving patient satisfaction. Despite the results, legislative regulations limited the use of TM in the pre-pandemic period. Thus, the legislation maintains brief references to: “defence telemedicine – through projects related to the processing of multimedia medical investigations for national defence (2020)” and “rural telemedicine” [8] through pilot projects on “Increasing the quality of medical care in rural areas by implementation of a Telemedicine Information System” approved by European Commission Decision no. 3472/12.07.2007. Over time, projects have proved inconsistent to develop and make operational the chosen fields [9].

Late 2020, the Romanian Government issued the Ordinance no. 196/2020 [10] amending the Healthcare reform Law no. 95/2006 [11, 12], to strengthen the telemedicine support framework. The Ordinance states that public and private “health units (...) have opportunities to provide medical care through telemedicine” defining it as “the sum of health services remotely provided by using all kinds of ICT means”. Moreover, TM has been also defined by the advantages supplied: a) emergency portable systems set on ambulances ensuring the real-time transmission of biometric and clinical data and the specialist indications transmitted and applied to patients by emergency paramedical staff; b) rapid and cheap access to recent data, scientific documents with the possibility of recognizing their scientific value and their innovative accuracy; c) permanent remote monitoring of patients, by optimal use of technological devices for chronic patients that can now benefit of the remote monitoring, audio-video dialogue with specialists accessing the necessary medical information of each patient, saved and preserved in a specific information system, through technological tools available to patients - telephone, tablet, computer, medical applications, specific monitoring equipment. In this sense, interactive TM proves to be the absolute operational form for the medical field, through technologies. It is based on the synchronous, real-time interaction between the patient and the physician, through audio and video technology. *Interactive TM* remains a viable alternative of the face-to-face consultations; avoid long distances, high costs and adverse weather conditions. TM is comparable to a consultation, diagnosis, prescription, and associated medical advice. TM supports permanent monitoring and an open dialog between doctors and patients any time is necessary. In specific cases, a nurse or technician may facilitate the consultation using e-health tools.

3. Methods

3.1. Study design and procedure

The present methodological approach is based on a four stages investigation, modelled as follows:

- identify the current state of knowledge in relation to the medical care provided through telemedicine and the current conceptual context in the international and national practice of TM during the pandemic;
- prepare and perform a questionnaire survey of physicians in assess their perception regarding the use of TM as a way of practicing healthcare;

- analyze the collected data
- highlight the positive aspects of the TM utility and its practical limits.

The main objectives are directed to conduct an impact analysis about using new technologies as innovative sources of reform, identify the physicians' perception. as major providers of health services about practicing telemedicine and to assess usefulness and side effects of this form of practicing medicine, with a reforming purpose, to improve the quality and availability of medical care in Romania. The research hypotheses proposed for testing highlight the following:

H1: During the pandemic, the practice of TM proved to be a useful alternative for over 75% of the doctors surveyed.

H2: TM provided the most services for the population with chronic diseases (diabetes, cardiovascular disease, neurological diseases) compared to other categories of patients, according to over 75% of doctors surveyed.

H3: Over 75% of respondents considered of urgent need the implementation of a national technological infrastructure and well-defined legal framework, for the optimal use of telemedicine for patients and society.

3.2. Study participants and sampling

Summarizing, from the total of 504 completed questionnaires, 416 questionnaires were validated fulfilling the initial conditions of the proposed study. A number of 88 completed questionnaires were excluded because they did not meet the selection criteria: 59 questionnaires were completed by doctors from outside Romania, 16 questionnaires were incomplete, and 13 questionnaires were completed by other non-medical staff rather than doctors.

3.3. Study instruments

The questionnaire, consisted of 14 questions with pre-formulated answers, of which 9 were single answer questions and 5 were multiple answer questions. The questions target the perception of doctors regarding the provision of medical care through TM in Romania during the pandemic. To obtain the highest level of statistical robustness, the research was conducted by analyzing and interpreting a number of 504 questionnaires filled by doctors active in Romania during the pandemic. The respondents of the valid questionnaires, considered relevant for research, are doctors in different stages of professional development (residents, specialists, primary care physicians / consultants / academics, dentists), over 24 years of age, affiliated or working in different health facilities (individual office / private clinic / state or private hospital, medical analysis laboratory - individual / private / in a hospital, dental office).

In the current context, dominated by social distance restrictions, the questionnaire was distributed and completed electronically by the respondents. Starting from the fact that currently in Romania, are 58 specialties of general medicine and 6 specialties in the field

of dentistry legally recognized, the respondents were selected based on two criteria, namely:

- professional training
- place of activity,

in order to capture the diversity of healthcare and appreciate the relevance of physicians' perceptions for the present study. Until present, the Romanian legislation has not established the medical specialties that can be the subject of telemedicine services. That is why the doctors were not asked about the specialty practiced.

3.4. Data analysis

The analysis considered exclusively the opinion of doctors who provided medical care in Romania during the SARS-CoV-2 pandemic because the activity carried out in another state could generate responses under other legislative incidences than those in our country, which could influence the results of this research. Incomplete questionnaires were excluded from the analysis. In short, the criteria for inclusion in the study refer to:

- the respondent is an active registered doctor, practicing on the Romanian territory during the SARS-CoV-2 pandemic;
- the medical unit is the doctor's affiliation / establishment where he usually carries out his activity;
- the included questionnaires were completed in full.

4. Results

The respondents of the questionnaire are doctors over 24 years of age, working in Romania between March 2021 and February 2022 in different stages of professional development (residents, specialists, primary care physicians / consultants / academics, dentists) being affiliated or employed in different types of health units (individual office / private clinic / state or private hospital, medical analysis laboratory, dental office) which currently provides medical services in Romania.

The patients' majority who completed this questionnaire were women (89.9%), and the rest of 10.1% was men. The age categories best represented are 31-40 years (33.7%), 41-50 years (28.8%), 51-60 years (19.5%), 24-30 years (11.8%), over 60 years (6.2 %).

The level of professional training of doctors participating in research overlaps, in general, with the best represented age ranges. The predominance of consultants / academics (46.9%) is noticeable, followed by the specialist doctors (34.5%), residents (13.8%) or dentists (4.8%) proving that in the field of medical education, the degree of vocational training is obtained through continuous medical training and specialization over time (fig. no. 1).

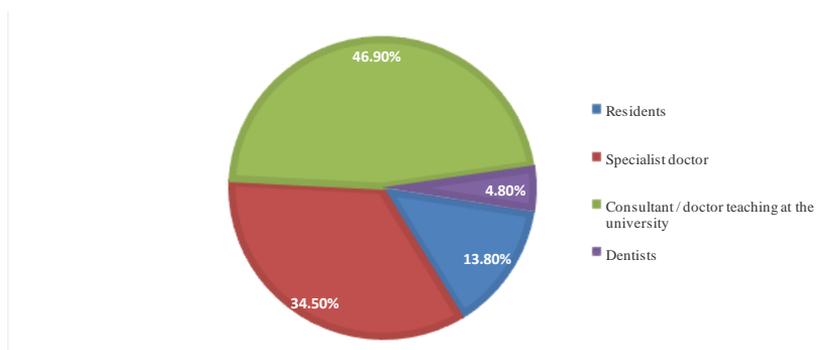


Figure 1. Respondents' distribution according to their professional training level

Regarding the place where they carry out their activity or the institution to which they are affiliated, 379 doctors (91.3%) of the respondents declared their affiliation to a health institution, individual office, private clinic, state or private hospital. Although during the research (March 2021-February 2022) most doctors (over 75% of respondents) performed their work mainly at work, practicing medicine in the classic way, face to face with the patient, however most of the respondents, over 90%, affirmed that they used modern means of communication (telephone, sums, email, video call, mobile applications) to strengthen the dialogue with patients, thus identifying what types of means of communication they helped them in clinical practice (fig. no. 2).

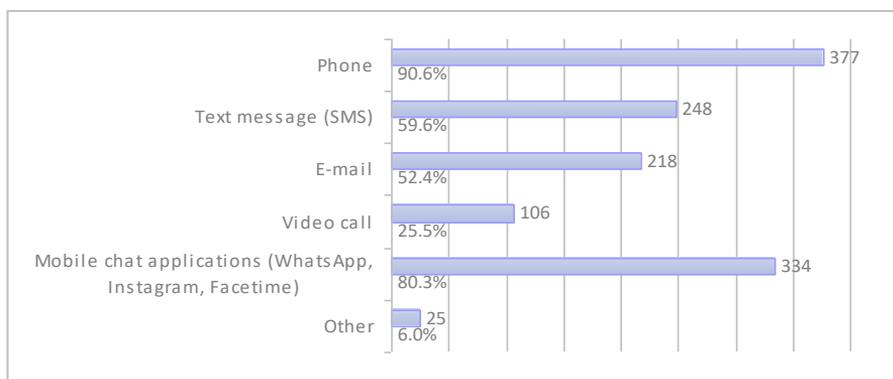


Figure 2. Distribution of electronic means of communication used in providing healthcare

Thus, 377 of the doctors (90.6%) state that they used the telephone as the main communication tool with patients to provide remote healthcare, while more than three quarters of the respondents, that is, a number of 334 doctors (80.3%) used mobile chat applications such as What'sApp, Facebook, Instagram, Facetime). Preference list continued with text messages (59.6%), emails (52.4%), video calls (25.5%) and other (6%).

Regarding the telehealth services provided, most doctors (305 respondents - 73.3%) specified that the dialogue and communication with patients took place through individual consultations / appointments previously established. The mail, couriers, messenger counted

for 28.6%. Only 34 doctors representing 8.2% used a platform created and intended for this purpose, a portal for patients. Discussion groups represented 3.8% (fig. no. 3).

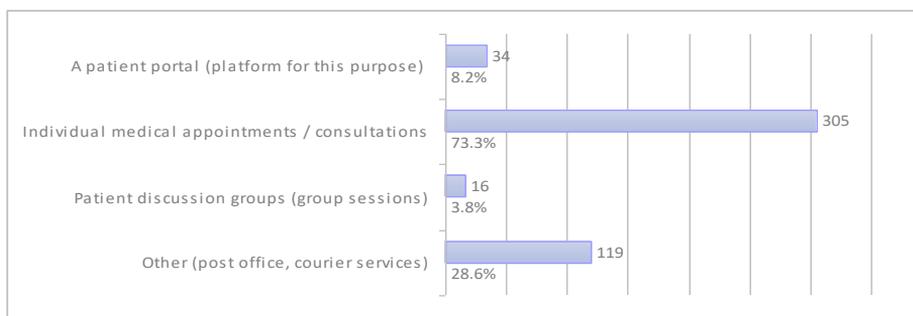


Figure 3. Distribution of electronic communication methods used for providing medical assistance

Most of the respondents participating in the research highlighted the following advantages of providing medical services through telemedicine:

- direct contact with the non-displaced / difficult to move or isolated patient at home (315 doctors - 75.7%),
- medical assistance for patients from hard-to-reach geographical areas (297 doctors - 71.4%),
- quick and valuable access to specialists and to all information necessary for the optimal development of the medical act and the indicated therapy (277 doctor - 66.6%),
- real-time monitoring of the patient's health evolution (265 doctors - 63.7%) according to figure no. 4.

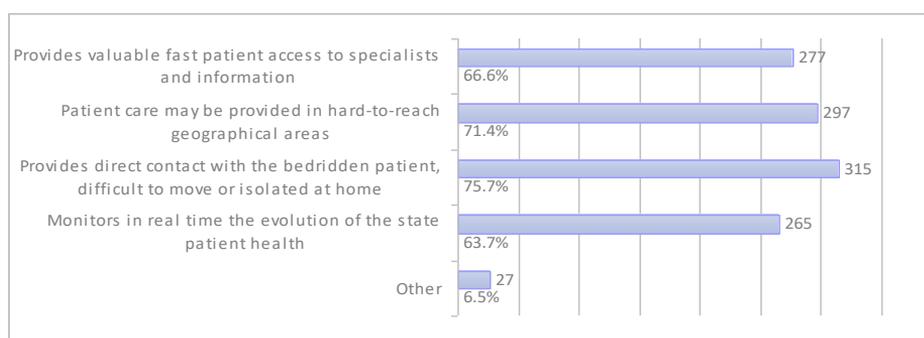


Figure 4. Benefits' distribution of providing medical services through TM

However, the provision of medical services through telemedicine has its own limitations. 374 doctors - 89.9% appreciated that the main inconvenient of teleworking in medicine was

the impossibility of diagnosing or treating certain health problems (38 doctors (57.2%) considered on the first place the lack of accessibility, 234 respondents (56.3%) faced the lack of the optimal legal framework for providing such medical care, while another 214 (51.4%) argued on the limitations and shortcomings generated by the lack of integrated technological infrastructure at national level for optimal health services . Inadequate payment was reported by 120 doctors (28.8%), and 17 respondents (4.1%) suggested other causes (fig. no. 5).

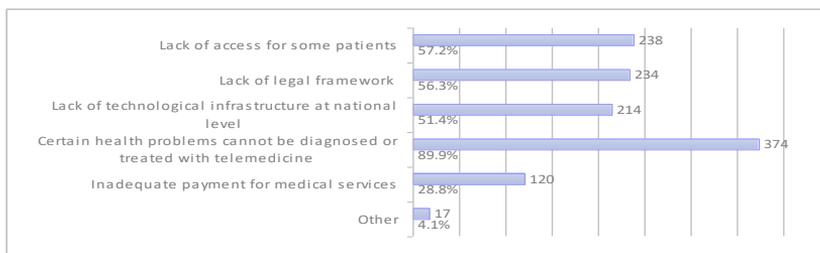


Figure 5. The limits of the distribution of the medical services used to provide TM

Respondent doctors considered that the biggest categories of patients benefitting from health services using TM were (fig. no.6):

- patients with chronic diseases (diabetes, cardiovascular diseases, neurological diseases (323 doctors - 77.6%);
- seniors with age-specific diseases (214 doctors - 51.4%);
- pediatric population (118 doctors - 28.4%);
- pregnant women (81 doctors - 19.5%);
- patients in need of medical rehabilitation (53 doctors - 12.7%).

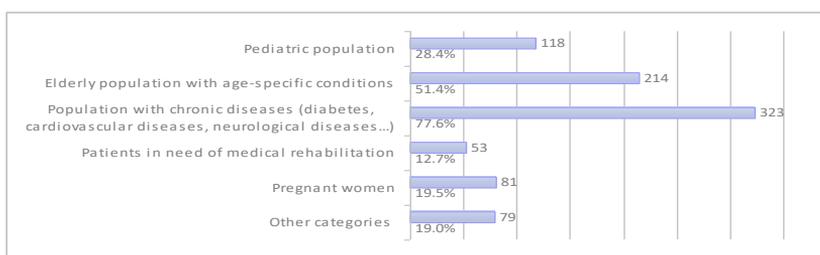


Figure 6. Distribution by categories of patients who benefited the most from TM services

The majority of respondents (322 doctors - 77.6%), considered the practice of telemedicine as a useful alternative in their specialty. Following the interpretation of the results of the questionnaire, 381 doctors (91.8%) appreciated the future implementation of a national technological infrastructure and a legal framework for providing telemedicine care not only useful, but also necessary.

5. Discussion

The level of usefulness in providing healthcare through telemedicine was followed from the perspective of physicians, as the sine-qua-non providers of health services within the system. In the health field, the medical professional evaluates and decides over the usefulness of providing certain health services, while the evaluation of the standards of quality of the health services are analyzed in relation with the patients' needs by the competent authorities, not by the patients themselves. Patients' satisfaction after receiving a health service is a component based on the patients' appreciation of the non- medical services (communication, information, relations with the employees of the medical unit) [15, 16]. The correlation between the level of doctors' professional training and the age's intervals is based on the medical professional training curriculum for doctors in Romania. The magnitude of the demand for medical services during the pandemic and the awareness of the support provided by TM are exemplified by the data reported at a single academic institution where the number of medical services increased from less than 100 consultations per day to more than 2200 consultations per day in a monitoring period of over 24 days. Telephone, video calls have been the most widely used means of communication [17].

The advantages of TM include the cost-effectiveness, the ability to extend access to health services to several categories of beneficiaries and the potential of this type of healthcare to alleviate the shortage of health professionals, as a general and well-known public health problem [18].

Health experts have reported challenges linked to TM implementation already known in international practice:

- lack of education of the consumer of medical services on the efficacy and safety of telemedicine in the context of the pandemic,
- patients' preferences for direct contact with the doctor,
- lack of understanding about how to access telemedicine care and
- lack of information about TM, as an option to contact a health specialist when needed.

Barriers to physical examination, partly overcome internationally in some medical specialties [18], also appear in the present research. We emphasize that, along with the literature [19, 20], this study also reflects the value and usefulness of teleworking in medicine through TM in the management of chronic diseases and treatment of patients with such diseases, but also in the management and administration of palliative treatments for those diagnosed with neuropsychiatric disorders. The reluctance and distrust shown by a minority of doctors (34 doctors representing 8.2%) in creating a technological infrastructure at national level and implementing a legal framework for providing healthcare through telemedicine is mainly due to the nature of the medical specialty they practice. Therefore, using TM in Romania post operative monitoring can be achieved, but only after the operative procedure programmed or in emergency was performed in person in the operating theatre, because there are no valid options at present to perform surgical interventions similar to USA or UAE. The sample of doctors who completed the questionnaire included the existing specialties in Romania, in order to keep them representative for the active population during the pandemic.

Covid-19 has challenged the health system around the world and pointed out the vulnerabilities of the health infrastructure in all countries, disregarding the level of development. As the pandemic is slowly releasing the burden, we are constantly reminded that this recent virus was not the first and will not be the last to test human immunity and the system's resilience to such a great threat. In Romania, the healthcare sector is recognized being a high need for a transformational reform, at any level, not a matter of choice and disposability to sustain more crucially [21], a resilient communication and reach in time the final receptors. In this regard, considering the role of the family doctors (general practitioners), a reform has to enhance their capabilities and extend their competencies to use innovative tools, such as telemedicine. Although accused of limiting the accessibility to face-to-face doctor appointments, the reform has to rely on the use of technology and develop alternative paths to access medical screening and treatment - online and in-person-can, in fact, prove to be one of the drivers of a sustainable, just and equitable health system, better prepared to face the next crisis. Currently, although research proves the benefits of combining traditional paths with the developing technology, in the current context - telemedicine, the decision-makers in the governmental structures turn a blind eye to the data and to the medical personnel's experience and choose once again political driven routes.

6. Conclusions

Societal turmoil such as pandemics require versatile and agile medical systems allowing very fast action responses, to minimize any negative impact on human, economic, financial, social, institutional, or societal, local, or global level. In the current pandemic context, TM represents a sustainable, rigorous, and profitable alternative to classical medicine, offering continuity in patients' accessibility to clinical services, in the social preventing anti-COVID-19 context (social distancing, isolation, quarantine).

The study shows that the usefulness of TM type of health care during the pandemic in Romania is a supporting pillar in the health system's effort to cope with negative effects caused by SARS-CoV-2 virus infection. The respondents of the questionnaire assessed the quality of these types of medical services according to several variables. The data analysis showed that the perception of medical service providers is positive and improved due to TM contribution.

Medicine is in a continuous transformation and adapted to modern times. The use of artificial intelligence in medicine, the planning of surgeries with computer technology, virtual reality for medical education, 3D technology in orthopedics, robotic surgery are just a few innovations that will transform and improve the way patients are cared for.

Using electronic devices and innovative ICT tools, telemedicine remains a definite possibility, a promising and effective approach to continuous care and monitoring of patients in need, in their efforts to access any kind of medical services. For this reason, the research remains open and will focus, in the near future, on the analysis of opportunities offered by artificial intelligence in finding solutions and perspectives for patient complex satisfaction, as the main beneficiary of these health services [22].

With OUG 196/2020 [10], the authorities took a concrete step forward in supporting telework in healthcare and offered to medicine an intelligent tool for remote working that

already proves its added values. However, to become an independent field in modern Romanian medicine, TM calls not only for norms and standards, recently and separately approved, but for a resilient vision embracing both the administrative and public policy aspects on the regulation, standardization, audit, and monitoring activities, namely:

- the list of medical specialties and nomenclature of medical services that can be provided by telemedicine,
- reimbursement of all medical services performed using TM,
- implementation of an electronic health card for each patient with doctor's access to the patient's electronic file,
- definition of electronic conditions and technological means of this type of medical assistance,
- evaluating the quality of the medical service offered by telemedicine and its validation,
- transmitting information in real time between different informatics systems (insurance company, pharmacy, health units, patients, medical services providers),
- securing of information,
- automatic generation based on digital certified signature of any documents required for various purposes (vaccine certificate, health passport, etc.).

This way, the remote activities, regardless of the field, will contribute to the consolidation of the societal value and the satisfaction of all the actors involved in such activities. After more than two years since the development of the general legal framework applicable to telemedicine, the methodological norms regulating the provision of remote medical services for more than 50 medical specialties are approved since September 2022. Their main target focuses on prevention. However, through the telemedicine service, two or more medical specialists can remotely form multi-disciplinary teams to analyze, interpret and diagnose patients with rare diseases or cases of chronic disease. This way, the legislative bases can favor new investments in TM platforms and increase the access to medical services. Several European studies like found already that telemedicine is appreciated as cost-effective in 73.3% of the cases addressed by the specialized literature: by reducing the costs of consultations, travel or time and increases the quality of life of patients.

TM and innovation can now better contribute to improving the human experience in healthcare - through efficient workflows and outstanding clinical expertise. Plenty of studies consistently show that a lack of workflow integration remains one of the main barriers to the adoption of more innovation in healthcare. They sustain the need for a human-centered system based on a fair relations' architecture. By putting people's needs in the foreground, TM can become even more useful to patients, health staffs and other economic operators, especially in situations of crisis, stress or strong pressure. We also need to keep in mind that the healthcare achievements can't exist without a healthy lifestyle and active education in the field.

Thanks to new preventive therapies, life expectancy can increase, and digital equipment can become essential in monitoring the patients' health by continuously transmitting data to doctors. If correctly used, TM has a significant potential firstly to cover those areas missing medical specialists, improve the quality and availability of medical care in Romania and reduce the pressure from the classic medical activity, carried out in health facilities lacking the necessary logistic, by multi-criteria selection of patients benefiting the most from this type of medical care. The disproportion between the advantages provided by scientific research and the clinical reality, illustrated especially in times of crisis or pandemic should never be forgotten or accepted.

References

1. WHO. *Global Observatory for eHealth – Telemedicine: opportunities and developments in Member States: report on the second global survey on eHealth*. World Health Organization. 2010. <https://apps.who.int/iris/handle/10665/44497>.
2. Tulu B; Chatterjee S & Laxminarayan S. *A Taxonomy of Telemedicine Efforts with Respect to Applications, Infrastructure, Delivery Tools, Type of Setting and Purpose* in Proceedings of the 38th Annual Hawaii International Conference on System Sciences, IEEE, Big Island, HI, USA; pp. 147b-147b, 2005. doi: 10.1109/HICSS.2005.56.
3. Sanjay S, Mbarika V, Jugoo S, Dookhy R, Doarn CR, Prakash N & Merrell RC. *Reviewed Perspectives and Theoretical Underpinnings – Telemedicine and e-Health*. 13(5):573-590. 2007. <http://doi.org/10.1089/tmj.2006.0073>.
4. Bashshur RL, Reardon TG, & Shannon GW. *Telemedicine: A New Health Care Delivery System – Annual Review of Public Health*. 21(1):613-637. 2000. <https://doi.org/10.1146/annurev.publhealth.21.1.613>.
5. Hoffman LC. *Shedding light on telemedicine & online prescribing: the need to balance access to health care and quality of care – Am J Law Med*. 46(2-3):237–51. May. 2020. doi: 10.1177/0098858820933497.
6. Tanțau AD, Vizitiu C & Văleanu V. *The Responsibility of Telemedicine Focused Organizations in regard to creating Compliant end Users Products and Services – Amfiteatru Economic*. 2014; XVI (35). RePEc:aes:amfeco:v:1:y:2014:i:35:p:108. Feb. 2014.
7. Moisil I & Jitaru E. *E-health progresses in Romania – Int J Med Inform*. 75(3-4):315-21. 2006. doi:10.1016/j.ijmedinf.2005.08.013.
8. Romania. Ministerul Fondurilor Europene. 2007-2013. *Programul Operațional Sectorial „Creșterea Competitivității Economice” 2007-2013. Axa Prioritară III: „Tehnologia Informației și Comunicațiilor pentru sectoarele privat și public”, Operațiunea 3.2.4: „Susținerea implementării de soluții de e-sănătate și asigurarea conexiunii la broadband, acolo unde este necesar” – la nivel central*. Bucharest: M.O. 2014. <http://www.fonduri-ue.ro/pocu-2014#implementare-program>.
9. Romania. Guvernul României. 2014-2020. *Strategia Națională de Sănătate 2014-2020*. MO.891 (bis/8.12):43- 44.

10. Romania. Guvernul României, *OU no. 196/14.11.2020, pentru modificarea și completarea Legii nr. 95/2006 privind reforma în domeniul sănătății* – M.O. 2020; 1108(19.11).
11. Romania. Guvernul României. *OUG no. 196/18.11.2020 pentru modificarea și completarea Legii nr. 95/2006 privind reforma în domeniul sănătății* – M.O. nr. 1108/19.11.2020. <https://legislatie.just.ro/Public/DetaliiDocumentAfis/233458>.
12. Mihoreanu L. *The Health Sector - From Desideratum to Real Reform* – Journal of Economic Development. Environment and People, 8(2):56-80. 2019. <http://dx.doi.org/10.26458/jedep.v8i2.627>.
13. Hodgins DC, Fick GH, Murray R & Cunningham JA. *Internet-based interventions for disordered gamblers: study protocol for a randomized controlled trial of online self-directed cognitive-behavioural motivational therapy* – BMC Public Health. 13(10). 2013. PMC 3545736 PMID 23294668.
14. Gunter, TD & Terry, NP. *The Emergence of National Electronic Health Record Architectures in the United States and Australia: Models, Costs, and Questions* – Journal of Medical Internet Research, 7, e3. 2005. <http://dx.doi.org/10.2196/jmir.7.1.e3>.
15. Mihoreanu L. *Innovative Partnering – The Key for a Healthy Society* in S.M. Riad Shams, D.Vrontis, Y.Weber, E.Tsoukatos and A. Galati (ed.) 2019, Stakeholder Engagement and Sustainability. The Annals of Business Research. 3(1):177-195, London and New York: Rutledge (Taylor & Francis Group); 2019.
16. Mihoreanu L. *A Retrospective and Prospective Analysis in the Health Management through Applied Innovation*, in Y.Weber, D.Vrontis, E. Tsoukatos and S.M. Riad Shams. Cross-Disciplinary Management Perspectives. Bingley, UK: Emerald Publishing Limited; 2019. <https://doi.org/10.1108/978-1-83867-249-220191014>.
17. Contreras CM, Metzger GA, Beane JD, Dedhia PH, Ejaz A. & Pawlik TM. *Telemedicine: Patient-Provider Clinical Engagement During the COVID-19 Pandemic and Beyond* – Journal of Gastrointestinal Surgery: Official Journal of the Society for Surgery of the Alimentary Tract. 24(7): 1692-1697. 2020.
18. Kichloo A, Albosta M, Dettloff K, Wani F, El-Amir Z, Singh J, Aljadah M, Chakinala RC, Kanugula AK, Solanki S & Chugh S. *Telemedicine, the current COVID-19 pandemic and the future: a narrative review and perspectives moving forward in the USA* – Family Medicine and Community Health. 8(3). 2020. PMID: 32816942 PMCID: PMC7437610 DOI: 10.1136/fmch-2020-000530.
19. Goodman-Casanova JM, Dura-Perez E, Guzman-Parra J, Cuesta-Vargas A & Mayoral-Cleries F. *Telehealth Home Support During COVID-19 Confinement for Community-Dwelling Older Adults with Mild Cognitive Impairment or Mild Dementia: Survey Study* – J Med Internet Res. 22(5): e19434. 2020. <https://doi.org/10.2196/19434>.
20. Rockwell KL & Gilroy AS. *Incorporating telemedicine as part of Covid-19 outbreak response systems* – Am J Manag Care. 26: 147–148. 2020. PMID: 32270980 DOI: 10.37765/ajmc.2020.42784.

21. Chirico, F, Nucera, G & Magnavita, N. *COVID-19: Protecting Healthcare Workers is a priority* – Infection Control & Hospital Epidemiology, 41(9), 1117-1117. 2020. doi:10.1017/ice.2020.148.
22. Pascu-Gabara EI & Mihoreanu L. *A Triple Layer Model to Manage Romania's Health Risks and Educational Consequences* – Journal of Economic Development, Environment and People, 8(1):29-37. 2019. doi: <https://doi.org/10.26458/jedep.v8i1.617>

ANALYSIS OF THE INFLUENCE OF NON-PERFORMING LOANS ON BANKING PERFORMANCE. CASE STUDY ON THE EXAMPLE OF THE ROMANIAN BANKING SYSTEM

Dumitru Mihai NEDELESCU¹

Oana CIULEI²

Abstract

In the current period, bank loans constitute an important component of the financial-banking systems, both at national and international level, with major implications in economic and social life, as a result of the fact that all economies are deeply concerned with ensuring a sustainable economic development and reducing the negative effects generated by the pandemic on the financial market. This study aims to analyze the relationship of variable NPL with Return on Equity (ROE), Return on Assets (ROA) and Solvency Ratio (SR). We used three linear regressions in order to analyze the influence of NPL on each of the dependent variables mentioned above. The population is represented by quarterly financial indicators reported by National Bank of Romania for the period September 2014 - June 2022. The results of this study indicate that NPL have a negative effect on financial performance (ROE), profitability (ROA) and solvency (SR).

Keywords: NPL, ROA, ROE, Solvency Ratio

JEL Classification: G21, G32.

1. Introduction

Currently, the banking system is in a permanent process of transformation, enough to place it in one of the leading positions in the process of international financial restructuring. Such an evolution is determined by the events that called into question the stability and health of the entire financial system due to the crisis. Economic conditions and market trends, as well as its dynamics, have significantly changed the configuration of banking products and services.

The role of banks is crucial in the economy as they provide a source of finance for businesses or households. Banking institutions carry out many activities to ensure their financial soundness and their continuity in the banking sector. The most well-known activities consist mainly of attracting resources in the form of deposits (passive operations) and placing them with customers in the form of loans (active operations). According to specialists in the field, lending is one of the most important activities carried out by banks,

¹ PhD Lecturer at Romanian-American University, School of Finance and Accounting, e-mail dumitru.mihai.nedelescu@rau.ro

² Student at Romanian-American University, Master of Business Management and Auditing, e-mail ciulei.d.oana21@stud.rau.ro

given the level of the loan portfolio and its share of total assets. Although lending is a main source of income, it can also be a significant source of risk for banks.

The lending activity must be efficient both for the financing institution, because by optimizing and diversifying the loan portfolio, it can obtain an increase in the degree of profitability, and for the client, who, on account of loans as the main source of financing, can develop the activity and obtain profit.

Credit risk expresses the possibility of the borrower's actual failure to meet its contractual obligations to the banking institution. This situation materializes in the inability of the bank's customers to repay loans when due and transform them into non-performing loans, negatively affecting the bank's profit and capital. A loan is considered to be non-performing if the likelihood of repayment by the borrower becomes uncertain or if the period of default exceeds 90 days.

Banks focus on monitoring loan performance during the lending process. Thus, there are many methodologies applied when granting loans to analyze the financial performance of borrowers (credit analysis), debt servicing (the borrower's ability to repay the debt when due) and the grouping of loans according to their quality.

Given the high exposure of banking activity, bank performance is a term that includes a diagnosis of profitability as well as a diagnosis of risk. In the literature, it is considered that one of the important factors reducing profitability is represented by the increase in non-performing loans. As Return on Assets and Return on Equity are the most commonly used indicators to measure a company's profitability, we chose to conduct a study on these indicators.

There is a variety of theoretical and empirical research in the literature on non-performing loans and credit risk. Many of the studies are linked to the profitability of the banks while other studies approach the factors that could determine the NPL. **Adela Socol and Adina Elena Danuletiu (2013)** analyzed the impact of loans on ROA and ROE in the period 2008-2014. Thus, the present study is a continuation of their study by analyzing the evolution of the influence of NPL on ROA and ROE for the period 2014-2022. As an extension, we will also analyze non-performing loans as the main part of a loan portfolio with direct implications for the profitability and solvency of banks.

To expand the implications of NPL on bank performance, we further decided to analyze the solvency of the banks. The solvency ratio is the ratio of total own funds (Tier 1 own funds and Tier 2 own funds) to risk-weighted assets. Solvency is achieved by reducing risk-weighted assets, while the level of own funds is kept constant or by the growth of own funds, which can imply a reduction in loans. On the other hand, the solvency can decrease with the growth in risk-weighted assets while the level of own funds is kept constant.

2. Literature review

In specialized literature, NPL are loans granted to customers with a damaged economic-financial situation, who can no longer ensure the repayment conditions. Lending, even under the conditions of achieving a balance between a prudent and efficient activity, can generate the appearance of certain dysfunctions in the form of NPL. The negative effects generated made it necessary to manage them separately by placing them in a special

portfolio. In order to keep NPL within controllable limits, banks must identify any dysfunctions that may arise in the lending process that could lead to the deterioration of the client's situation and move, as the case may be, to the application of prudential measures to recover the sums owed (amicably, execution of guarantees or initiation of bankruptcy proceedings).

According to **Stuti and Bansal (2013)**, the best indicator of the banking industry's solidity is the level of non-performing loans in the country's financial system.

Gup and Kolari (2011) state that at the time of approval, all credit decisions act as accurate credit decisions but unpredictable conditions in the economic situation and other factors such as: shocks in interest rates, changes in tax laws etc. result in credit problems.

Jolevski, Ljube (2017) studied the influence of the non-performing loans ratio on profitability indicators in the banking system of the Republic of Macedonia for the period 2007- 2015. The results of the study show a moderately high negative correlation between the non-performing loans ratio and rates of return on equity (ROE) and return on assets (ROA). According to their study, an increasing amount of nonperforming loans causes a decrease in the two main bank profitability indicators: ROA and ROE.

Achda Vellanita et al. analyzed the relationship of variable NPL with ROE at PT. BANK CENTRAL ASIA 2014 – 2018. They concluded that there is a strong negative correlation, which means that any increase in the NPL ratio will reduce the ROE ratio.

The results of the empirical study (**Kusmayadi, nd**) show that the NPL has no effect and is not significant on the profitability of Return on Assets (ROA) whereas (**Hantono, 2017**) shows that Non-Performing Loans (NPL) has a negative effect on profitability. **Pirmanta Sebayang** used a multiple regression and concluded that NPL does not affect the Return On Equity (ROE) and the increase or decrease in the ratio of NPL does not have an impact on Return On Equity (ROE).

Aysegul Berrak Koten (2021) studied the effect of non-performing loans on profitability for public and private banks in the Turkish banking system. **In this way, it was found that non-performing loans had a decreasing effect on the return on assets in the Turkish banking system in parallel with many studies in the literature.** The purpose of this study was to determine the effects of Non-Performing Loans/Total Loans and Loan/Deposit Ratio on the Return on Assets for the period 2010.Q1-2020.Q4 for 3 public capitals, 8 private capitals, and 16 foreign capital banks in the banking system with the panel regression analysis as a result of which it was found that when the Non-Performing Loans/Total Loans variable increased 1 unit, the ROA variable decreased 0.230 units, and when the Loan/Deposit Ratio increased 1 unit, the ROA variable increased 0.115 units. That being said, some studies show different relationships between NPL and profitability indicators of the banks.

Petr Jakubík and Thomas Reininger provide a macroeconomic model for nonperforming loans (NPLs) for the Central, Eastern and Southeastern European (CESEE) countries. Their model is based on panel data for Bulgaria, Croatia, the Czech Republic, Hungary, Poland, Romania, Russia, Slovakia and Ukraine. In line with current literature, their empirical analysis confirmed that economic growth is the main driver that is negatively correlated with NPL development.

Other authors determine that increased competition among banks affects increasing banks' exposure to credit risk, i.e. their credit portfolio quality is reduced as a result of relaxation of lending standards and criteria to collect greater credit market share (Jeong and Jung, 2013; Bolt and Tieman, 2004).

As said before, a big part of empirical literature is focused on examining the determinants of non-performing loans. A relevant study that investigates the impact of macroeconomic factors on non-performing loans is the one conducted by Teodor Hada et al. (2019) for Romania. Most studied macroeconomic factors are: gross domestic product growth, inflation rate, unemployment rate, interest rates and the exchange rate.

In the study conducted by **Isaiah Oino** it was concluded that efficiency, asset quality, and economic growth have a significant positive effect on the solvency of banks. This paper studies the effect of liquidity and credit risks on banking solvency using a panel dataset of the UK's ten major banks from 2009 to 2018. The results indicate that both credit and liquidity risk are significant in influencing the solvency of banks.

3. Methodology

We developed three regression models (NPL_ROA and NPL_ROE and NPL_SR) to determine if the NPL ratio affects ROA, ROE and SR in the Romanian banking system. The data is collected from the electronic web page of National Bank of Romania during September 2014 to June 2022 on a quarterly basis. The dependent variables are considered ROA, ROE and the Solvency Ratio (SR), while the independent variable is NPL.

4. Conceptual Framework

The specialized literature highlighted a series of quasi-unanimous indicators accepted by banks for the analysis of economic and financial performance. Some of them have imposed themselves in banking practice in the form of requirements promoted by the domestic and international legislation that regulates the activity of banks, while others represent an effective tool for analyzing banking performance.

The analysis of these indicators provides, to the management body of the banks, information of great importance both for the future evolution and for their performance. The purpose of this analysis is to frame the banks' activity in the management body's strategy, focused on financial performance, prudence, legislative and competitive restrictions.

The responsible management of non-performing loans represents an important activity of banking institutions and is an effective way of managing credit risks and regrouping the funds needed for lending.

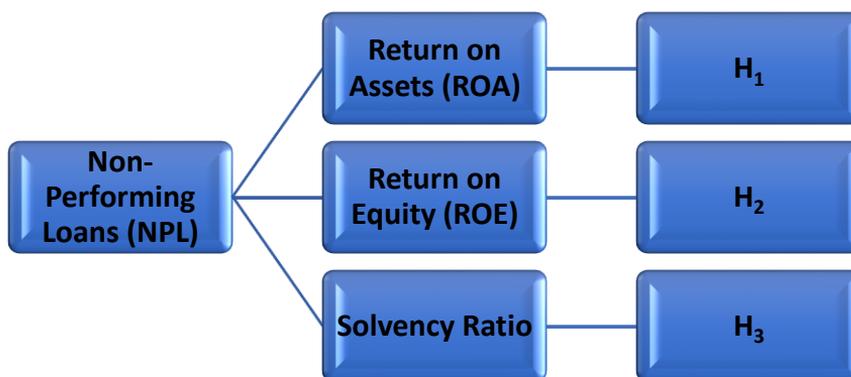


Figure 1: Research Concept Framework

The coefficients of correlation between the non-performing loans ratio and the specific indicators showing the degree and direction of their connection are presented in the following table:

Indicators	Pearson correlation coefficient with the share of non-performing loans to total loans
Return on assets (ROA)	-0.7285
Return on equity (ROE)	-0.72206
Solvency Index	-0.74344

Table 1. Coefficients of correlation

Profitability indicators show a negative correlation with non-performing loans ratio. There is a negative correlation of -0.7285 between the rate of return on assets (ROA) and the non-performing loans ratio (NPL), indicating that the increased amount of non-performing loans has a significant impact on reducing the profitability ratio. As the rate of Return on Assets can reflect the efficiency in generating revenues through company’s assets, it can be concluded that a higher indicator of non-performing loans could contribute to reducing the effective management of assets.

The rate of return on equity (ROE) and NPL shows a similar negative correlation of -0.72206. The correlation coefficient indicates that with increasing the non-performing loans ratio, the rate of return on equity is decreased. This result can be explained by the fact that by increasing NPLs, banks are forced to recognize provisions that will further affect the capital structure and profit structure.

We further analyzed the influence of the NPL on the solvency of Romania’s banking institutions. In Romania, credit institutions shall be required to maintain at all times the indicator at a level of at least 12%.

The solvency indicator shows a negative correlation with non-performing loans ratio. There is a negative correlation of -0.74344 between the Solvency Ratio (SR) and the non-performing loans ratio (NPL), indicating that the increased amount of non-performing loans has a significant impact on reducing the solvency ratio. As SR measures how well a company's cash flow can cover its long-term debt, it can be concluded that a higher indicator of non-performing loans could contribute to reducing the effective management of cash flow.

Specification of the econometric model describing the link between the two variables

From the Scatter Diagram it can be seen that the distribution of points x_i, y_i can be approximated very well with a straight line (trendline), so it can be assumed that the econometric model describing the relationship between variables is a linear model: $y = E(Y|X) = \alpha + \beta x + \varepsilon$, where α and β -parameters of the model. It is observed that $\beta < 0$ (slope/slope of the line) which confirms the hypothesis that the variables are directly negatively related: increasing x leads to decreasing y .

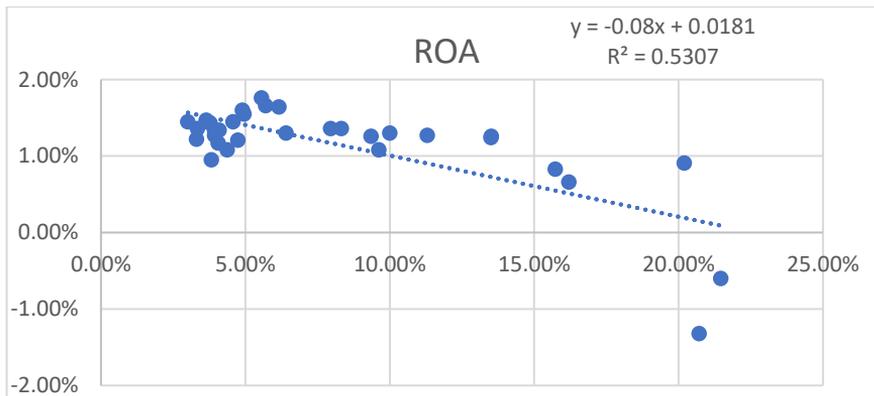


Figure 2: Scatter Diagram ROA

The scatter diagram for ROE shows a similar result, whereas NPL has a more significance on ROE, compared to ROA.

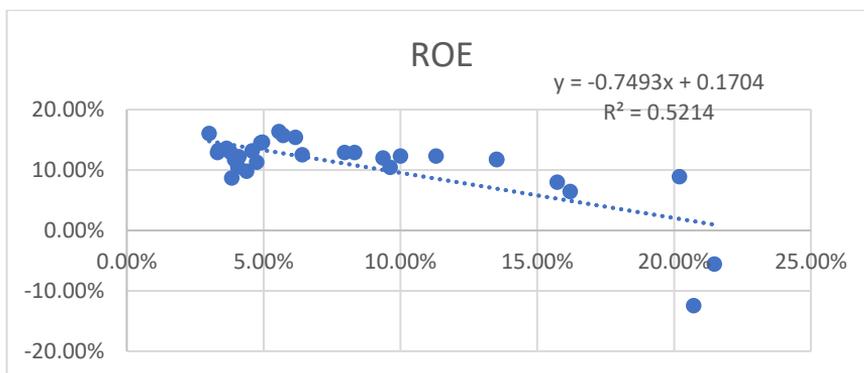


Figure 3: Scatter Diagram ROE

The negative correlation is also proven for the relationship between NPL and Solvency Ratio through the following figure:

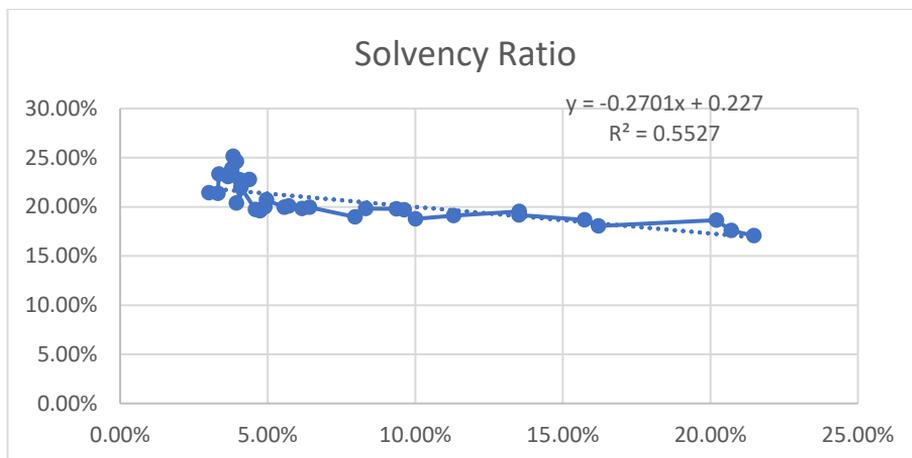


Figure 4: Scatter Diagram Solvency Ratio

We will further conduct the regression analysis on these indicators to determine how the change in the movement of non-performing loans affects the movement of ROA, ROE and SR. Data processing conducts to the following results considering the dependent variable ROA (Return on assets), ROE (Return on equity) and SR (Solvency Ratio).

Characteristics of the ROA - Return on assets regression model

<i>Regression Statistics</i>	
Multiple R	0.728502486
R Square	0.530715872
Adjusted R Square	0.515073068
Standard Error	0.004245689
Observations	32

Based on the econometrical model we can estimate the quality on the model using the value of R-squared. That being said, we can appreciate that 53.07% of ROA could be explained by the variation of NPL.

Characteristics of the ROE - Return on equity regression model

<i>Regression Statistics</i>	
Multiple R	0.722058368

R Square	0.521368286
Adjusted R Square	0.505413896
Standard Error	0.040520479
Observations	32

A similar result is obtained for ROE where 52.14% of ROE can be explained by the variation of the NPL. The value of the R-squared shows that the dependent variables are influenced by other factors that weren't considered in the analysis. The residual part of the variation shows that 46,03% of ROA is explained by other factors and 47,86% of ROE is explained by other factors and NPL is not the only determinant variable.

Characteristics of the SR – Solvency Ratio regression model

<i>Regression Statistics</i>	
Multiple R	0.743447
R Square	0.552713
Adjusted R Square	0.537803
Standard Error	0.013713
Observations	32

The regression analysis on these indicators determines how the change in the movement of NPL affects the movement of Solvency Ratio. Based on the econometrical model, we can appreciate that 55.27% of Solvency Ratio could be explained by the variation of NPL. The value of the R-squared shows that the dependent variable is influenced by other factors that weren't considered in the analysis. The results are similar to the previous regression model. Following the same idea, the residual part of the variation shows that 44,13% of movement in the Solvency Ratio can be explained by other factors and NPL is not the only determinant variable.

ROA regression model is represented by the estimation equation:

$$y = - 0.08x + 0.0181$$

The regression equation calculation concludes that if the share of non-performing loans in total loans is increased by 1 percentage point, the indicator of return on assets will be reduced by 0.08 pp.

ROE regression model is represented by the estimation equation:

$$y = - 0.7493x + 0.1704$$

From the regression equation it can be concluded that if the non-performing loans ratio is increased by 1 percentage point, then the rate of return on equity will be reduced by 0.7493 pp.

The results of the analysis confirm that non-performing loans may significantly impact the profitable position of banks for the studied period (Q3 2014 – Q2 2022), however it leaves space to study other variables that may affect the profitability indicators.

Solvency Ratio regression model is represented by the estimation equation:

$$y = - 0.0018x + 0.235$$

The regression equation calculation concludes that if the share of non-performing loans in total loans is increased by 1 percentage point, the indicator of solvency will be reduced by 0.0018 pp. On the other hand, in the specialized literature, it is considered that credit institutions increase their solvency levels through disintermediation, i.e. by decreasing loan balances (thus decreasing the NPL).

The results of the analysis are similar to the previous ones, confirming that non-performing loans may significantly impact the solvency banks for the studied period (Q3 2014 – Q2 2022) and that other variables could affect the solvency ratio of the banks.

Non-performing loans and performance in the banking system in Romania

The pro-cyclical character of banks' operations is perceived not only through the movement of loans, but also through the profitability and efficiency of the banking system (Jolevski, Ljube (2017). Figure 2 shows the movement in the NPLs rate, ROA and ROE from starting with Q3 2014 to Q2 2022.

The deteriorated quality of loan portfolio in 2014 and the fall of ROE can be explained by the initiation of the process of writing-off the unrecoverable NPLs. The process of writing-off the uncollectable nonperforming loans was considered a necessary condition for the sustainability of credit portfolios.

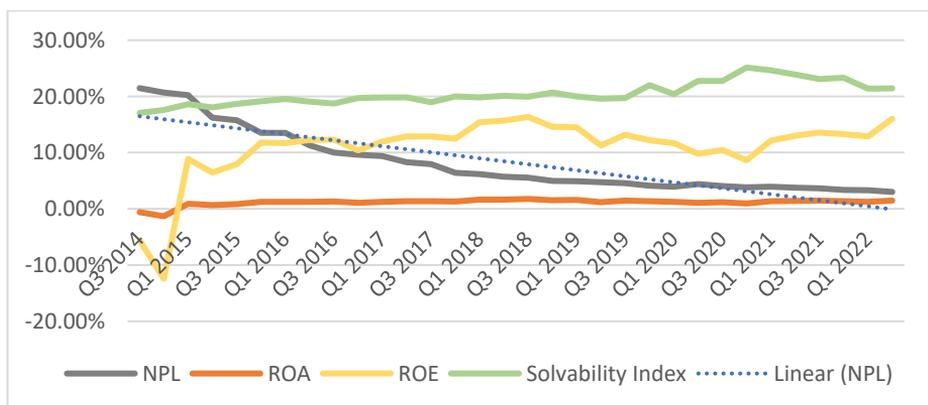


Figure 5. Quarterly Evolution of the Basic performance indicators and NPL ratio between 2014 –2022 (Source: National Bank of Romania)

Thus, starting with 2014 the NPL rate registered a continuous decrease in the balance sheet of the banks operating in Romania. This is a result of the recommendation made by the National Bank of Romania – to register adjustments for depreciation.

The results of this initiative cause a decrease in the NPL rate from 21.47% in September 2014 to 3.01% in June 2022. ROE started with a minimum of -12.45% in December 2014 and registered 16.02% in June 2022. On the other hand, ROA registered more constant values with a minimum of -1.32% in December 2014 to a maximum of 1.76% in September 2018. Out of the three indicators, the Solvency Ratio had the most constant evolution, starting from the base point of 17.06% in December 2014 to 21.43% in June 2022.

On a historical basis, when the global financial crisis effects were felt by the Romanian economy, non-performing loans started to increase. However, for the period 2019-2021, non-performing loans did not record significant increases amid the COVID-19 crisis. These results show sound governance which requires constant supervision and measures to control non-performing loans. We should consider that the effects of crises are known with a delay. According to GEO 37/2020 as amended by GEO 227/2020, Suspension of payment consists of suspending, at the client's request, the obligation to pay the instalments (representing capital instalments, interest and credit fees) for up to 9 months. Variations may occur after the end of the suspension period if the customer is still in difficulty.

The risk picture for Romania's banking sector shows solid capitalization, while asset quality and solvability has improved, with banks reporting a lower rate of non-performing loans.

According to Romanian banks, the risk of default on loans contracted by the non-governmental sector represents a high/difficult to manage systemic risk. Credit risk remains important for the banking sector, although developments in have led to a decline in non-performing loan (NPL) ratios. As the average interest rates on new and existing term loans have accelerated considerably in recent months so it is of interest to monitor the evolution of NPLs in the future.

5. Conclusions

The results of the analysis are in accordance with the literature review, showing that NPL has a negative influence on ROA, ROE and Solvability Ratio. An increase in NPL causes reduction of 0.08 pp in ROA, 0.7493 pp in ROE and 0.0018 pp in solvability ratio. Thus, the highest impact of NPL growth is reflected towards ROE and ROA. This conclusion can be explained by the fact that banks are recognizing provisions to cover the NPL, affecting the result and equity structure. Also, the increase in NPL affects the quality of asset portfolio.

We have highlighted the importance of lending in economy and the role of banks as intermediaries. As companies and households are facing difficulties to grant their loans, banks are also faced with the risk of uncollectable loans and interests. To cover this credit risk, banks must analyze borrower's creditworthiness and tighten credit standards in case of high NPL growth. This practice could further slowdown the growth in loan portfolio but could stabilize the solvency of the bank institutions. Other specialists also say that credit

institutions increase their solvency levels through disintermediation which means a decreasing in loan balances.

In this way, our study proved that credit risk - manifested through growth of NPL, is one of the most important factors affecting the soundness of the bank institutions in Romania banking system. We found that Romania banking system successfully controlled the variation of NPL by constantly decreasing this indicator for the period Q3 2014 – Q2 2022. This positive result (decreasing of NPL) is obtained thanks to a sound regulation and supervision implemented by National Bank of Romania. The implication of NBR shows significant results on the Solvability Ratio as Romanian commercial banks have undertaken not to lower this indicator below 10%. This has been successfully achieved with the lowest solvency ratio of 17.06% being registered in 2014.

This study can be the basis for further research on another NPL implications. Such research can include the influence of macroeconomic factors on non-performing loans ratio in the banking system of Romania. A similar study has been conducted before; however it would be relevant to further analyze the impact of external factors on NPL in an inflationary economy shadowed by the military conflict as can be seen in 2022.

The limitations of this study were represented by data collection as NBR publishes the information for the key performance indicators only, such as ROA, ROE, NPL, or Solvency Ratio. Thus, we were limited to analyzing a tighter spectrum of indicators. However, these limitations make room for another study that could focus on NPL's influence on other profitability indicators for the top-ranked banks in Romania. The performance indicators are presented in the Financial Reports published by the banks.

References

1. Achda Vellanita, I Gede Arimbawa, Elok Damayanti (2019) “*Relationship between non-performing loans (NPL), capital adequacy ratio (CAR), loan to deposit ratio (LDR) towards return on equity (ROE) at pt. bank central asia 2014 – 2018*” in Journal of World Conference Vol.1 No.2 (2019), pp.211-216
2. Gup, B. and Kolari, G. (2005) „*Commercial banking - Risk management*“, Skopje, Ars Lamina
3. Jolevski, Ljube (2017): *Non-performing loans and profitability indicators: The case of the Republic of Macedonia*, Journal of Contemporary Economic and Business Issues, ISSN 1857-9108, Ss. Cyril and Methodius University in Skopje, Faculty of Economics, Skopje, Vol. 4, Iss. 2, pp. 5-20
4. Hada, Teodor, Nicoleta Bărbuță-Mișu, Iulia Cristina Iuga, and Dorin Wainberg, 2020, "Macroeconomic Determinants of Nonperforming Loans of Romanian Banks", Sustainability 12, no.18: 7533. <https://doi.org/10.3390/su12187533>
5. Hantono. (2017). *Effect of capital adequacy ratio (CAR), loan to deposit ratio (LDR) and non-performing loan (NPL) to return on assets (ROA) listed in banking in Indonesia stock exchange*, 5(1), 69–80.

6. Isaiah Oino (2021). *Bank solvency: The role of credit and liquidity risks, regulatory capital and economic stability*. *Banks and Bank Systems*, 16(4), 84-100. doi: 10.21511/bbs.16(4).2021.08
7. Jakubík P. and Reininger T. 2014. *What are the Key Determinants of Nonperforming Loans in CESEE?*
8. Jeong, S. and Jung, H. (2013) “*Bank Wholesale Funding and Credit Procyclicality: Evidence from Korea*”, *Panoeconomicus*, pp. 615-631 available at: https://www.researchgate.net/publication/254444639_Bank_Wholesale_Funding_and_Credit_Procyclicality_Evidence_from_Korea (accessed 13 November 2022)
9. Kusmayadi, D. (2018). *Analysis of Effect of Capital Adequacy Ratio, Loan to Deposit Ratio, NonPerforming Loan, BOPO, and Size On Return On Assets In Rural Bank at Indonesia*, *Saudi Journal of Business and Management Studies*, 3(7), 786-795
10. Koten, A.B., (2021). *Determination of the relationship between non-performing loans and profitability in the Turkish banking system with panel regression analysis*, *PressAcademia Procedia (PAP)*, 14, 14-19.
11. Sebayang P (2020), *The Impact of the Capital Adequacy Ratio, Non-Performing Loan Against to Return on Equity (Case Study PrivateBank in Indonesia)*. SHS Web of Conf 76:01035. (PDF) *The impact of green lending on credit risk: evidence from UAE's banks*. Available from: https://www.researchgate.net/publication/358075063_The_impact_of_green_lending_on_credit_risk_evidence_from_UAE's_banks [accessed Nov 20 2022].

INDUSTRY 4.0 AND DIGITAL GREEN INNOVATION WITH THE MEDIATING ROLE OF DIGITAL GREEN KNOWLEDGE CREATION: AN EVIDENCE FROM VIETNAM

Yao Lin Ong¹

Bo Hsiao²

Nguyen Hong Huan³

Abstract

Digital and green innovations are Industry 4.0's sustainable development trends. Eco-friendly innovation must include digital technologies to boost its performance and firm competitiveness. This study uses 171 Vietnamese manufacturing staff survey data to examine a new conceptual framework. The structural model is analyzed using PLS-SEM. The study illustrates a positive association between Industry 4.0 (I4.0), digital business intensity (DBI), and digital green innovation performance (DGIP) through mediating role of digital green knowledge creation (DGKC). The findings enrich the body of the current literature on high-technical factors impacting DGIP and the role of DGKC with DGIP in the technology eco-friendly integration context. It also provides several practical implications to help businesses improve their competitiveness, survival, and development.

Keywords: Industry 4.0, Digital Business Intensity, Digital Green Innovation Performance, Digital Innovation, Green Innovation, Digital Green Knowledge Creation, Knowledge Management

JEL Classification: I6

1. Introduction

Industry 4.0 is widely applied worldwide, making companies and organizations more concerned about the environment. It requires the design of pollution prevention and mitigation measures for business activities. In addition, governments and corporations also emphasize green innovation as a solution to environmental and economic challenges (Tang et al., 2020). The term "green innovation" includes techniques, products, services, businesses, and management strategies to reduce environmental risks and pollution through the rational use of resources and applying alternative solutions. Companies have used more environmentally friendly materials and less damaging processes (Ma et al., 2018). This has been so widespread that many predict that industrial companies will improve the environment and quality of life by encouraging companies to create environmentally friendly technologies and promote their long-term viability (Mubarak et al., 2021).

¹ Professor, Chang Jung Christian University, ylong@mail.cjcu.edu.tw

² Professor, Chang Jung Christian University, bhsiao@mail.cjcu.edu.tw

³ PhD Student, Chang Jung Christian University, 111D00111@mail.cjcu.edu.tw

Most research on green innovation focuses on technology or processes, and it is crucial to understand how green products and digital innovation will be integrated (Cheng et al., 2021). Wicki & Hansen (2019) has found the link between human knowledge and green technology and its consequences. According to Meirun et al. (2021), companies must choose between economic development and environmental protection in a sustainable economy. Despite many investigations of innovation in green technology, very few studies have examined green innovation and digital technology (Yin & Yu, 2022). The authors also suggested that future research in digital green innovation could use the PLS-SEM model to get more reliable research results and increase the variety and breadth of sample sources. Therefore, they suggested including them in future research to gain a deeper understanding of the issue.

The research provides several academic contributions:

- (1) It studies the impact of DGKC on DGIP in the context of the Vietnamese manufacturing sector.
- (2) It examines why high-tech investments and practices are necessary for increasing DGIP.
- (3) It proves the influence of I4.0 and DBI on DGIP with DGKC-mediated support. Besides, the article also helps businesses overview how high-tech practices and investments such as I4.0 and DBI have affected DGKC and DGIP.

2. Literature review

2.1 Concept definition

2.1.1 Industry 4.0

I4.0 is the next generation of business breakthroughs that transcends earlier ones, such as electricity and automation, in which people, machines, and computer systems share real-time data (Maganga & Taifa, 2022). It provides businesses with more efficient ways to manage their supply chains and operations by digitizing nearly all of their manufacturing processes and allowing them to offer new products and services to their electronic customers. In addition, this technology can assist leaders by making management more collaborative and enabling firms to produce outstanding results (Bai et al., 2020). The assembly of manufacturing components enhances the company's processes, operational efficiency, quality, responsiveness, and overall performance. Ghobakhloo (2020) says that I4.0 improves processes, makes them more efficient, fixes quality problems, and gives real-world ways to reduce rework and waste (Liu et al., 2022).

2.1.2 DBI

According to Nwankpa et al. (2022), DBI represents the strategic growth of a company's technology through investments in analytics, cloud infrastructure, social networking sites, mobile platforms, and big data. DBI is founded on strategic investment decisions for future commercial, transactional, and functional differentiation, distinct from the theoretical underpinnings of information technology (IT) capabilities, consisting of existing systems, processes, channels, and people. In contrast to IT's concentration on optimizing present

assets, DBI research focuses primarily on identifying prospective future investment prospects; when a company invests in cutting-edge, emerging technology, this is known as disruptive business innovation (or DBI). Businesses utilize DBI to adapt IT resources to a changing business environment and enhance performance. It is crucial for a company's success that organizations with a high DBI integrate cutting-edge digital technology into their processes, hence boosting performance (Nwankpa & Datta, 2017).

2.1.3 DGKC

The past economies will be replaced by new, superior economic growth fueled by digitization, cloud computing, artificial intelligence, and the Internet. This change is primarily attributable to the continuous discovery and development of new information (Yin & Yu, 2022). As information-based innovation activities gain prominence, the generation of new knowledge has become a crucial aspect of the development and survival of businesses. During the age of digitalization, the capacity to gather enormous amounts of cyberspace data using AI technology and other technical advances is essential for strengthening innovation capabilities. Thus, industrial firms can achieve sustainable growth by renewing digital technology and creating eco-friendly knowledge (Chen et al., 2019). Prior research has focused chiefly on sustainable knowledge creation in sustainability practices, whereas information resource generation in digitalization has received relatively less focus (Magnier-Watanabe & Benton, 2017). From a knowledge-based perspective, Yin & Yu (2022) state that knowledge capital is a crucial factor that impacts corporate strategy selection and resource allocation, as well as a significant source of competitive advantage for the business.

2.1.4 Knowledge-based view

Since digital innovation includes knowledge discovery, application, and transformation, the knowledge-based view (KBV) acts as the conceptual framework basis for this research (Saldanha et al., 2020). According to the KBV, knowledge is the most critical strategic asset for value development and competitiveness (Alavi & Leidner, 2001; Grant, 1996). Previous research indicates that innovations are the consequence of a company's quest for new opportunities and its willingness to experiment with relevant information to expand current progress into novel sectors of the economy (Saldanha et al., 2020). Innovative learning and problem-solving skills are associated with knowledge management techniques. Companies with superior knowledge management, especially knowledge creation, may stimulate innovation (Plessis, 2007). I4.0 and DBI highlight an organization's proactive information-collecting and synthesis activities. KBV adapted its operations to the digital economy by concentrating on DBI and I4.0 procedures. Knowledge is an essential asset for generating value as well as accumulating economic rents. The emphasis has switched from gathering information as a resource towards integrating explicit and tacit knowledge to providing non-replicable, unique, and enduring value (Nwankpa et al., 2022).

2.2 Hypotheses development and research model

2.2.1 The impact of DGKC on DGIP

Resources, the environment, and digital and physical transformations limit green digital innovation; exploitative knowledge development helps businesses decrease variability and duplication of information (Nair & Munusami, 2019). Businesses cannot randomly embrace environmental and technological transformation, but only expertise that has been successfully accepted and shown helpful in other organizations will be used. Modest competencies in DGIP enable firms to enhance digital green products or access current markets, which helps firms dominate the market for digital green goods (Shen et al., 2020). The previous studies have shown that information use enhances company creativity (Jiang et al., 2020). The discussion provides the following hypothesis:

H1: DGKC has a positive impact on the DGIP.

2.2.2 The impact of I4.0 on DGIP performance

I4.0 approaches to maximize the utilization of energy, assets, and people (Lasi et al., 2014). It also encourages using big data, blockchain technology, and the Internet of Things to make manufacturing more autonomous (Mubarak et al., 2021). According to (Machado et al., 2020), environmental performance could be improved by synchronizing the deployment of I4.0 technologies with desired environmental outcomes that assure maximum sustainable output. Song & Wang (2016) say that making industrial processes more eco-friendly is possible by looking at I4.0 developments and data from several IoT devices. Productivity is boosted by using quality management and digital technology. Economic, social, and administrative potential are all enhanced by I4.0 sociotechnical developments (Beier et al., 2020). I4.0 may aid green technological advancements. Environmental measures taken during the whole life cycle of a product lead to sustainable and ethical business practices (Gurtu & Johny, 2019). According to Piyathanavong et al. (2019), I4.0 skills and investment are required to enhance DGIP performance. Presented in this argument is the following hypothesis:

H2. I4.0 has a positive impact on the DGIP.

2.2.3 The impact of I4.0 on DGKC

I4.0 was created to enhance global competitiveness and adapt production to fluctuating market demands (Capestro & Kinkel, 2020). Due to these needs, modern production methods like unsupervised robots, efficient production technologies, additive manufacturing, and simulation have become much more productive and efficient (Rojko, 2017). Nevertheless, I4.0 is a comprehensive solution connecting all value chain actors with production and commercial operations. Therefore, information and past knowledge are vital for expanding corporate operations (Agrawal et al., 2018). Coordination and information are vital to digital transformation's economic and industrial benefits (Müller, 2019). Ardito et al. (2019) state new technologies for collecting, storing, and making data make integration easier for the supply chain. In a broader sense, the digital revolution generates new data that enhances selection, altering the company's business operations and architecture (Jerman et al., 2019). The authors, based on the argument, present the following hypothesis:

H3. I4.0 has a positive impact on the DGKC.

H4. I4.0 has a positive impact on the DGIP through DGKC.

2.2.4 The impact of DBI on DGIP

According to KBV's view, research into the past indicates that DBI will affect digital innovation. Through connectedness, adaptability, and reengineering, digital resources may stimulate creativity. In a digitally pervasive society, anecdotal evidence suggests that digital tools stimulate creativity. Technological developments provide digital features that allow firms to produce information, facilitate various operations, and efficiently utilize internal resources (Yoo et al., 2012). Trantopoulos et al. (2017) demonstrated that investing in digital technology allows businesses to develop new ideas, reposition and incubate, leading to technology transformation and achievements. Digital technology helps organizations to collect and promote external digital innovation. Combining the digital and physical economies improves innovation output, efficiency, and costs, making it an essential starting point for addressing environmental issues (Wei et al., 2022). Consequently, The DGIP efforts of industrial enterprises and the influence of digital technology on green innovation should be investigated. Therefore, the following hypothesis based on the above justifications has been proposed:

H5. DBI has a positive impact on the DGIP.

2.2.5 The impact of DBI on DGKC

As a result of the insights gleaned by big data, firms may utilize the additional time and money to expand in different ways. Data analytics consumption patterns and information strengthen knowledge management operations and strategies. In fact, Sumbal et al. (2017) have demonstrated that using big data in the fossil fuel industries may enhance knowledge management and result in better-informed choices. In addition to being crucial to knowledge management, data, information, and knowledge sharing are extensively distributed through digital platforms and technology (Razmerita et al., 2009). Khan & Vorley (2017) digital service platforms are essential to accumulating and exchanging enormous quantities of explicit knowledge, which is essential for information management. Additionally, innovative technologies enable individuals in many locations to produce new information and disseminate already-created information (Von Krogh et al., 2012). Companies are enhancing their DBI by integrating digital technologies into their operations. DBI creates vast quantities of data, information, and knowledge by combining connectivity with big data (Bharadwaj et al., 2013). This trend is expected to continue as these tools facilitate the development of novel methods for creating, sharing, and collaborating on information. The authors thus expect this association to hold the following:

H6. DBI has a positive impact on the DGKC.

H7. DBI has a positive impact on the DGIP through DGKC.

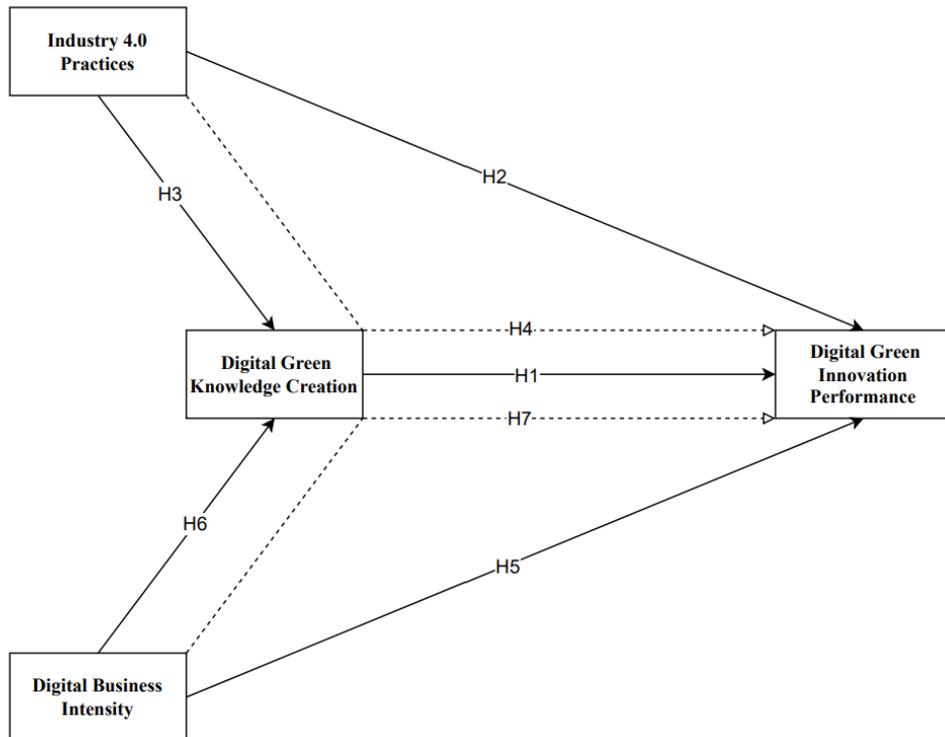


Figure 1. Research model

3. Research design

3.1 Measures

Measurements of numerous factors were derived from several prior research investigations. Items for I4.0 were derived from Saha et al. (2022). Digital business intensity measurement items were adapted from Nwankpa et al. (2022). DGKC and innovation performance indicators were adapted from Yin & Yu (2022).

3.2 Sampling Design

The data was acquired using convenience approaches from Vietnam's manufacturing operators working for various companies. Due to the Covid epidemic, only electronic communications were used to get the necessary data. The data was collected using email and Google forms and gathered in October 2022 in Vietnam by distributing a link to electronic questionnaires to manufacturing staff. Respondents were asked to rate their degree of agreement with statements on a scale ranging from one to five, with one denoting severe strong disagreement and five representing strong agreement. The questionnaire was completed by 171 respondents, and legible replies were chosen for further analysis; thus, the collected responses may be efficiently utilized to assess the hypothesis of this study. The characteristics of the sample are illustrated in Table 1 below.

Characteristics	Distribution	Frequency	%
GENDER	Male	122	71.35%
	Female	49	28.65%
AGE	20-30	96	56.14%
	30-40	48	28.07%
	40-50	16	9.36%
	>50	11	6.43%
EDUCATION	Bachelor	167	97.66%
	Master	4	2.34%

Table 1. Sample characteristics⁴

3.3 Data Analysis

The SPSS 26 and SmartPLS 3.3 software are used to analyze data. Smart partial least squares, a structural equation modelling (SEM) method based on variance, was used to analyze the data (Smart-PLS). Path analysis was created for hypothesis testing, and smart-PLS was used to implement structural equation modelling (Le, 2022).

4. Finding

4.1 Measurement model analysis

The measuring model was evaluated to determine the reliability and validity of the items used to evaluate I4.0, DBI, DGKC, and DGIP. The key metrics to examine the reported reliability and validity are shown in Table 2 below. Cronbach's Alpha indexes for all variables and all composite reliability among the defined factors are more than 0.70, confirming the validity of all measures in this research (Hair et al., 2017). Regarding the reliability test, the findings indicate that specific factor loadings and average variance extracts (AVE) for all items are more prominent than 0.7 and 0.5, which is acceptable compared to the acceptance standards (Hair et al., 2017). Convergent validity was thus supported. According to Hair et al. (2014), discriminant validity is demonstrated if one structure is sufficiently distinguishable from the others. According to Fornell & Larcker (1981), discriminant validity is demonstrated once the square root of each construct's AVE is larger than the correlations between the constructs. Table 3 displays the values that satisfy the requirements specified by Fornell & Larcker (1981).

Furthermore, for a model to be well-structured, the Heterotrait-Monotrait Ratio (HTMT) must be less than 1.0. However, Henseler et al. (2015) argue that a discriminant value is formed between the selected pair of constructs if HTMT is less than 0.9. Table 4 illustrates that all values within the table are respectively less than 0.9. This confirms the conclusion that all reliability and validity have been shown.

⁴ Source(s): Author's work

Constructs	Items	Factor loading	Cronbach's Alpha	Composite reliability	AVE
DBI	DBI_1	0.837	0.872	0.913	0.723
	DBI_2	0.846			
	DBI_3	0.875			
	DBI_5	0.843			
DGIP	DGIP_1	0.866	0.894	0.922	0.703
	DGIP_2	0.813			
	DGIP_3	0.804			
	DGIP_4	0.837			
	DGIP_5	0.871			
DGKC	DGKC_1	0.826	0.888	0.918	0.691
	DGKC_2	0.813			
	DGKC_3	0.859			
	DGKC_4	0.813			
	DGKC_5	0.845			
I4.0	I40_1	0.848	0.887	0.917	0.688
	I40_2	0.819			
	I40_3	0.833			
	I40_4	0.806			
	I40_5	0.840			

Table 2. Result of reliability and convergent validity

	DBI	DGIP	DGKC	I4.0
DBI	0.850			
DGIP	0.756	0.839		
DGKC	0.788	0.786	0.832	
I4.0	0.725	0.738	0.790	0.829

Table 3. Fornell-Larcker Criterion

	DBI	DGIP	DGKC	I4.0
DBI				

DGIP	0.853		
DGKC	0.892	0.878	
I4.0	0.823	0.826	0.888

Table 4. Heterotrait-Monotrait Ratio

4.2 Indexes of Fit

The following model fit indexes have been evaluated: R^2 has values of 0.685 and 0.722 for DGKC, and DGIP. Besides, DGKC and DGIP have respective Q^2 values of 0.490 and 0.473, which are more than 0. The f^2 values of all variables were superior and more than 0.02. The SRMR value of 0.049 (<0.08) indicated that the model fits the data well (Hair et al., 2017). The findings demonstrate that the indices meet the standards suggested by the present research. Thus, the model has a high degree of predictive ability.

4.3 Hypothesis testing and discussion

The hypothesized hypothesis and path coefficients were tested using the bootstrapping method with a 5,000-sample loop once the validity and reliability of the measurement model and the overall model fit had been validated. The results of the SEM analysis are shown in Table 5.

Table 5 shows that DGKC positively and significantly influences DGIP (0.369; $p<0.001$). The discovery of a positive link between DGKC and DGIP is consistent with the research of Albort-Morant et al. (2018), which knowledge management found to enhance an organization's capacity to use natural resources effectively to become environmentally friendly. Knowledge creation promotes innovation, allowing businesses to generate high-quality goods and services at a reduced cost and with little natural resource use. The analytical results support Hsu and Sabherwal (2012), who found knowledge management a vital innovation precursor. This finding is also corroborated by Song et al. (2020). They found that green knowledge enhances a company's ability to use resources and expand sustainably efficiently. This indicates that the capacity of an organization to manage green knowledge is directly proportional to its capacity for green innovation; the greater it is capacity to manage green knowledge, the greater it is capacity for green innovation. This conclusion is inferentially significant because companies should not make digital expenditures in a vacuum; instead, their digital investment decisions should reflect their current knowledge and management skills.

Further, the statistical results confirm the existence of positive and significant relationships between the remaining variables, particularly between I4.0 and DGIP (0.230; $p\leq 0.001$) and DGKC (0.460; $p<0.001$); between DBI and DGIP (0.298; $p\leq 0.001$) and DGKC (0.454; $p<0.001$). The analytical result also demonstrates a correlation between DBI and I4.0 on DGIP and provides empirical support for previously anecdotal findings about the influence of DBI and I4.0 on innovation (Trantopoulos et al., 2017). Our findings underscore the enabling function of technology investments and applications and contribute to the expanding body of research that tries to comprehend the processes through which businesses may exploit digital investments to foster innovation and current strengths.

Moreover, a well-aligned DBI and I4.0 may foster knowledge creation, thus boosting innovation performance. However, a misaligned DBI and I4.0 might bring disruptive developments that may inhibit an organization's ability to exploit its knowledge management skills. Consequently, managers must grasp that technology investments and applications are fundamentally strategic.

Besides, the analysis results indicate p-values less than 0.001 for the relationships I4.0→DGKC→DGIP and DBI→DGKC→DGIP. The link between I4.0 and DGIP, as well as DBI and DGIP, is thus mediated by DGKC. In other words, in this circumstance, I4.0 and DBI influence DGIP through DGKC. Therefore, it may be concluded that all study hypotheses were supported.

Hypothesis	Relationship	Paths Coefficients	t-statistics	p-values	Conclusions
H1	DGKC → DGIP	0.369	4.860	0.000	Supported
H2	I4.0 → DGIP	0.230	3.296	0.001	Supported
H3	I4.0 → DGKC	0.460	6.756	0.000	Supported
H4	I4.0 → DGKC → DGIP	0.170	3.805	0.000	Supported
H5	DBI → DGIP	0.298	3.267	0.001	Supported
H6	DBI → DGKC	0.454	6.524	0.000	Supported
H7	DBI → DGKC → DGIP	0.168	3.952	0.000	Supported

Table 5. Path analysis and hypothesis testing

5. Implications

This study's findings are significant for the digital green knowledge creation processes of manufacturing businesses in Vietnam's implementation of digital transformation to accomplish sustainable objectives. During the adoption phase of digital green knowledge production, businesses must prioritize investments in high-tech and digital technological practices, such as big data, AI, Blockchain, and IoT. The data indicate that DGKC has the most significant influence on promoting DGIP. I4.0 and DBI have a significant boosting impact on DGKC. Some theoretical and standardized information is complex for firms to use immediately. However, such information may assist businesses in gaining a deeper understanding of the fundamental causes of innovation issues and exploring digital green knowledge production schemes based on their organizational context. Managers should devote sufficient resources and time to the process of creating digital solutions for the development of environmentally friendly knowledge. In this way, not only can employees get a comprehensive and accurate understanding of digital green knowledge development, but they can also make practical implementation. Businesses should also consider the amount of digital green knowledge creation. Companies should not rely excessively on previous achievements. Businesses must be more patient when exploring digital green knowledge production.

6. Conclusions, limitations, and future research

In conclusion, our research demonstrates that DBI and I4.0 are necessary and effective catalysts for following digital green innovations in a world where digital technologies and innovation are prevalent. In analyzing the downstream consequences of DBI and I4.0 practices, we reveal how knowledge management, particularly DGKC, functions as a catalyst and mediator for DGIP. Organizations must use their DBI and implement I4.0 to achieve a knowledge management state. Attempting to exploit a current DBI while examining for unforeseen situations might result in an overload of information and hinder a company's ability to embrace new performance. This study provided a more complex depiction of innovation success by emphasizing the intersections and interactions of downstream responsibilities and expectations for investments and digital technologies utilization.

The study, like several other studies, has several drawbacks. First, the study focused on Vietnamese circumstances, although differences in contextual variables may impact the relevance of research results and implications for practice in other contexts. Consequently, future research may compare outcomes with more regionally unique characteristics in various situations. The current study focuses on the manufacturing sector. To broaden the perspectives, future research might concentrate on additional domains. Third, although this study mainly relied on quantitative approaches, future research may choose a blended multi-methods strategy to bring additional views.

Bibliography

Agrawal, A., Schaefer, S., & Funke, T. (2018). Incorporating Industry 4.0 in Corporate Strategy. In *Analyzing the Impacts of Industry 4.0 in Modern Business Environments* (pp. 161–176). IGI Global.

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly: Management Information Systems*, 25(1), 107–136.

Albort-Morant, G., Leal-Rodríguez, A. L., & de Marchi, V. (2018). Absorptive capacity and relationship learning mechanisms as complementary drivers of green innovation performance. *Journal of Knowledge Management*, 22(2), 432–452.

Ardito, L., Petruzzelli, A. M., Panniello, U., & Garavelli, A. C. (2019). Towards Industry 4.0: Mapping digital technologies for supply chain management-marketing integration. *Business Process Management Journal*, 25(2), 323–346.

Awan, U., Kraslawski, A., & Huiskonen, J. (2018). The impact of relational governance on performance improvement in export manufacturing firms. *Journal of Industrial Engineering and Management*, 11(3), 349–370. <https://doi.org/10.3926/jiem.2558>

Bai, C., Dallasega, P., Orzes, G., & Sarkis, J. (2020). Industry 4.0 technologies assessment: A sustainability perspective. *International Journal of Production Economics*, 229, 107776. <https://doi.org/10.1016/J.IJPE.2020.107776>

- Beier, G., Ullrich, A., Niehoff, S., Reißig, M., & Habich, M. (2020). Industry 4.0: How it is defined from a sociotechnical perspective and how much sustainability it includes – A literature review. *Journal of Cleaner Production*, 259, 120856.
- Bharadwaj, A., Sawy, O. A. el, Pavlou, P. A., & Venkatraman, N. (2013). Digital Business Strategy: Toward a Next Generation of Insights. *MIS Quarterly*, 37(2), 471–482.
- Capestro, M., & Kinkel, S. (2020). Industry 4.0 and knowledge management: A review of empirical studies. *Knowledge Management and Organizational Learning*, 9, 19–52. https://doi.org/10.1007/978-3-030-43589-9_2/TABLES/2
- Ceptureanu, S. I., Ceptureanu, E. G., Luchian, C. E., & Luchian, I. (2018). Community Based Programs Sustainability. A Multidimensional Analysis of Sustainability Factors. *Sustainability 2018, Vol. 10, Page 870, 10(3)*, 870.
- Chen, T., Fu, M., Liu, R., Xu, X., Zhou, S., & Liu, B. (2019). How do project management competencies change within the project management career model in large Chinese construction companies? *International Journal of Project Management*, 37(3), 485–500. <https://doi.org/10.1016/j.ijproman.2018.12.002>
- Cheng, Y., Awan, U., Ahmad, S., & Tan, Z. (2021). How do technological innovation and fiscal decentralization affect the environment? A story of the fourth industrial revolution and sustainable growth. *Technological Forecasting and Social Change*, 162, 120398. <https://doi.org/10.1016/J.TECHFORE.2020.120398>
- Dalenogare, L. S., Benitez, G. B., Ayala, N. F., & Frank, A. G. (2018). The expected contribution of Industry 4.0 technologies for industrial performance. *International Journal of Production Economics*, 204, 383–394.
- Dong, X., Köhler, M. H., Jakobi, M., & Koch, A. W. (2019). Hyperspectral imaging microscopy for thickness measurement and surface characterization of layered MoS₂. In P. Lehmann, W. Osten, & A. Albertazzi Gonçalves (Eds.), *Optical Measurement Systems for Industrial Inspection XI* (Vol. 11056, p. 60). SPIE.
- du Plessis, M. (2007). The role of knowledge management in innovation. *Journal of Knowledge Management*, 11(4), 20–29.
- Elibal, K., & Özceylan, E. (2022). Comparing industry 4.0 maturity models in the perspective of TQM principles using Fuzzy MCDM methods. *Technological Forecasting and Social Change*, 175, 121379.
- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1), 39–50.
- Ghobakhloo, M. (2020). Industry 4.0, digitization, and opportunities for sustainability. *Journal of Cleaner Production*, 252, 119869.
- Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, 17(S2), 109–122. <https://doi.org/10.1002/SMJ.4250171110>
- Gurtu, A., & Johny, J. (2019). Potential of blockchain technology in supply chain management: a literature review. *International Journal of Physical Distribution and Logistics Management*, 49(9), 881–900.

- Hair, J. F., Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G. (2014). Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *European Business Review*, 26(2), 106–121.
- Hair Jr, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling (PLS-SEM)*. Sage publications.
- Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, 43(1), 115–135.
- Jerman, A., Potniški, L., Ivan, S., Tpv, E., & Bertoneclj, S. A. (2019). The Influence of Critical Factors on Business Model at a Smart Factory: A Case Study. *Business Systems Research : International Journal of the Society for Advancing Innovation and Research in Economy*, 10(1), 42–52. <https://doi.org/10.2478/bsrj-2019-0004>
- Jiang, W., Rosati, F., Chai, H., & Feng, T. (2020). Market orientation practices enhancing corporate environmental performance via knowledge creation: Does environmental management system implementation matter? *Business Strategy and the Environment*, 29(5), 1899–1924. <https://doi.org/10.1002/BSE.2478>
- Kerin, M., & Pham, D. T. (2019). A review of emerging industry 4.0 technologies in remanufacturing. *Journal of Cleaner Production*, 237, 117805.
- Khan, Z., & Vorley, T. (2017). Big data text analytics: an enabler of knowledge management. *Journal of Knowledge Management*, 21(1), 18–34.
- Kim, C., & Park, J. H. (2013). Explorative search for a high-impact innovation: the role of technological status in the global pharmaceutical industry. *R&D Management*, 43(4), 394–406. <https://doi.org/10.1111/RADM.12026>
- Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business and Information Systems Engineering*, 6(4), 239–242.
- Le, T. T. (2022). Corporate social responsibility and SMEs' performance: mediating role of corporate image, corporate reputation and customer loyalty. *International Journal of Emerging Markets, ahead-of-print*(ahead-of-print).
- Levy, M. (2009). WEB 2.0 implications on knowledge management. *Journal of Knowledge Management*, 13(1), 120–134.
- Liu, Q., Trevisan, A. H., Yang, M., & Mascarenhas, J. (2022). A framework of digital technologies for the circular economy: Digital functions and mechanisms. *Business Strategy and the Environment*, 31(5), 2171–2192. <https://doi.org/10.1002/BSE.3015>
- Lu, Y., Papagiannidis, S., & Alamanos, E. (2018). Internet of things: A systematic review of the business literature from the user and organisational perspectives. *Technological Forecasting and Social Change*, 136, 285–297.
- Ma, Y., Hou, G., Yin, Q., Xin, B., & Pan, Y. (2018). The sources of green management innovation: Does internal efficiency demand pull or external knowledge supply push? *Journal of Cleaner Production*, 202, 582–590.

- Machado, C. G., Winroth, M. P., & Ribeiro da Silva, E. H. D. (2020). Sustainable manufacturing in Industry 4.0: an emerging research agenda. *International Journal of Production Research*, 58(5), 1462–1484.
- Maganga, D. P., & Taifa, I. W. R. (2022). Quality 4.0 conceptualisation: an emerging quality management concept for manufacturing industries. *TQM Journal*.
- Magnier-Watanabe, R., & Benton, C. (2017). Management innovation and firm performance: the mediating effects of tacit and explicit knowledge. *Knowledge Management Research & Practice*, 15(3), 325–335.
- Meirun, T., Mihardjo, L. W., Haseeb, M., Khan, S. A. R., & Jermsittiparsert, K. (2021). The dynamics effect of green technology innovation on economic growth and CO2 emission in Singapore: new evidence from bootstrap ARDL approach. *Environmental Science and Pollution Research*, 28(4), 4184–4194.
- Mubarak, M. F., Tiwari, S., Petraite, M., Mubarik, M., & Raja Mohd Rasi, R. Z. (2021). How Industry 4.0 technologies and open innovation can improve green innovation performance? *Management of Environmental Quality: An International Journal*, 32(5), 1007–1022. <https://doi.org/10.1108/MEQ-11-2020-0266>
- Müller, J. M. (2019). Antecedents to Digital Platform Usage in Industry 4.0 by Established Manufacturers. *Sustainability 2019, Vol. 11, Page 1121, 11(4)*, 1121.
- Nwankpa, J. K., & Datta, P. (2017). Balancing exploration and exploitation of IT resources: The influence of Digital Business Intensity on perceived organizational performance. *European Journal of Information Systems*, 26(5), 469–488.
- Nwankpa, J. K., & Roumani, Y. (2016). IT Capability and Digital Transformation: A Firm Performance Perspective. *Thirty Seventh International Conference on Information Systems*.
- Nwankpa, J. K., Roumani, Y., & Datta, P. (2022). Process innovation in the digital age of business: the role of digital business intensity and knowledge management. *Journal of Knowledge Management*, 26(5), 1319–1341. <https://doi.org/10.1108/JKM-04-2021-0277>
- Pavlou, P. A., & el Sawy, O. A. (2011). Understanding the Elusive Black Box of Dynamic Capabilities. *Decision Sciences*, 42(1), 239–273.
- Piyathanavong, V., Garza-Reyes, J. A., Kumar, V., Maldonado-Guzmán, G., & Mangla, S. K. (2019). The adoption of operational environmental sustainability approaches in the Thai manufacturing sector. *Journal of Cleaner Production*, 220, 507–528.
- Razmerita, L., Sudzina, F., & Kirchner, K. (2009). Personal knowledge management: The role of Web 2.0 tools for managing knowledge at individual and organisational levels. *Online Information Review*, 33(6), 1021–1039.
- Rojko, A. (2017). Industry 4.0 concept: Background and overview. *International Journal of Interactive Mobile Technologies*, 11(5).
- Saha, P., Talapatra, S., Belal, H. M., & Jackson, V. (2022). Unleashing the Potential of the TQM and Industry 4.0 to Achieve Sustainability Performance in the Context of a Developing Country. *Global Journal of Flexible Systems Management*.

- Saldanha, T. J. v., Sahaym, A., Mithas, S., Andrade-Rojas, M. G., Kathuria, A., & Lee, H.-H. (2020). Turning Liabilities of Global Operations into Assets: IT-Enabled Social Integration Capacity and Exploratory Innovation. *Information Systems Research, 31*(2), 361–382. <https://doi.org/10.1287/isre.2019.0890>
- Schroeder, A., Ziaee Bigdeli, A., Galera Zarco, C., & Baines, T. (2019). Capturing the benefits of industry 4.0: a business network perspective. *Production Planning & Control, 30*(16), 1305–1321. <https://doi.org/10.1080/09537287.2019.1612111>
- Sedera, D., Lokuge, S., Grover, V., Sarker, S., & Sarker, S. (2016). Innovating with enterprise systems and digital platforms: A contingent resource-based theory view. *Information & Management, 53*(3), 366–379.
- Shen, H., Lan, F., Xiong, H., Lv, J., & Jian, J. (2020). Does top management Team's academic experience promote corporate innovation? Evidence from China. *Economic Modelling, 89*, 464–475.
- Song, M., & Wang, S. (2016). Can employment structure promote environment-biased technical progress? *Technological Forecasting and Social Change, 112*, 285–292.
- Song, M., Yang, M. X., Zeng, K. J., & Feng, W. (2020). Green Knowledge Sharing, Stakeholder Pressure, Absorptive Capacity, and Green Innovation: Evidence from Chinese Manufacturing Firms. *Business Strategy and the Environment, 29*(3), 1517–1531. <https://doi.org/10.1002/BSE.2450>
- Sumbal, M. S., Tsui, E., & See-to, E. W. K. (2017). Interrelationship between big data and knowledge management: an exploratory study in the oil and gas sector. *Journal of Knowledge Management, 21*(1), 180–196.
- Tang, K., Qiu, Y., & Zhou, D. (2020). Does command-and-control regulation promote green innovation performance? Evidence from China's industrial enterprises. *Science of The Total Environment, 712*, 136362.
- Trantopoulos, K., von Krogh, G., Wallin, M. W., & Woerter, M. (2017). External knowledge and information technology. *MIS Quarterly, 41*(1), 287–300.
- Nair, B., & Munusami, C. (2019). Knowledge management practices: An exploratory study at the Malaysian higher education institutions. *Journal of Research in Innovative Teaching & Learning, 13*(2), 174–190.
- von Krogh, G., Nonaka, I., & Rechsteiner, L. (2012). Leadership in Organizational Knowledge Creation: A Review and Framework. *Journal of Management Studies, 49*(1), 240–277. <https://doi.org/10.1111/J.1467-6486.2010.00978.X>
- Wei, S. W., Du, L. M., & Pan, S. (2022). How can digital economy promote green innovation—Empirical evidence from Chinese cities. *Financ. Econ, 1–14*.
- Wicki, S., & Hansen, E. G. (2019). Green technology innovation: Anatomy of exploration processes from a learning perspective. *Business Strategy and the Environment, 28*(6), 970–988. <https://doi.org/10.1002/BSE.2295>
- Yayavaram, S., & Ahuja, G. (2008). Decomposability in Knowledge Structures and Its Impact on the Usefulness of Inventions and Knowledge-base Malleability. *Administrative Science Quarterly, 53*(2), 333–362.

Yin, S., & Yu, Y. (2022). An adoption-implementation framework of digital green knowledge to improve the performance of digital green innovation practices for industry 5.0. *Journal of Cleaner Production*, 363.

Yoo, Y., Boland, R. J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for Innovation in the Digitized World. *Organization Science*, 23(5), 1398–1408.

ADVANTAGES AND CHALLENGES REGARDING THE USAGE OF DRONES IN E-COMMERCE

Dana-Mihaela PETROȘANU¹

Alexandru PÎRJAN²

Abstract

E-commerce has been on the rise in recent years, as more and more businesses have moved their operations online. There are many advantages to this shift, including increased reach, lower costs, and greater convenience. However, there are also some challenges that need to be addressed, such as security and delivery. One potential solution to some of these challenges is the use of drones. Drones have many advantages when it comes to e-commerce, such as being able to navigate around obstacles, carrying heavy loads, and working in difficult weather conditions. They also have the potential to be much faster than traditional delivery methods. Nevertheless, there are also some challenges that need to be considered when using drones for e-commerce. These include the potential for crashes, regulations, and privacy concerns. Under these circumstances, this paper aims to study the use of drones in e-commerce, in view of identifying directions that have to be followed in view of improving the efficiency and safety of e-commerce.

Keywords: E-commerce, Drones, Advantages, Challenges, Delivery

JEL Classification: L62, L81, L87, L93

1. Introduction

E-commerce is currently one of the most popular methods of shopping, however it has several areas in which it could be improved. One such area is the use of drones to improve the efficiency of e-commerce. Due to the increasing popularity of drones, it is important to study the current state of their usage in e-commerce activity. There is a growing body of literature on the subject, which suggests that drones can have a positive impact on e-commerce. The main challenges for using drones in e-commerce are safety and regulation. However, there are drone-based solutions for these challenges.

A drone is an unmanned aircraft or spacecraft, typically controlled by a remote pilot or by on-board computers. Drones have a long history, with the first UAVs being used in World War I for reconnaissance missions. Modern drones are used for a variety of purposes, including surveillance, photography, mapping, search and rescue. A brief history of drones would start with the use of balloons for surveillance during the American Civil War followed by the use of unmanned, remotely piloted aircraft during World War I. Drones

¹ PhD Lecturer, Department of Mathematics-Informatics, University Politehnica of Bucharest, dana.petrosanu@upb.ro

² PhD Hab. Professor, School of Computer Science for Business Management, Romanian-American University, alex@pirjan.com

truly came into their own during the Cold War with the use of reconnaissance drones by both the United States and the Soviet Union [1].

In recent years, there has been an exponential increase in drone usage by both civilian and military organizations around the world. Drones can be classified according to a plethora of criteria, such as their range, flight time, payload, and autonomy. Controlled drones are those that are always under the control of a remote pilot, while autonomous drones are capable of flying without human intervention. The main features of controlled drones include their small size, quiet operation, and ability to fly in difficult-to-reach places. Potential applications for controlled drones include surveillance, mapping, delivery, search and rescue. The main features of autonomous drones include their ability to fly for long periods of time and to cover large areas. In addition, they can also be classified into categories based on their weight, size, intended use, and how they are launched.

According to [1], the four main categories are "multi-rotor", "single-rotor", "helicopter", and "fixed-wing". Multi-rotor drones are the most popular type of drones. They are easy to fly and can stay in the air for a long time. Single-rotor drones are harder to fly but can go faster and further. Helicopter drones are the most stable in the air but can only stay in the air for a short time. Fixed-wing drones are the fastest but are more difficult to control. Another common classification method of drones is by the altitude criteria. Drones can be classified as "either low", "medium", or "high altitude". Low altitude drones are those that fly below 400 feet, medium altitude drones fly between 400 and 10,000 feet, and high-altitude drones fly above 10,000 feet. The criteria "range" is also commonly used as a method of classification. Therefore, drones can be classified as either short range, medium range, or long range. Short range drones have a range of less than 50 miles, medium range drones have a range of 50 to 500 miles, while long-range drones have a range of greater than 500 miles.

Drones can be either controlled or autonomous. Controlled drones are those that require a human operator to control them, while autonomous drones are those that can operate without a human operator. Autonomous drones are further classified as either "semi-autonomous" or "fully autonomous". Semi-autonomous drones are those that require a human operator to control them part of the time, while fully autonomous drones are those that can always operate without a human operator [1].

The weight of a drone determines how much it can carry and how much power it needs. The heavier the drone, the more powerful the motors and batteries need to be. The size of a drone determines how much space it takes up and how much wind it can fly in. The larger the drone, the more space it will need to take off and land. The smaller the drone, the less wind it can fly in. The intended use of a drone determines what it can be used for. Drones can be used for photography, videography, mapping, surveying, search and rescue, and for more other activities. The way a drone is launched determines how it gets into the air. Drones can be launched by hand, from a ground station, or from a ship or vehicle.

Several companies are already making use of drones, including Amazon [2], Google [3], Apple, Intel, Microsoft, Uber [4], Prime Time Air, FedEx, UPS Flight Forward, DHL Parcelcopter, Wing, Matternet, Zipline, Flytrex, Flirtey, Wingcopter [5]. These companies use drones for a variety of purposes including delivery, data collection, and mapping. There

are a number of legal aspects concerning drones that are still being worked out, but there are some concerns about privacy and safety.

As the usage of drones or Unmanned Aerial Vehicles (UAVs) has increased rapidly in recent years, covering a wider range of applications such as photography, journalism, search, rescue, and delivery services, a number of legal aspects concerning drones have emerged. This increase in popularity has been accompanied by a corresponding increase in the number of legislative issues. The main legislative challenges faced by drone operators relate to obtaining operating licenses, ensuring regulatory compliance, addressing privacy and liability concerns. Operating licenses are typically required for commercial drone operations, and the process for obtaining a license can be complex and time-consuming. In order to ensure regulatory compliance, drone operators must be aware of the relevant rules and regulations governing the use of UAVs in their jurisdiction.

Privacy issues are of particular concern when drones are equipped with cameras, and there have been a number of instances where drone operators have been accused of invading the privacy of individuals. In order to address these concerns, drone operators should take steps to ensure that they are not capturing images of individuals without their consent. Liability issues can also arise in relation to the use of drones, particularly in the event of an accident or incident involving a UAV. In order to address these concerns, drone operators should ensure that they have adequate insurance coverage in place. Airspace issues can also be a challenge for drone operators, as there are a number of restrictions in place on the use of UAVs in certain areas. In order to overcome these challenges, drone operators should familiarize themselves with the relevant rules and regulations governing the use of UAVs in their jurisdiction.

The use of drones for e-commerce has been of great interest to many countries and organizations for a variety of reasons. One of the most important reasons is the potential for increased efficiency and productivity. Current postal and shipping systems are often slow and unreliable, and drones could provide a much-needed update. In addition, the use of drones could also help to reduce traffic congestion and pollution.

There is a substantial body of literature on the subject that argues for the importance of studying this topic. In particular, the current literature points to the potential of drones to improve the efficiency and effectiveness of e-commerce. The advantages of using drones in e-commerce are many and varied. Drones can be used to deliver goods to customers in a timely and efficient manner. They can also be used to improve the accuracy of inventory management and to reduce the need for manual labor in the warehouse. In addition, drones offer the potential to improve customer service by providing real-time information on the status of orders and by offering customer assistance. The main challenges for using drones in e-commerce are also numerous. These include issues related to regulatory hurdles, public acceptance, technology, safety and security. However, there are drone-based solutions for each of these challenges. With proper planning and execution, drones can be used to improve the efficiency and effectiveness of e-commerce.

The study of drones in e-commerce is important for several reasons. Firstly, the use of drones in e-commerce is a rapidly growing phenomenon. Secondly, the literature on drones in e-commerce is still in its infancy, and there is a need for more research in this area.

Thirdly, the use of drones in e-commerce has the potential to improve the efficiency and effectiveness of e-commerce operations.

The purpose of this paper is to review the scientific literature regarding the usage of drones in e-commerce activity. It will argue that drones can improve e-commerce by increasing efficiency and reducing costs. The paper highlights the advantages of using drones in e-commerce, as well as the main challenges that need to be overcome in order to make this a reality. It is important to study this topic in order to better understand the potential benefits and drawbacks of using drones in e-commerce, as well as the feasibility of this technology.

There is a rapidly growing interest in the use of drones in e-commerce, as evidenced by the sharp increase in the number of scientific articles published on the subject in recent years. Some of the benefits of conducting a literature review on drones and e-commerce include understanding the potential benefits of using this technology, familiarizing oneself with the current state of the art, and becoming familiar with the current debates surrounding the use of drones. In addition, this research can help identify gaps in the existing literature and provide suggestions for future research.

Arguments in favor of the importance of carrying out this review include the following: (1) the potential of drones to revolutionize e-commerce by providing fast, efficient, and cost-effective delivery of goods; (2) the need to better understand the opportunities and challenges posed by drone technology; and (3) the scarcity of empirical research on the use of drones in e-commerce.

The upcoming sections of the paper are as follows. In section 2, "Research Methodology" there are presented the search query, the filtering process, details regarding the final pool of scientific papers concerning the number of publications per year, the classification of the retrieved publications by type, the number of article type documents by subject area, the number of article type documents by Web of Science index. Section 3, "Results" presents a synthesis of several scientific articles tackling the role of drones in e-commerce, selected by applying the devised methodology (3 of the most recent articles, along with 3 of the most highly cited ones) and an interpretation of this synthesis. Afterwards, Section 4, "Discussion and Conclusions", highlights the most important findings of the paper, presents an analysis of the conducted review research, highlighting a few limitations of this study and future research directions.

2. Research Methodology

To evaluate the potential of drones for e-commerce, it is necessary to first understand the existing literature on the topic. The academic scientific community has been discussing the feasibility of using drones for e-commerce for many years. Recently, there have been more studies that focus on the need and benefits of reviewing the scientific literature on this topic. The Web of Science (WoS) database is a good place to start because it includes a large number of journals and other sources that cover a wide range of topics. In this purpose, we have used the Web of Science database for querying the terms "drone*" and "*commerce", we have not limited our search to a certain publication period and, as a first remark, we have noticed that due to the actuality of the approached subject, the search within the WoS database has returned scientific papers published within the period 2016-2022.

By running the search query on the 5th of September 2022, we have obtained an Initial Pool of Scientific Papers (IPSP) from the literature, consisting of 43 papers. Afterwards, after having filtered the IPSP, 40 papers remained that were further considered in this study, representing the Final Pool of Scientific Papers (FPSP). The above-mentioned filtering process consists of eliminating the irrelevant papers in what concerns each of these criteria: the type of the publication, its title, the abstract, the content.

In the following, we present a series of plots based on the obtained IPSP, plots that we have computed in view of achieving a preliminary image regarding these papers, in what concerns their publication year (Figure 1), their classification (Figure 2), the approached subject area(s) (Figure 3), their corresponding Web of Science Index (Figure 4). Regarding the Figures 3 and 4, one must note that article type document might appear in several categories, this being the reason that the total number of papers depicted in these Figures surpasses 43.³

The data retrieved from Clarivate Web of Science and depicted in Figure 1 indicate that the interest for the topic of using drones in e-commerce has increased significantly over the last years. The number of publications has tripled since 2018 (from 5 scientific papers up to 15 papers in 2022). This is a clear indication that the scientific community is interested in the topic and is carrying out research on it.

In Figure 2, we have depicted the number of publications by type on the topic of using drones in e-commerce based on the data retrieved from Clarivate Web of Science. The data reveals that there are a total of 43 (89.58%) article type documents, 4 (8.33%) early access article type documents, and 1 (2.08%) book chapter article type. An early access article is a type of article that is published online in advance of its official publication in a peer-reviewed journal. Early access articles are typically made available as soon as they have been accepted for publication, having undergone complete peer-review, only the date of official publication having not being set for them. Early access articles are relevant for our conducted review study because they provide timely access to new research findings. In addition, early access articles are often free to access, which makes them a very good source of information for our study.

The data retrieved from Clarivate Web of Science and represented in Figure 3 indicates that there is a total of 43 article type documents that have been published on the topic of using drones in e-commerce covering various subject areas. The analysis depicts that the majority of publications on the topic of using drones in e-commerce are in the fields of Management, Operations Research Management Science, and Transportation Science Technology. There are also a significant number of publications in the fields of Computer Science Information Systems, Engineering Multidisciplinary, Engineering Electrical Electronic, Environmental Studies, Telecommunications and Transportation.

³ Source: The figures were devised based on the official data provided by Clarivate Web of Science on 5th of September 2022.

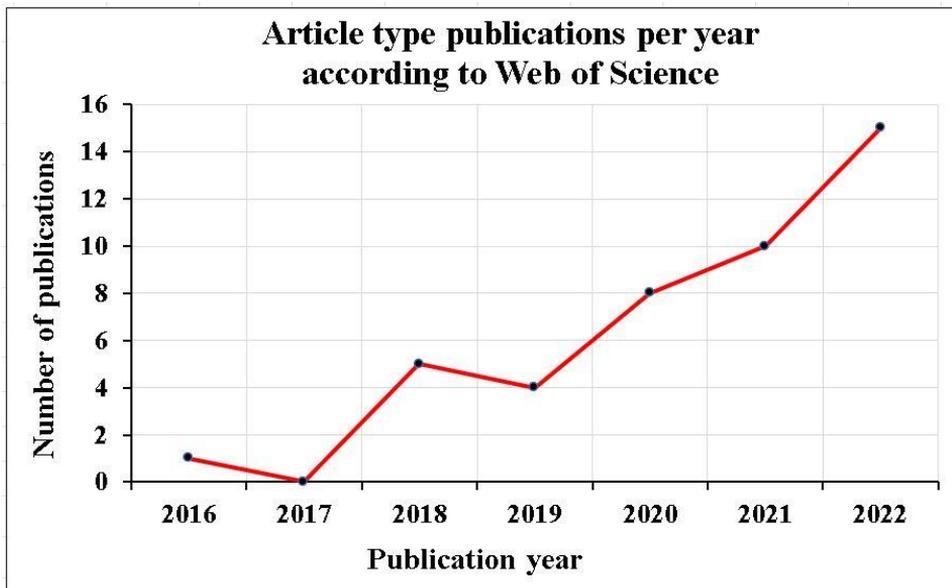


Figure 1. Article type publications per year according to WoS

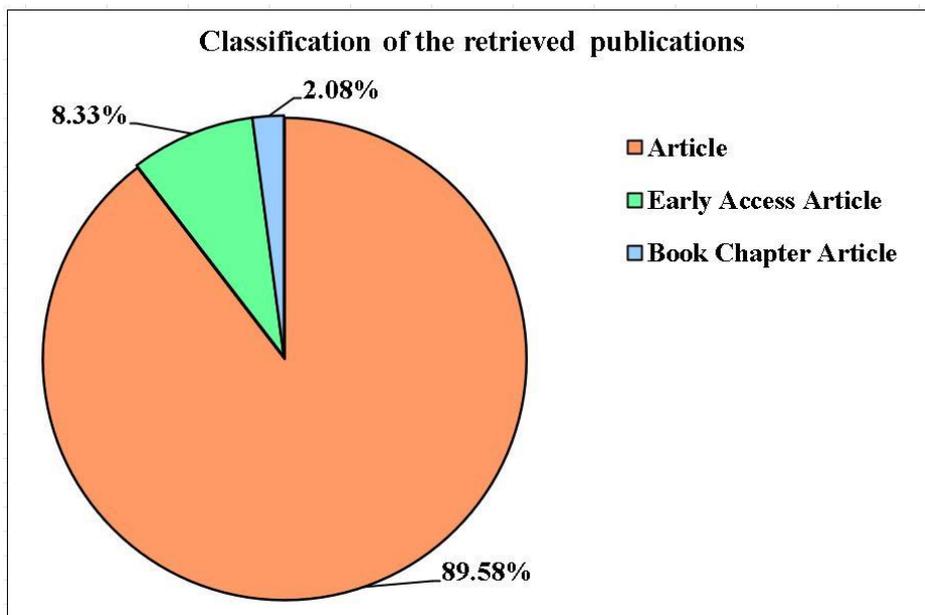


Figure 2. Classification of the retrieved publications

This is to be expected, because these are the fields that are most directly related to the topic, as they deal with the technology and infrastructure that is necessary for the use of drones in e-commerce. Overall, the data indicates that there is a significant amount of interest in

the topic of using drones in e-commerce, this amount being likely to increase in the future, as the use of drones in e-commerce becomes more widespread.

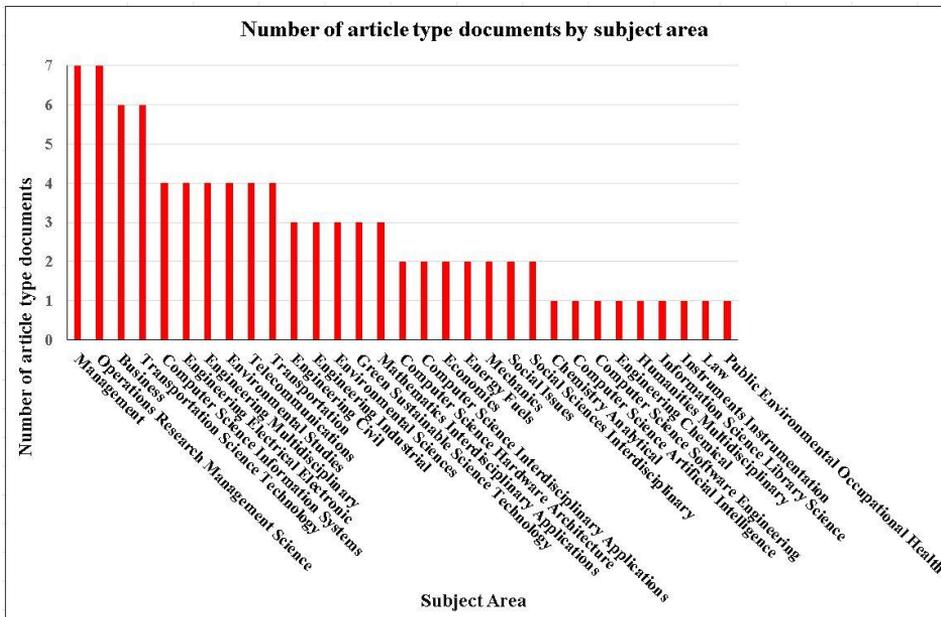


Figure 3. Number of article type documents by subject area

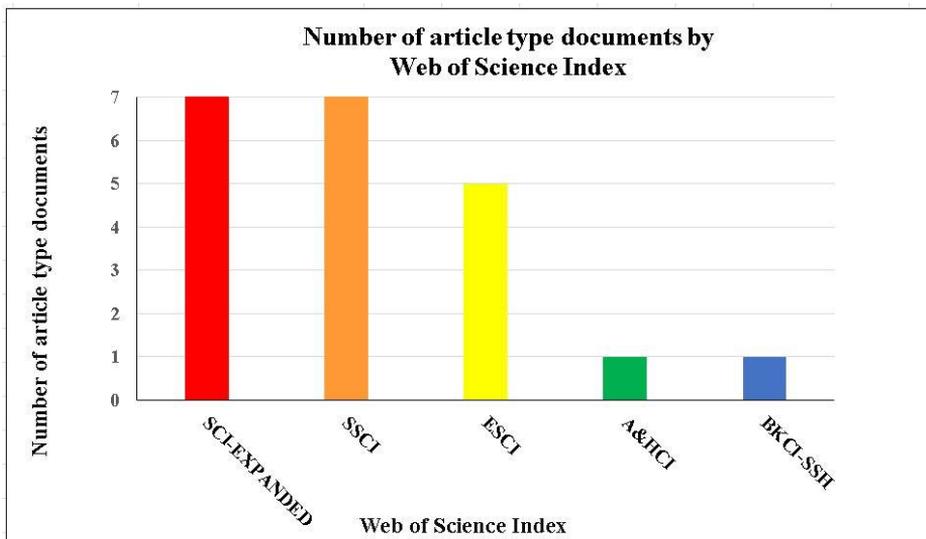


Figure 4. Number of article type documents by WoS index

It is important to analyze the number of publications by Web of Science Index in order to understand the prevalence of the topic referring to the usage of drones in e-commerce. Based on the Clarivate Web of Science data, we have noticed that this topic started to be

researched quite extensively. There are a total of 27 articles indexed in the Science Citation Index Expanded (SCI-EXPANDED), 24 in the Social Sciences Citation Index (SSCI), 5 in the Emerging Sources Citation Index (ESCI), one article in the Book Citation Index - Social Sciences & Humanities (BKCI-SSH), and one in the Arts & Humanities Citation Index (A&HCI) (Figure 4).

For the time being, only the Social Sciences Citation Index (SSCI) and Science Citation Index Expanded (SCI-EXPANDED) have an impact factor. However, this will change starting with 2023 when all journals indexed in the WoS Core Collection will have an impact factor, including the journals indexed in the A&HCI⁴. Overall, this data shows that using drones in e-commerce is a popular topic of research and one that is growing in popularity.

3. Results

The studies from the FPSP database cover a wide range of targets, such as: "last mile drone delivery" [6-14], customer acceptance [6, 7, 15-19], delivery optimization [12, 20-27], secure commerce [28-30], environmental impact [8, 12, 14, 23, 31, 32], the usefulness of drones during the pandemic [6-8, 13, 14, 18, 20]. Regarding the devised and implemented approaches, the studies made use of single, stand-alone methods [8, 19, 31, 33-35] or hybrid, combined ones [6, 7, 9, 15-17, 20, 21, 27, 36-38].

Based on the above-mentioned methodology, we have summarized a number of 6 articles from the scientific papers pool that tackle the role of drones in e-commerce, selecting 3 of the most recent along with 3 of the most highly cited papers (Table 1). When we constructed the final pool of scientific papers (FPSP) after devising the search query on the 5th of September 2022, we have identified 3 of the most recently published papers [6], [15] and [33] (published in 2022) and the most highly cited papers, namely [27] (89 citations), [38] (85 citations) and [19] (64 citations).

No.	The reference number, the publication year	The purpose of the study	The implemented methods	The obtained results
1	[6] 2022	analyzing the adoption of drone delivery in Thailand	an online survey combined with specific frameworks (Diffusion of Innovations Theory", "Word-of-Mouth Marketing",	Consumers are willing to accept drone delivery. The intention to adopt such services is strongly influenced by the ease of use and is very little influenced

⁴ Source: <https://clarivate.com/news/clarivate-announces-changes-to-the-2023-journal-citation-reports/> (accessed on 25-09-2022).

			"Technology Acceptance Model")	by the perceived usefulness.
2	[15] 2022	identifying the mechanisms that influence the intention of customers to use drone delivery	a survey combined with "structural equation modeling and a consistent partial least squares algorithm"	Customers are satisfied in what concerns the speed of drone delivery and the positive effects on the environment, but the risks related to confidentiality and vulnerability affect their decision to switch to this delivery method.
3	[33] 2022	developing a model that enables a drone to store the important data that it requires during its flight within a lightweight blockchain system	"an efficient blockchain model for the Internet of Drones"	The proposed model proves to be more advantageous compared to other Internet of Drones blockchain systems.
4	[27] 2019	investigating the possibility of reducing delivery times and costs by using a combination of drones and trucks for last mile delivery	mixed integer programming and heuristic algorithms	The drone delivery system presented a potential operational advantage compared to conventional delivery methods.
5	[38] 2018	an investigation into a new type of delivery problem that has arisen from e-commerce and logistics firms attempting to implement drones into their business in order to increase	an iterative algorithm based on a decomposition approach with the intention of minimizing delivery completion time	By comparing the developed algorithm with state-of-the-art implementations, it was found that the solution's times in the case of the developed algorithm are lower.

		efficiency and reduce delivery times		
6	[19] 2018	analyzing the factors that affect the attitude of consumers regarding the drone delivery service and the intention to adopt it	online survey and its analysis	The analysis of the obtained results highlighted the factors that affect positively (speed of delivery, environmental protection) and negatively (risks of underperformance and security) the adoption of the use of drones for delivery, while the decision to adopt this type of delivery differs depending on the area of residence of the customer.

Table 1. Six scientific articles tackling the role of drones in e-commerce (3 of the most recent along with 3 of the most highly cited)

Examining the 6 papers selected and summarized in Table 1, one can remark that 66,67 % of them approach issues regarding the implementation of drone delivery [6, 15, 19, 38], while the remaining percentage is equally shared by papers that refer to the data stored by drones [33], or to the reduction of the delivery cost by using drones [27].

4. Discussion and Conclusions

In recent years, the role of drones in e-commerce activities has been the subject of much debate. The increase in popularity of drones has led to a corresponding increase in the number of scientific papers published on the topic. In order to better understand the role of drones in e-commerce, a review of the scientific literature has been conducted. The Web of Science (WoS) database was used as a starting point for this review due to its prominence, visibility, and accessibility within the scientific community. A custom-tailored search was devised within the WoS database, which allowed for the assessment of the evolution of the targeted subject.

The popularity of drones has increased tremendously in recent years, primarily due to advances in technology that have made them more affordable and easier to use. Drones have a variety of uses, including aerial photography, delivery of goods, and even agricultural applications. With the rise of e-commerce, drones are being used more and more for delivery of goods, raising questions about their efficiency and safety.

There is no doubt that the COVID-19 pandemic has had a profound impact on the way we live and work. One of the most significant changes has been the way in which people all over the world purchase goods and services. While e-commerce was already on the rise prior to the pandemic, the COVID-19 crisis has accelerated its growth. With the rapid growth of e-commerce, there is an increasing need for efficient and cost-effective delivery solutions. This is where drones come in. Drones are already being used by some companies for last-mile delivery, and the pandemic has only increased demand for this type of service [6-8].

There are several potential benefits of using drones for e-commerce delivery, especially during pandemic periods. Firstly, during a pandemic, drones could be used to deliver e-commerce orders in a contactless way. This would minimize human-to-human contact and help prevent the spread of the disease [13, 14]. Secondly, drones can operate 24 hours a day, 7 days a week, meaning that they can provide a more flexible and timely delivery service than traditional delivery methods, with increased efficiency and speed of delivery. This can be beneficial for both businesses and consumers. Businesses can reduce the time it takes to fulfill orders and consumers can receive their orders more quickly. In addition, drones can help reduce congestion because they can deliver items to homes without the need for cars or other vehicles [18, 20]. Thirdly, drones are relatively cheap to operate, meaning that businesses can pass on the savings to consumers in the form of lower prices. Finally, drones can cover a large area in a short amount of time, meaning that they can reach more consumers. Drones could also be used to disinfect public areas, which would further help to reduce the spread of the disease [37].

E-commerce has indisputable advantages when compared to classical purchasing methods [39]. Regarding the delivery method, the current conducted study looked in particular at the use of drones in e-commerce and found that they have a number of advantages over traditional delivery methods. Drones are faster and more efficient than trucks or cars and can be used in a variety of weather conditions. They are also less likely to get lost or stolen and can be tracked more easily. However, there are some challenges that need to be addressed before drones can be widely used for delivery of goods.

One of the biggest challenges is energy consumption. Drones need to be recharged frequently, and battery technology has not yet progressed to the point where they can stay in the air for long periods of time. Another challenge is data transmission security. When sensitive information is being transmitted, there is a risk that it could be intercepted by someone with malicious intent [40]. Finally, there is the issue of delivery security. Drones could be stolen or damaged, and there is also a risk that they could fall out of the sky and injure someone. Additionally, the availability of information contained within our review study is limited in time due to the extremely rapid development of the electronic devices involved, along with the emergent body of knowledge and corresponding scientific literature. Despite the challenges, the use of drones in e-commerce is likely to continue to grow. Some specific directions for future research in this field include drone patents awarded as well as those in the process of being awarded, which address topics related to the development of e-commerce activities using drones.

After having conducted the current review on the topic of the role of drones in e-commerce, we have found relevant aspects that have the potential to shape the face of the future state of knowledge on this topic's evolution. There is a real need for further exploration of the

feasibility and desirability of using drones for e-commerce delivery and improvement of the whole e-commerce sector, for assessing the impact of drones on e-commerce businesses, including how these businesses can use drones to improve efficiency, competitiveness and ultimately, a thorough investigation of the societal and policy implications of widespread use of drones in e-commerce.

References

- [1] Ralph DEFRANGESCO, Stephanie DEFRANGESCO - *The Big Book of Drones* - Pages 1-150. ISBN 9781032062822. Published by CRC Press, Taylor & Francis eBooks.2022
- [2] Amazon, <https://www.aboutamazon.com/news/transportation/how-amazon-is-building-its-drone-delivery-system> - How Amazon is building its drone delivery system (accessed on 25-09-2022).
- [3] Forbes, <https://www.forbes.com/sites/johnkoetsier/2021/10/06/world-first-drone-delivery-googles-wing-starts-mall-to-home-flights/?sh=2f47f58211f0> - Google's Wing Kicks Off Mall-To-Home Drone Delivery Service (accessed on 25-09-2022).
- [4] The Guardian, <https://www.theguardian.com/technology/2018/may/10/apple-microsoft-uber-drones-approved-testing-amazon> - Apple, Microsoft and Uber test drones approved but Amazon left out in cold (accessed on 25-09-2022).
- [5] Emergen Research, <https://www.emergenresearch.com/blog/top-10-companies-in-the-drone-package-delivery-industry> - Top 10 Companies in the Drone Package Delivery Industry (accessed on 25-09-2022).
- [6] Charlie CHEN, Steve LEON, Peter RACTHAM - *Will customers adopt last-mile drone delivery services? An analysis of drone delivery in the emerging market economy* - Cogent Business & Management, volume 9 no. 1. ISSN 2331-1975. May 2022
- [7] Amalia POLYDOROPOULOU, Athena TSIRIMPA, Ioannis KARAKIKES, Ioannis TSOUROS, Ioanna PAGONI - *Mode Choice Modeling for Sustainable Last-Mile Delivery: The Greek Perspective – Sustainability*, volume 14 no. 15. ISSN 2071-1050. July 2022
- [8] Fabio BORGHETTI, Claudia CABALLINI, Angela CARBONI, Gaia GROSSATO, Roberto MAJA, Benedetto BARABINO - *The Use of Drones for Last-Mile Delivery: A Numerical Case Study in Milan, Italy – Sustainability*, volume 14 no. 3. ISSN 2071-1050. February 2022
- [9] Steven LEON, Charlie CHEN, Aaron RATCLIFFE - *Consumers' perceptions of last mile drone delivery* - International Journal of Logistics Research and Applications. ISSN 1367-5567. July 2021
- [10] Clément LEMARDELÉ, Miquel ESTRADA, Laia PAGÈS, Mònika BACHOFNER - *Potentialities of drones and ground autonomous delivery devices for last-mile logistics*

- Transportation Research Part E: Logistics and Transportation Review, volume 149 no. 1. ISSN 1366-5545. May 2021
- [11] Claudia ARCHETTI, Luca BERTAZZI - *Recent challenges in Routing and Inventory Routing: E-commerce and last-mile delivery – Networks*, volume 77 no. 2. ISSN 1097-0037. October 2020
- [12] Michele D. SIMONI, Erhan KUTANOGLU, Christian G. CLAUDEL - *Optimization and analysis of a robot-assisted last mile delivery system* - Transportation Research Part E: Logistics and Transportation Review, volume 142 no. 1. ISSN 1366-5545. October 2020
- [13] Nils Boysen, Stefan Fedtke, Stefan Schwerdfeger - *Last-mile delivery concepts: a survey from an operational research perspective* - OR Spectrum, volume 43 no. 1. ISSN 1436-6304. September 2020
- [14] Miguel A. FIGLIOZZI - *Carbon emissions reductions in last mile and grocery deliveries utilizing air and ground autonomous vehicles* - Transportation Research Part D: Transport and Environment, volume 85 no. 1. ISSN 1361-9209. August 2020
- [15] Wei XIE, Charlie CHEN, Juthamon SITHIPOLVANICHGUL - *Understanding e-commerce customer behaviors to use drone delivery services: A privacy calculus view* - Cogent Business & Management, volume 9 no. 1. ISSN: 2331-1975. August 2022
- [16] Christian Nedu OSAKWE, Marek HUDIK, David ŘÍHA, Michael STROS, T. RAMAYAH - *Critical factors characterizing consumers' intentions to use drones for last-mile delivery: Does delivery risk matter?* - Journal of Retailing and Consumer Services, volume 65 no. 1, ISSN 0969-6989. March 2022
- [17] Rico Merkert, Nichel C.J. Bliemer, Nuhammad Fayyaz - *Consumer preferences for innovative and traditional last-mile parcel delivery* - International Journal of Physical Distribution & Logistics Management, volume 52 no. 3, ISSN 0960-0035. February 2022
- [18] Lanhui CAI, Kum Fai YUEn, Diancen XIE, Mingjie FANG, Xueqin WANG - *Consumer's usage of logistics technologies: Integration of habit into the unified theory of acceptance and use of technology* - Technology in Society, volume 67 no. 1, ISSN 0160-791X. November 2021
- [19] Wonsang YOO, Eun YU, Jaemin JUNG - *Drone delivery: Factors affecting the public's attitude and intention to adopt* - Telematics and Informatics, volume 35 no. 6, ISSN 0736-5853. September 2018
- [20] Seung Yeob LEE, So Rim HAN, Byung Duk SONG - *Simultaneous cooperation of Refrigerated Ground Vehicle (RGV) and Unmanned Aerial Vehicle (UAV) for rapid delivery with perishable food* - Applied Mathematical Modelling, volume 106 no. 1, ISSN 0307-904X. June 2022
- [21] Darshan Rajesh CHAUHAN, Avinash UNNIKRISHNAN, Stephen D. BOYLES - *Maximum Profit Facility Location and Dynamic Resource Allocation for Instant Delivery Logistics* - Transportation Research Record, volume 2676 no. 7, ISSN 2169-4052. March 2022

- [22] Qingkui CAO, Xuefei ZHANG, Xiangyang REN - *Path Optimization of Joint Delivery Mode of Trucks and UAVs* - Mathematical Problems in Engineering, volume 2021 no.1, ISSN 1563-5147. November 2021
- [23] Adrian SERRANO-HERNANDEZ, Aitor BALLANO, Javier FAULIN - *Selecting Freight Transportation Modes in Last-Mile Urban Distribution in Pamplona (Spain): An Option for Drone Delivery in Smart Cities* – Energies, volume 14, no. 16, ISSN 1996-1073. August 2021
- [24] Heng CHEN, Zhangchen HU, Senay SOLAK - *Improved delivery policies for future drone-based delivery systems* - European Journal of Operational Research, volume 294 no. 3, ISSN 0377-2217. November 2021
- [25] Taner COKYASAR - *Optimization of battery swapping infrastructure for e-commerce drone delivery* - Computer Communications, volume 168 no. 1, ISSN 0140-3664. February 2021
- [26] Marlin W. ULMER, Sebastian STRENG - *Same-Day delivery with pickup stations and autonomous vehicles* - Computers & Operations Research, volume 108 no.1, ISSN 0305-0548. August 2019
- [27] Patchara KITJACHAROENCHAI, Mario VENTRESCA, Mohammad MOSHREF-JAVADI, Seokcheon LEE, Jose M.A. TANCHOCO, Patrick A. BRUNESE - *Multiple traveling salesman problem with drones: Mathematical model and heuristic approach* - Computers & Industrial Engineering, volume 129 no.1, ISSN 0360-8352. March 2019
- [28] Shehzad Ashraf CHAUDHRY - *Drone-based secure communication model for goods collection and delivery: a strategic management perspective* - Journal for International Business and Entrepreneurship Development, volume 13 no 3-4, ISSN 1747-6763. February 2022
- [29] Sandra Pérez ARTEAGA, Luis Alberto Martínez HERNÁNDEZ, Gabriel Sánchez PÉREZ, Ana Lucila Sandoval OROZCO, Luis Javier García VILLALBA, - *Analysis of the GPS Spoofing Vulnerability in the Drone 3DR Solo* - IEEE Access, volume 7 no. 1, ISSN 2169-3536. April 2019
- [30] Il-Kyu HA - *Use of Drones for Secure Mobile-Commerce: A Secure Commerce Platform Provides Target Information using Drones and CCTV* - International Journal of Grid and Distributed Computing, volume 11 no. 5, ISSN 2005-4262. May 2018
- [31] Weiliang LIU, Xu SUN - *Energy-Aware and Delay-Sensitive Management of a Drone Delivery System* - Manufacturing and Service Operations Management, volume 24 no. 3, ISSN 1523-4614. November 2019
- [32] N. BELMONTE, S. STAULO, S. FIOROT, C. LUETTO, P. RIZZI, M. BARICCO - *Fuel cell powered octocopter for inspection of mobile cranes: Design, cost analysis and environmental impacts* - Applied Energy, volume 215 no. 1, ISSN 0306-2619. April 2018
- [33] Khaleel MERSHAD - *PROACT: Parallel multi-miner proof of accumulated trust protocol for Internet of Drones* - Vehicular Communications, volume 36 no. 1, ISSN 2214-2096. August 2022

- [34] Lu PENG, Kai Way LI - *Perceived difficulty, flight information access, and performance of male and female novice drone operator* – Work, volume 72 no. 4, ISSN 1875-9270. August 2022
- [35] Svea BRAEUNERT - *Shifting the pattern: lateral thinking and machine vision* - The Senses and Society, volume 15 no. 3, ISSN 1745-8927. October 2020
- [36] D. Nageswara RAO, G. VIDHYA, M. V. RAJESH, Vipin JAIN, Adel R. ALHARBI, Harish KUMAR, Awal HALIFA - *An Innovative Methodology for Network Latency Detection Based on IoT Centered Blockchain Transactions* - Wireless Communications & Mobile Computing, volume 2022 no. 1, ISSN 1530-8669. May 2022
- [37] Debapriya BANIK, Niamat Ullah Ibne HOSSAIN, Kannan GOVINDAN, Farjana NUR, Kari BABSKI-REEVES - *A decision support model for selecting unmanned aerial vehicle for medical supplies: context of COVID-19 pandemic* - The International Journal of Logistics Management, ahead-of-print, ISSN 0957-4093. March 2022
- [38] Emine Es YUREK, H. Cenk OZMUTLU - *A decomposition-based iterative optimization algorithm for traveling salesman problem with drone* - Transportation Research Part C: Emerging Technologies, volume 91 no. 1, ISSN 0968-090X. June 2018
- [39] Dana-Mihaela PETROȘANU, Alexandru PÎRJAN, George CĂRUȚAȘU, Alexandru TĂBUȘCĂ, Daniela-Lenuța ZIRRA, Alexandra PERJU-MITRAN - *E-Commerce Sales Revenues Forecasting by Means of Dynamically Designing, Developing and Validating a Directed Acyclic Graph (DAG) Network for Deep Learning* – Electronics, volume 11 no. 18, ISSN 2079-9292. September 2022
- [40] Alexandru TĂBUȘCĂ, Silvia-Maria TĂBUȘCĂ - *Impact of 5G technology in global economy. Cybersecurity and legal issues* - Journal of Information Systems & Operations Management, volume 13 no. 2, ISSN 1843-4711. December 2019

E-COMMERCE AND DISRUPTIVE TECHNOLOGIES FOR HIGHER EDUCATION

Ioan-Matei PURCĂREA¹

Abstract

In the era of digital-first, in order to align with the expectations of their students, staff, and faculty, universities continue to transition into the e-commerce sector, where electronic methods of payment can help higher education institutions automate, secure and offer more flexible payments across the entire campus services, adding tailored payment plans to protect and increase enrollment, as well as a broad array of solutions and implementations. E-commerce solves pain points and makes higher education smarter by implementing a suite of must-have rather than nice-to-have digital tools such as marketplaces to create and manage bookstores, alumni goods, fundraising and registration sites, campus commerce solutions integrating seamless digital shopping experiences for students regarding choices of accommodation, together with campus ID solutions offering mobile credential access with safely integrated payment processing. In a very competitive and innovative digital environment, higher education institutions need to streamline activities and empower them by the use of e-commerce tools, use the digital twins for e-commerce engagement, add value through greater efficiency in the new challenging digital economy.

Keywords: E-commerce, Higher education, Disruptive technologies, Digital twins

1. Introduction

The Covid-19 pandemic has been a catalyst for the radical transformation in revolution and disruption of the digitization of higher education institutions in the digital society. In this context, more and more universities took advantage of the benefits of leveraging e-commerce for various activities, a must have for tuition payment, alumni goods, fundraising, bookstores and others, allowing greater connectivity with no space-time barriers and opportunities emerging. Accelerating the dynamics of the profound digital transformation by enhancing digital skills among employees, promoting university values through digital tools and data, while following the digital transition with a holistic approach, has to be a top priority in order to achieve greater efficiencies.

2. Adding value through greater efficiency in the new challenging digital economy

In today's omnichannel world, on the path to customer value, e-commerce has witnessed the disruptive impacts of latest groundbreaking technologies that has revolutionized the way our lives unfold.

¹ PhD Candidate, Institute of National Economy, Romanian Academy, matei.purcarea@rau.ro

Artificial Intelligence is one example of a game-changing role in the e-commerce space with omnichannel connections, more qualified leads and very good return on investments through its instances such as:

- **Intelligent Virtual Agent (IVA)** – AI powered digital assistant software easy-to-use and cost-effective (more advanced than chatbots) that performs product offerings, engages with customers (in a way that mimics humans) and facilitates transactions, delivering 24/7 digital support with almost no downtime;²
- **Personal shopping assistant** – help shoppers easier identify the products they've been looking for, offer a more personal and human touch to the e-commerce experience, real time digital conversations and the ability to handle tasks regarding shopping carts or checking out, place an order, as well as add or remove items, provide discount codes, give personalized gift suggestions and recover abandoned shopping carts;³
- **Personalized product recommendation** – Tailored customer experience is provided with the help of AI analytics tools used for predictive analytics, providing immersive journeys across the online store, alongside personalized recommendations, seamlessly delivering high-performing next-generation recommendations to any touchpoint, dynamically adapting to real-time customer behaviors and improving meaningful metrics;⁴
- **Visual search engine** –The development of search methods has been facilitated by AI, the traditional keyword search can be accompanied by image recognition technology for a powerful search experience with increased discoverability and improved overall customer experience, especially for image-dominant social commerce platforms, along with the development of the process of adding textual parameters to a visual search.⁵

According to ultimate.ai, IVAs, through a combination of AI, natural language processing (NLP), machine learning and natural language understanding (NLU), have the potential of changing the way a business engages with its customers. Personalized insights and tailored experiences are provided to customers after machines analyze data, streamline interactions, eliminate wait times and dramatically improve the customer service process. Ultimate.ai also points out that existing customer agents can go on to more challenging work and leave the repetitive one to the IVAs.

According to tidio.com, around 45 million digital shoppers in the U.S.A. used voice assistant in 2021 while exploring online stores and around 88% had no less than one

² Nord T., What Is an Intelligent Virtual Agent (IVA)? (April 13, 2022). Retrieved from: <https://www.ultimate.ai/blog/ai-automation/what-is-an-intelligent-virtual-assistant-iva>

³ Rajnerowicz K., Beginner's Guide to Virtual Shopping Assistants & Bots (May 28, 2022). Retrieved from: <https://www.tidio.com/blog/virtual-shopping-assistant/>

⁴ Google Cloud. Recommendations AI. Deliver highly personalized product recommendations at scale. Retrieved from <https://cloud.google.com/recommendations>

⁵ NEXT-GEN TECHNOLOGY, Is visual search the future of search engines? (June 21, 2022). Retrieved from <https://www.telusinternational.com/articles/future-of-visual-search-engines>

conversation with an e-commerce chatbot in 2022. As businesses are searching new ways to boost sales and create new innovative online shopping experiences, personal virtual shopping assistants make shopping easier and more enjoyable. They include:

- Conversational AI;
- Widgets;
- Mobile apps;
- Chatbots;
- Popups;
- Browser plugins.

According to Purcarea I.M., detailed aspects regarding key technologies shaping the future of e-commerce are conversational commerce, headless commerce technology, personalization technology, 3D assets, metaverse shopping and Crypto wallets.⁶

Higher education can revolutionize shopping of products and services for a wide range of services, through self-managed customized online shops secure and convenient, with multiple payment processors, integrated functions for selling goods to collecting all type of payments, from the sale of books or e-books, educational materials, promotional items, alumni goods, raise funds to the collection of tuition, fees and charges.⁷

According to SHIFT4SHOP, the benefits of e-commerce for higher education institutions include:⁸

- Visitors can quickly complete their purchase through a website (easier to use) with a greater variety of payment types, without actually going to the campus;
- The option to have an online catalogue with the institution's merchandise and sell more products to a wider audience;
- Increase in the overall strong digital presence due to the e-commerce website's sheer versatility, offering a variety of options including a built-in blog for upcoming events, news and relevant articles, customer records to enable complete recordkeeping (payments, purchases and donations associated with the customer records) and others;
- All the sold products and services can be tracked with the inventory management capability to ensure that single products are never sold twice, a built-in tool to accept customer returns, including Return Merchandise Authorization (RMA) system to create a detailed return policy, along with a variety of shipping methods,

⁶ PURCAREA, Ioan Matei, 2022. "The Future of E-Commerce, Technology Priorities and the Challenge of Metaverse," Romanian Distribution Committee Magazine, Romanian Distribution Committee, vol. 13(2), pages 40-50, June.

⁷ DOQSOFT, E-commerce in Education. Retrieved from: <https://www.doqsoft.com/en/ecommerce-for-education/>

⁸ SHIFT4SHOP, eCommerce Solutions for Higher Education. Retrieved from: <https://www.shift4shop.com/plans/ecommerce-solutions-for-higher-education.html>

free delivery for picking up from the dorms to sending to a specific location or picking up at a given location, charging real-time shipping rates.

3. Using the digital twins for e-commerce engagement in higher education

Digitizing products is a necessity to fulfill customers' needs and expectations, as well as reaching customers at all digital touchpoints with relevant quick and easy information and a consistent product story. The digital twins, as the new means of representing products in e-commerce, craft powerful experiences and easily connect to new emerging sales channels, unlocking the true power of product content and dominating the market. The digital twins consist of the data which is centralized in the product content catalog. Other systems can be exchanged for this particular data via an Application Programming Interface (API), enabling the product sale on any virtually channels, online marketplaces, social media, comparison websites.⁹

The digital twins enable businesses to be predictive, cost-efficient and proactive by using smooth integration of real time data feeds. The Internet of things (IoT) offers relevant information about the physical world, while the digital twins leverage and send the information for analysis, testing and optimization. IoT together with the digital twins form the digital threads and deliver seamless real-time data flows allowing this way the traceability throughout the life cycle of an asset. The digital twins use technologies to mirror physical systems with the help of digital simulation, integrating big datasets collected by smart sensors, creating this way digital replicas easier to analyze, measure and comprehend, also reducing the complexity of IoT systems.¹⁰

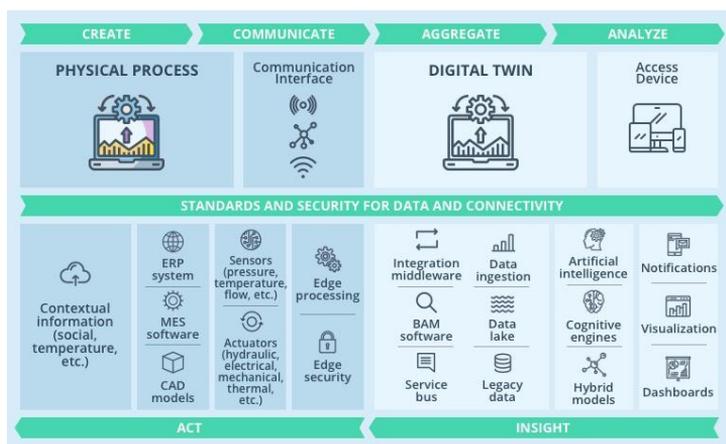


Fig. 1. “Digital twin conceptual architecture”¹¹

⁹ Mitros G., Digital Twins: A Smarter Way of Commerce (March 10, 2020). Retrieved from: <https://innovationmanagement.se/2020/03/10/digital-twins-a-smarter-way-of-commerce/>

¹⁰ Martinova O., Creating Digital Replicas Using IoT: How Digital Twin Technology Works in Practice (April 28, 2020). Retrieved from: <https://intellias.com/creating-digital-replicas-using-iot-how-digital-twin-technology-works-in-practice/>

¹¹ Retrieved from: <https://intellias.com/creating-digital-replicas-using-iot-how-digital-twin-technology-works-in-practice/>

Thanks to the IoT and Augmented Reality (AR), the internet is more aligned to things we all do in real life, consumers spending more and more money on e-commerce websites. Nowadays, brands, in search of versatility, quality and safety, as well as affordability, are now looking at the digital twins (digital models of physical objects) to create seamless experiences, build better relationships with customers and decrease operating costs, all based on real-world data gathered from IoT sensors and devices.¹²



Fig. 2. "Total worldwide ecommerce sales in trillions of U.S. dollars"¹³

New doors of opportunities are opened by e-commerce to brands, as more and more consumers increasingly rely on online shopping, the estimates show that 95% of purchases will be made online by 2040. Amazon is a good example of a successful business, accounting for 44% of all e-commerce sales in the US, and a 23% growth rate Year-on-Year (YoY), the fastest-growing product groups (Fig. no. 3 and 4) include:¹⁴

- luxury beauty with total estimated sales >\$400M (YoY 47%);
- Pantry with total estimated sales >\$500M (YoY 38%);

¹² Torres Al., Using Digital Twins For E-Commerce Engagement (March 26, 2019). Retrieved from: <https://www.forbes.com/sites/forbestechcouncil/2019/03/26/using-digital-twins-for-e-commerce-engagement/>

¹³ Source: Osman M, Ecommerce Statistics for 2022 – Chatbots, Voice, Omni-Channel Marketing (May 24, 2022), Retrieved from: <https://kinsta.com/blog/e-commerce-statistics/>

¹⁴ Osman M, Ecommerce Statistics for 2022 – Chatbots, Voice, Omni-Channel Marketing (May 24, 2022). Retrieved from: <https://kinsta.com/blog/e-commerce-statistics/>

- Grocery with total estimated sales >\$1.5B (YoY 33%);
- Furniture with total estimated sales >\$1.5B (YoY 33%);
- Consumer electronics with total estimated sales >\$8.5B (YoY 5%);
- Home & kitchen with total estimated sales >\$5.5B (YoY 20%);
- Publishing with total estimated sales >\$5B (YoY 3%);
- Sports % outdoors with total estimated sales >\$4B (YoY 11%).



Fig. 3. “AMAZON.COM TOP GROWTH PRODUCT GROUPS: 2017 ESTIMATED SALES”¹⁵



Fig. 4. “AMAZON.COM TOP GROWTH PRODUCT GROUPS: 2017 ESTIMATED SALES”¹⁶

¹⁵ Source: Osman M, Ecommerce Statistics for 2022 – Chatbots, Voice, Omni-Channel Marketing (May 24, 2022), Retrieved from: <https://kinsta.com/blog/ecommerce-statistics/>

¹⁶ Source: Osman M, Ecommerce Statistics for 2022 – Chatbots, Voice, Omni-Channel Marketing (May 24, 2022), Retrieved from: <https://kinsta.com/blog/ecommerce-statistics/>

The use of digital twin technology in higher education supports personalized learning, motivates students by offering them the possibility of learning highly engaging tasks, accelerates and facilitates overall understanding and improves immersive learning experiences. **Stanford University** and **Copenhagen School of Marine Engineering and Technology Management** are good examples of universities already using digital twin technology in their teaching curricula.¹⁷

4. Conclusions

1. Higher education institutions can embrace growth and build resilience in times of economic uncertainty by opening new doors of opportunities with e-commerce and disruptive technologies, building sheer digital versatility, creating powerful immersive experiences and fulfilling needs and expectations for both students and university, revolutionizing the way students' lives unfold.
2. The digital twins offer higher education institutions the opportunity to play a transformational role and build market differentiation, as well as brand consistency, tie the virtual and physical together, offer hyper-personalized services and products with real-time operational data, improving overall outcomes.
3. Unlocking the true power of higher education is a matter of strategic courage in times of volatility, building a productive digital culture that shapes the education sector in terms of collaboration, innovation, openness and agility.
4. Higher education institutions have a major digital transformation role in driving a major change in shaping a collaborative multi-disciplinary sustainable digital environment, make digital culture happen and gain significant advantages to perform ahead of competition in the new operating models, enabling first-mover opportunities.

References

1. DOQSOFT, E-commerce in Education. Retrieved from: <https://www.doqsoft.com/en/ecommerce-for-education/>
2. Fourtané S., Future of Higher Ed: Digital Twin Technology on the Horizon (January 28, 2022). Retrieved from <https://www.fierceeducation.com/student-engagement/future-higher-ed-digital-twin-technology-horizon>
3. Google Cloud. Recommendations AI. Deliver highly personalized product recommendations at scale. Retrieved from <https://cloud.google.com/recommendations>

¹⁷ Fourtané S., Future of Higher Ed: Digital Twin Technology on the Horizon (January 28, 2022). Retrieved from <https://www.fierceeducation.com/student-engagement/future-higher-ed-digital-twin-technology-horizon>

4. Nord T., What Is an Intelligent Virtual Agent (IVA)? (April 13, 2022). Retrieved from: <https://www.ultimate.ai/blog/ai-automation/what-is-an-intelligent-virtual-assistant-iva>
5. Martinova O., Creating Digital Replicas Using IoT: How Digital Twin Technology Works in Practice (April 28, 2020). Retrieved from: <https://intellias.com/creating-digital-replicas-using-iot-how-digital-twin-technology-works-in-practice/>
6. Mitros G., Digital Twins: A Smarter Way of Commerce (March 10, 2020). Retrieved from: <https://innovationmanagement.se/2020/03/10/digital-twins-a-smarter-way-of-commerce/>
7. NEXT-GEN TECHNOLOGY, Is visual search the future of search engines? (June 21, 2022). Retrieved from <https://www.telusinternational.com/articles/future-of-visual-search-engines>
8. Osman M, Ecommerce Statistics for 2022 – Chatbots, Voice, Omni-Channel Marketing (May 24, 2022). Retrieved from: <https://kinsta.com/blog/ecommerce-statistics/>
9. PURCAREA, Ioan Matei, 2022. "The Future of E-Commerce, Technology Priorities and the Challenge of Metaverse," Romanian Distribution Committee Magazine, Romanian Distribution Committee, vol. 13(2), pages 40-50, June.
10. Rajnerowicz K., Beginner's Guide to Virtual Shopping Assistants & Bots (May 28, 2022). Retrieved from: <https://www.tidio.com/blog/virtual-shopping-assistant/>
11. SHIFT4SHOP, eCommerce Solutions for Higher Education. Retrieved from: <https://www.shift4shop.com/plans/ecommerce-solutions-for-higher-education.html>
12. Torres Al., Using Digital Twins For E-Commerce Engagement (March 26, 2019). Retrieved from: <https://www.forbes.com/sites/forbestechcouncil/2019/03/26/using-digital-twins-for-e-commerce-engagement/>

THE EUROPEAN WAVE OF DIGITAL TRANSFORMATION AND THE WORKFORCE MIGRATION

Sarina ROSENBERG¹

Dragoş Sebastian CRISTEA²

Cristina Gabriela ZAMFIR³

Abstract

This article presents the current European context regarding the extent of the labour migration phenomenon, along with the evolution of the digitalization process of the Union, using as a reference point the dynamics of the Digital Economy and Society Index in economically developed and emerging European states. It is based on the examination of the specialized academic literature and the official reports of the institutions on the evolution of the European labour market and digitalization. It tries to capture the direction and the way of labour force migration. A strong DESI level is the equivalent of a complete digital infrastructure, of a level of self-sufficient individual digital skills, and a high-performance digital integration of companies. Also, it is equivalent to the loss of obsolete jobs and the birth of new ones, for which a high level of human resources skills and knowledge is necessary. An elevated digital state can no longer be the equivalent of the destination of GIG workers from economic branches characterized by a workforce equipped with only essential digital skills.

Keywords: digitalization, DESI, GIG workers, labour force, migration

JEL: J21, J6, O33

1. Introduction

In the current global context, in the period of sanitary, energy, food and political crisis, the GIG workforce migration question arises: what future will the employees, GIG workers who worked in fields where digital was not needed have? Generally, the question could have three answers: re-conversion to digital, transition to an unemployment state, or changing the destination of migration to less digitized states, in which there are still areas that are not digitized fully or partially, and for which raw or seasonal work is still needed? On the other hand, the GIG economy is also based on digital work platforms, the area where

¹ “Dunărea de Jos” University of Galaţi, Faculty of Economics and Business Administration, 800008, Galaţi, Romania; sarina17.rosenberg@gmail.com

² “Dunărea de Jos” University of Galaţi, Faculty of Economics and Business Administration, 800008, Galaţi, Romania; dragoscristea@yahoo.com

³ “Dunărea de Jos” University of Galaţi, Faculty of Economics and Business Administration, 800008, Galaţi, Romania; cristinagabrielazamfir@yahoo.com

the competitiveness and highly qualified labour force are present. A strong DESI is the equivalent of increasing job opportunities for as many highly skilled people as possible, GIG workers or not. A high degree of competitiveness in the labour force means the delivery of performance work results and simultaneously, the increase in the performance of companies that use this employment model.

The fourth technological revolution, called Revolution 4.0 is that of automation, artificial intelligence and digitization. According to the analyzes and results of the European Center for the Development of Vocational Training (CEDEFOP), artificial intelligence and automation represent promoters of jobs transformation and in no case factors with a crisis effect in the labour market, adapting to the new transformations actually representing an element of opportunity, in the context where at least half of jobs will be automated in the future [3].

Conclusions regarding the benefits of going through the digital transformation refer to significant increases in the financial and economic performance of companies, the profitability of the investments carried out, and beyond financial considerations, to the improvement of work relations between employees and employers, or those of business with partners, suppliers and customers, to a positive impact on economic growth, environmental and sustainability indicators, referring, in general, to progress.

The analysis carried out is empirical, statistical data being collected and processed on the basis of the Eurostat archive and official European specialist reports or large global analysis and consulting companies.

2. Digitalization – general approach to the impact on companies and workforce evolution

Digitalization means the transformation of information, documents, objects, sound or image, in digital format [1], and in a broader sense, digital technologies and their use for the general purpose of streamlining activities, domestic, personal, or related to work or production of value [2]. Digitization of processes can be turned into a benefit, given the results in the efficiency of communication, planning activities, archiving, monitoring results, document management or improving time management indicators.

An important characteristic of the current technological transformations is the very high speed of the innovation cycles, with a different pace compared to the evolution of the past years. The creation of new products and the application of digital marketing have become much faster, the workforce has become more flexible, classic forms of work can be easily replaced by contingent or freelancing forms (platformers), and the extension of "digital innovators" in the digital environment participate in the intensification of the competitive process. The increase in demand for products and services in recent years is justified, along with other factors, by the offer diversification, in terms of volume, quality and price, with direct effects in the creation of new jobs.

Current technological development and especially the speed with which these transformations are taking place may lead to even greater discrepancies in income inequalities. The degree of adaptability of workers to environmental changes is predicted to be different, depending on the age groups, for example, so that the new generations will

have the advantage of understanding and getting used to the technological and digital diversification immediately, to the detriment of the older age groups . Consequently, the labour market will be affected by these phenomena, with existing studies and research giving contradictory results as to how the effects will be felt. Both positive effects of adaptability of the working population with new technologies and artificial intelligence are appreciated, as well as negative results.

3. The benefits of digital transformation on companies' evolutions

Business models will be resized and reoriented through digital transformation, operating models, customer relations and the digitized interaction with the customers, marketing processes will also be adapted, depending on the companies` digital integration levels, but also depending on the future requirements and needs of consumers. A study operated by Deloitte [4] expresses results regarding the correlation between the companies` degree of digitalization integration and the evolution of income growth, as well as the increase in the degree of global income reporting. The efficiency of organizational processes is related to the existing level of digitization, so any action in this regard, for example, recalibration and flexibility of the infrastructure through cloud services, will lead to time savings and the efficiency of data center maintenance costs.

According to Deloitte [5], digitization is the basis of the development of processes for collecting information, data and managing databases, so that the actions of customizing products and services and their quality will be optimized according to customer requirements. The results will be seen in increased sales volume or in the critical performance indicators improvement. And speaking about business collaboration, the digitization process results will support and stimulate the development of relations with external partners. Human capital represents another beneficiary of the implementation of the digitization process, in a sense in which, simultaneously with the continuous process of developing digital skills, the knowledge received will bring added value to individual or company results. Relations between workers and employers are stimulated and improved in this regard.

In order for the results to appear in closer form to the optimal version, digitization must be implemented in accordance with development strategies based on this tool, depending on the specifics of the companies, the development objectives, the economic sectors in which they operate, both at the individual level (companies) and at the national level.

4. The Digital Economy and Society Index (DESI)

The digital performance and progress recorded by the EU member states in implementing digitization measures are given by a set of indicators, which together form the Digital Economy and Society Index (DESI) being grouped thematically, in key implementation areas (digital public services, connectivity, integration of digital technology and human capital). DESI reflect the dimension of the European information society, allowing the comparative analysis of digital development at the European level [6].

Thus, according to the results of the *EU DESI 2022* Report [7], during the COVID-19 pandemic (2020-present), positive and increasing results were recorded regarding the

achievement of the general objectives of the process of digital transformation, although a slower advance was reported in terms of development on 5G digital infrastructure components, digitalization in SMEs or digital skills. The purpose of digitalization policies initiated during the pandemic, aimed to intensify the use of digital solutions, and subsequent statistical data confirmed results in this regard, both at individual and business environment level [8]. The strongest emphases were recorded in the areas of workforce mobility, work remote, automation or e-commerce (as a percentage of total retail sales), while digital transformation at the citizen or enterprise level, as mentioned before, did not achieve the expected results [9]. The McKinsey Global Institute study, *The future of work after COVID-19*, was carried out based on the analysis of socio-economic data on a panel of 8 globally developed economies countries, which together form approximately 62% of global GDP and represent over half of the world's population (China, India, Japan, US, UK, Spain, France and Germany).

The results of the *DESI 2022 Report for Europe* confirm the maintenance of the trends from previous years, in the sense of a positive progress registered at a general level, with discrepancies, however, on the key development components. Barriers and gaps are registered in the area of development of digital skills, expansion of infrastructure networks and the transfer of SMEs to cloud or big data services. The repercussions of these sustained delays and blockages on these 3 components will materialize in the digital gap, the risk of digital exclusion, the decrease in the degree of competition and the slowdown of economic growth.

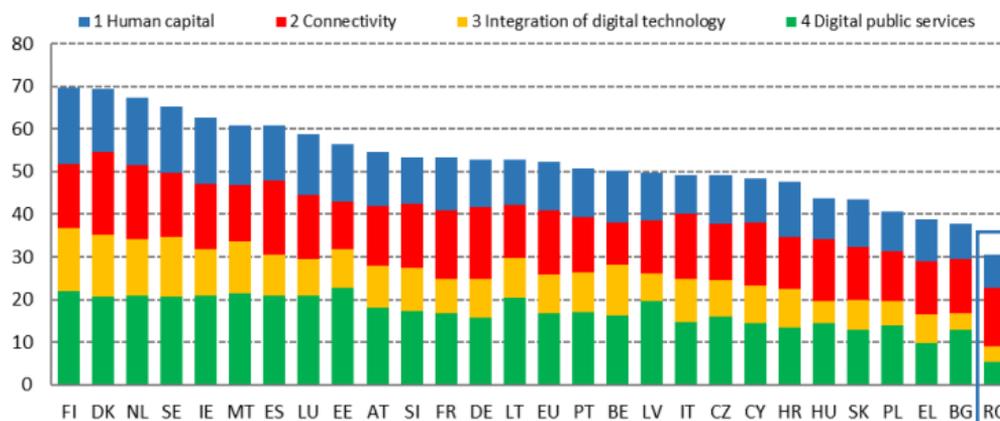


Figure 1. DESI 2022 ranking⁴

The 4 digital key implementation areas, public services, connectivity, integration of digital technology and human capital demonstrate a different evolution in the EU member states (figure 1), DESI placing Finland, Denmark, Holland, Sweden on the first places in the ranking and at the opposite pole, Romania, Bulgaria and Greece.

⁴ source: <https://digital-strategy.ec.europa.eu/en/policies/desi-romania>

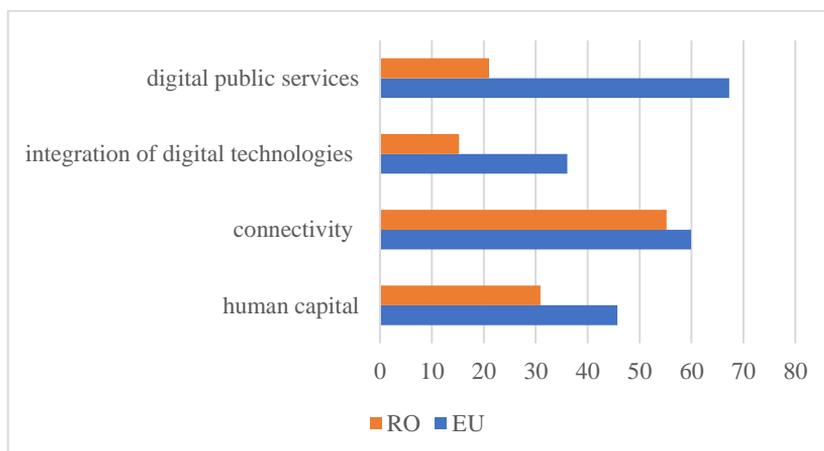


Figure 2. DESI components level for RO and EU, 2022⁵

On DESI` 4 components, Romania records the following results, for 2022: human capital 30.9% compared to EU average 45.7%, connectivity 55.2% compared to EU average 59.9%, the integration of digital technologies 15.2%, compared to EU average of 36.1% and digital public services 21% compared to EU average of 67.3%, according to statistical data (figure 2).

5. The impact of technological change, of digitization and automation on the labour market

The consequences of the worldwide initiation of automation and digitization processes, together with other significant determinants, were not slow to appear and the recovery efforts are significant, whether at the individual, community, society, state or regional level, the vast majority of the workforce being affected, obviously, in different proportions, but negatively, in general.

Technology has also made it easier to create jobs by working online or joining the so-called GIG economy. What is currently being observed is the increasingly rapid development of the skills necessary for the performance of work and the growing demand for new skills and abilities. Starting from the ever-increasing number of new jobs, in new economic areas and implicitly carrying new or rare requirements and skills, the demand for work is transformed in terms of the quality of skills and abilities, or educational level. The workforce, on the other hand, have increasingly easy access to tools for improvement, personal development or, where appropriate, professional reconversion and simultaneously, online, to the offer of available jobs.

A category of the criteria for classifying the effects are those related to the geographical area analyzed and the level of regional economic development, the economic field evaluated and its correlation with the present and future technological expansion. An advanced economy, for example, whose degree of sustainability is high, can cover the

⁵ source: <https://digital-strategy.ec.europa.eu/en/policies/desi-romania>

expenses of these structural transformations, if we refer to the costs of the transition period. On the other hand, states with developing economies will feel the effects of these movements more deeply, with future generated costs much higher than developed states. Extrapolating, a more economically advanced region will adapt more easily to the new wave of change than less favored areas. From the economic sectors point of view, as an image of the future under the effect of these changes, it can be appreciated that technology will bring beneficial changes in any field, but the fields close to the ICT area will register the most fulminant rise, reaching the automation of tasks routine and to the creation of new jobs, different from the present ones. Consequently, the demand for ICT specialists is born in all economic fields and the pressure on the demand for digital skills of an increasingly high level in the fields supplemented with the ICT area (tasks) is accentuated [10].

The skills required for work today will give way in the future to the skills required for the emerging jobs of the future. CEDEFOP statistical data and specialist reports, through the *European Skills and Jobs Survey (ESJS)* [11] indicate a minimum 35% share of current skills that will be gradually replaced, refer to the current fields of study and qualification in education system that they will not find in the same proportion in the future and suggests that 65% of today's students will have jobs that do not exist today. It also indicates 14% of current jobs are being fully automated, with work tasks completely replaced by automated learning models, and around 18 million workers in the European Union at risk of losing their jobs due to this phenomenon. According to the estimates of *Factory 4.0 & Frames* analysts, there is confirmation of the phenomenon of gradual replacement of non-current jobs in the context of a wave of demand for labour in the area of support services in the public or private sector, until the end of this decade [12].

6. The European Employees – Where To?

Regarding the social-economic trends of 2011-2020 period, according to Emergent Research [13] and Intuit [14], there will be increasingly accentuated migratory flows of the labour force, their destination keeping the same directions until now: towards the states with advanced economies and from rural to urban area. With the increase in the scale of the digitalization phenomenon, it is assumed that migration will have relocation tendencies in the digital area, for digitally remodeled workplaces and for the employees' categories with advanced education and skills. At the opposite pole, workers with education up to the tertiary level, will compete for jobs not yet digitized. Other research [15] refer to the agglomeration of job offer in the most popular freelancing fields (e.g. design and technology) as a result of the intensification of the digitization process. Research by the McKinsey Institute refers to the intensification of the relocation of headquarters and economic activities of large companies to emerging markets, until 2030 [16], with an impact on the structure and volume of future workforce migratory flows, the workforce mobility magnitude being predicted on average, 65 million people annually and an increasing trend.

The shock effect on the economy, as a result of job losses due to the pandemic, energy, climate crises, further leads to significant structural changes in the labour market, in terms of, but not limited to, patterns of work engagement. There is a transition from classic forms of work to temporary ones, either due to the loss of the current job, or due to the need for additional income.

Globally, for 2019, the general picture of the volume and structure of the migrant workforce [17] describes two-thirds of the total as being concentrated in the developed states of the world and about 25% localized in Europe, 22% in North America and 14% in Arab states. Another essential feature highlighted is the increase in the volume of flows, from year to year.

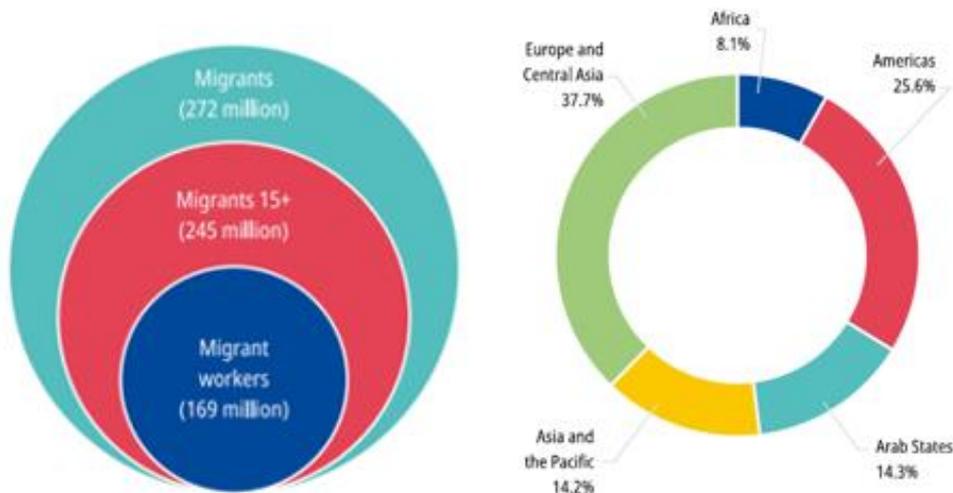


Figure 3. The volume and global migrant workers distribution, by region, 2019⁶

272 million migrants were registered, of which 245 million were over 15 years old and 169 million migrant workers (figure 3). As a concentration, from a regional point of view, (figure 3) statistical data show the highest share (37.7%) in Europe and Central Asia, 25% in the US and Central and South America, 14.8 in the Arab States, 14.2 % in Asia and the Pacific and about 8% in Africa. By gender category, the gender composition shows a share of 58.5% men and 41.5% women.

At European level, the migratory volume has a strong upward trend for the last period and large regional or temporal variations of the migratory phenomenon are highlighted (figure 4). According to ESPON GECT, the last two decades were characterized by a positive global net migratory balance, the number of immigrants (incoming labour force) being higher than that of emigrants (outgoing labour force). It can observe the states and regions that send the labour force outside the borders, and in this sense, Romania, southern Italy, Spain, Portugal, Bulgaria, in general the southern and eastern regions of Europe, states or regions with no developed very good economic conditions can be highlighted. At the opposite pole, the labor-receiving states are generally the countries of northern and central Europe.

⁶ source: [wcms_808935.pdf \(ilo.org\)](#)

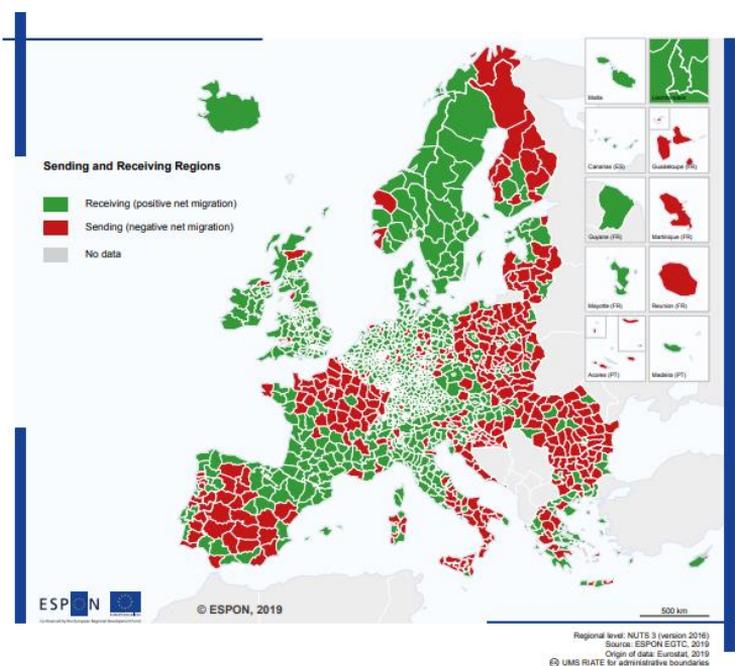


Figure 4. In- and out-migration, 2017⁷

The specialized literature describes a strong relationship between the labour force migratory structure and volume and the level of economic development of the states, respectively GDP/capita or the labour market state. Thus, the movement of migratory flows is directed towards economically developed states, with an intensified status of labour demand [18]. According to the mentioned study, there is a close connection between the workers migration pattern and the knowledge economy status, so the indicators that define it (level of tertiary education, investments in research and development, the intensity of patenting activity, the share of the force of active work in the technological and scientific domains) become essential factors in the dynamics of the migratory flow (figure 5).

The highly educated migrants tend to concentrate in regions where highly educated natives are intensive working [19]. Based on the statistical data provided by Eurostat, we can outline a general framework of the ranking of the EU member states in terms of the employment rate of people with a tertiary level of education (table 1). The European average, for the year 2021 quarter 4 is 85.8%, the countries with a high value of the infector being Malta (92.2%), Hungary (90.8%), Poland (90.4%), Slovenia (90%) and the lowest values, but over 77%, are registered by Greece (77.7%), Italy (80.7%), Spain (81.1%) and France (84.4). Romania has a tertiary employment rate of 88.2%, higher than the EU average.

⁷source: ESPON EGTC,
<https://www.espon.eu/sites/default/files/attachments/ESPON%20Policy%20Brief%2C%20Labour%20migration%20challenges.pdf>

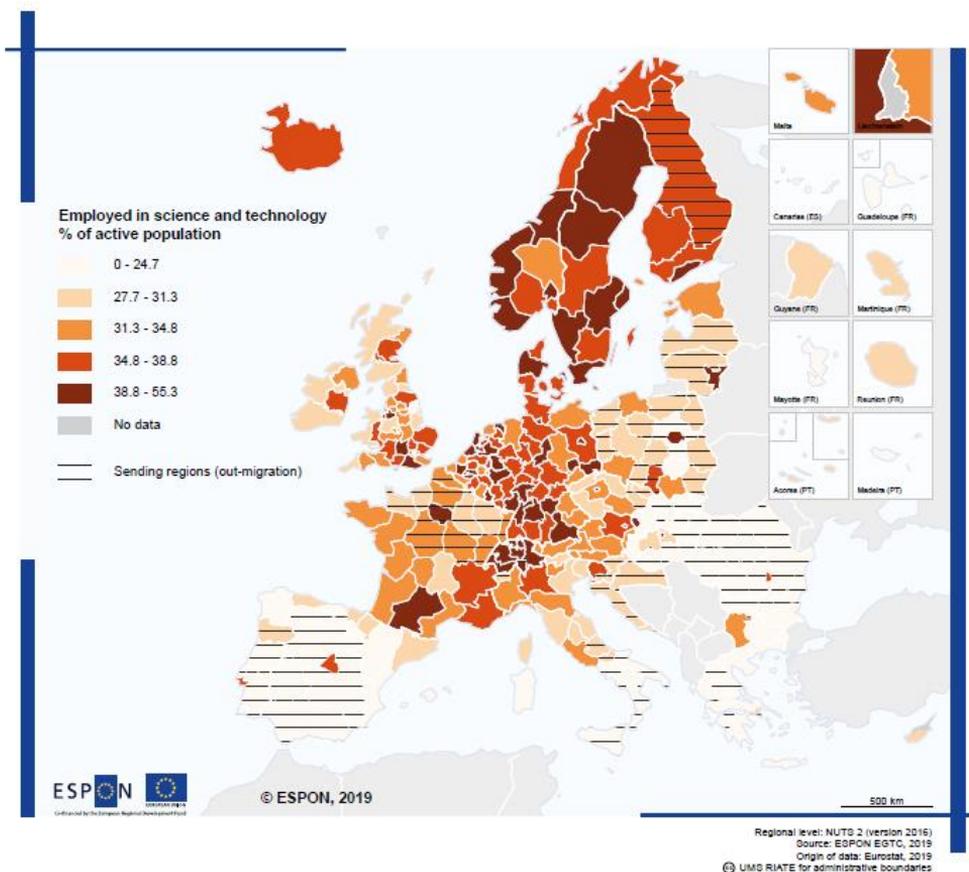


Figure 5. Relationship between knowledge economy and out-migration, 2017⁸

GEO /TIM E	201 9- Q1	201 9- Q2	201 9- Q3	201 9- Q4	202 0- Q1	202 0- Q2	202 0- Q3	202 0- Q4	202 1- Q1	202 1- Q2	202 1- Q3	202 1- Q4
Malt a	88, 6	88, 6	87, 5	88, 5	92, 3	90, 3	86, 9	88, 1	90, 2	89, 7	89, 1	92, 2
Hun gary	85, 5	85, 8	84, 8	84, 9	85, 1	84, 8	85, 4	85, 7	89, 1	89, 7	90, 0	90, 8
Pola nd	87, 6	87, 7	87, 9	88, 4	88, 1	87, 4	88, 2	88, 5	89, 3	90, 1	89, 8	90, 4
Slove nia	89, 4	89, 3	88, 7	90, 6	90, 2	89, 0	89, 2	89, 2	86, 1	88, 8	89, 2	90, 0

⁸ source: ESPON EGTC, <https://www.espon.eu/sites/default/files/attachments/ESPON%20Policy%20Brief%2C%20Labour%20migration%20challenges.pdf>

GEO /TIM E	201 9- Q1	201 9- Q2	201 9- Q3	201 9- Q4	202 0- Q1	202 0- Q2	202 0- Q3	202 0- Q4	202 1- Q1	202 1- Q2	202 1- Q3	202 1- Q4
Lith uani a	91, 2	90, 9	89, 8	91, 4	90, 4	89, 7	88, 4	89, 4	88, 6	89, 2	89, 8	89, 6
Swed en	87, 6	89, 0	88, 7	89, 9	88, 1	88, 0	87, 4	88, 3	86, 4	88, 3	89, 3	89, 6
Bulg aria	87, 6	89, 2	88, 6	88, 7	88, 7	86, 2	87, 1	88, 4	88, 0	88, 3	89, 3	89, 3
NL	88, 6	89, 0	88, 5	88, 6	88, 6	88, 5	88, 0	88, 8	88, 6	88, 2	88, 3	88, 7
Ger man y	88, 6	89, 0	89, 0	89, 2	:	:	:	:	87, 0	87, 5	88, 2	88, 6
Esto nia	86, 3	85, 7	85, 9	87, 8	85, 7	82, 9	84, 0	85, 8	86, 6	85, 6	87, 8	88, 4
Finla nd	85, 8	86, 2	86, 2	86, 7	86, 4	85, 8	86, 2	86, 5	86, 4	87, 2	87, 1	88, 3
Den mark	86, 9	87, 4	87, 1	87, 4	87, 4	87, 4	86, 3	87, 2	86, 0	88, 3	86, 9	88, 2
Rom ania	89, 2	89, 6	88, 9	89, 0	89, 3	88, 7	88, 7	88, 6	87, 5	88, 8	89, 3	88, 2
Latvi a	89, 3	88, 8	88, 8	89, 3	85, 5	86, 1	86, 4	87, 0	85, 6	84, 8	85, 1	87, 5
Irela nd	85, 2	85, 4	84, 6	85, 9	86, 3	82, 7	82, 9	83, 6	82, 9	84, 4	85, 5	87, 2
Port ugal	85, 6	86, 6	84, 5	85, 3	85, 5	84, 3	83, 7	84, 2	84, 4	86, 9	85, 9	86, 3
Slova kia	80, 8	80, 7	80, 3	80, 7	81, 0	80, 1	79, 5	80, 4	84, 9	85, 5	85, 4	85, 9
EU 27	84, 6	85, 1	84, 4	85, 0	84, 4	83, 5	83, 3	84, 1	84, 0	85, 0	84, 9	85, 8
LU	85, 1	85, 7	84, 4	83, 7	82, 7	84, 5	82, 9	82, 8	82, 8	83, 6	84, 1	85, 8
Czec hia	86, 0	85, 0	84, 6	84, 2	84, 5	83, 7	83, 4	84, 0	84, 4	84, 7	84, 7	85, 6

GEO /TIM E	201 9-Q1	201 9-Q2	201 9-Q3	201 9-Q4	202 0-Q1	202 0-Q2	202 0-Q3	202 0-Q4	202 1-Q1	202 1-Q2	202 1-Q3	202 1-Q4
Austria	84,5	85,0	84,7	85,3	84,6	83,9	85,2	85,0	84,1	84,3	85,4	85,6
Croatia	80,1	81,1	83,2	83,1	82,1	83,8	84,0	83,5	83,7	83,8	83,8	85,1
Belgium	84,3	84,2	83,1	83,8	83,9	83,7	83,0	83,6	83,6	84,3	83,6	84,9
Cyprus	83,2	83,6	82,6	83,7	83,9	84,1	81,2	83,3	82,3	83,1	84,7	84,6
France	83,6	83,9	82,5	83,4	83,5	82,7	81,8	82,4	83,6	84,9	84,2	84,4
Spain	79,9	80,8	79,9	80,7	79,8	77,0	77,6	78,4	78,4	79,6	79,6	81,1
Italy	78,7	80,0	77,9	79,0	79,0	78,0	76,3	78,7	78,4	79,8	77,9	80,7
Greece	74,9	76,3	75,0	74,6	74,9	74,5	74,2	74,5	71,2	74,8	76,7	77,7

Table 1. EU, the tertiary education (5-8) employment rate, age 20-64⁹

An EU overview of the employment rate for people with an 0-2 education level (**less than primary, primary and lower secondary education**) is captured by Eurostat statistical data (table 2). A low level of the employment rate for 0-2 level category can be interpreted from the perspective of some highly developed economic sectors, whose labour demand is concentrated at the tertiary level, while the need for the 0-2 level is insignificant, just as, it can also be interpreted as an work market instability or dysfunction of the in the case of economic sectors where the demand is predominant for level 0-2. At the opposite pole, a significant employment rate may mean the existence of economic sectors that predominantly require a labour force with an educational level of 0-2.

Starting from the European average of the indicator (55.7% in 2019, decreasing with the outbreak of the pandemic to 54.8% in 2020 and 54.9% in 2021) and the fact that 20 of the Union states register over 50%, it is observed that the highest values of the low-skilled employment rate are recorded in Portugal (69.3% in 2021 compared to 69.1% in 2020 and 69.8% in 2019), the Netherlands (with an increase important in 2021 (66.7%) compared to 2020 (62.9%), Malta (65.3% in 2021 compared to 64% in 2020 and 64.5% in 2019), Cyprus (64.5% in 2021 compared to 64% in 2020 and 63.2% in 2019), Estonia (62.7% in 2021), Germany (61.9% in 2021) and Denmark (61.2% in 2021). The lowest values are recorded in Slovakia (26.9% in 2021 compared to 34% in 2020 and 36.1% in

⁹ Source: Eurostat, author's processing

2019), Croatia (42.1% in 2021 compared to 38.5% and 39.5% in 2019) and Romania (42.5% in 2021 vs. 55.7% in 2020 and 56.8% in 2019).

GEO/TIME	2019	2020	2021
Portugal	69,8	69,1	69,3
Netherlands	63,2	62,9	66,7
Malta	64,5	64,0	65,3
Cyprus	63,2	64,0	64,5
Estonia	62,8	60,9	62,7
Germany	61,8	61,2	61,9
Denmark	59,5	58,9	61,2
Luxembourg	57,6	56,9	59,6
Hungary	55,7	54,6	57,8
Spain	57,8	55,4	57,2
Sweden	61,2	57,4	56,9
Latvia	59,9	61,3	56,7
Austria	55,7	54,2	55,0
EU 27	55,7	54,8	54,9
Czechia	53,4	54,7	53,7
Finland	52,0	51,5	53,2
Greece	50,2	49,9	52,5
France	51,8	52,5	51,8
Lithuania	47,9	48,2	51,5
Ireland	52,4	51,3	51,3
Italy	52,1	50,9	50,8
Slovenia	50,2	47,4	49,5
Poland	44,6	45,2	46,8
Bulgaria	51,2	48,1	46,3
Belgium	46,3	45,6	44,7
Romania	56,8	55,7	42,5
Croatia	39,5	38,5	42,1

GEO/TIME	2019	2020	2021
Slovakia	36,1	34,0	26,9

Table 2. EU, 0-2 education level employment rate, age 20-64¹⁰

The most important points of acceleration of the indicator values are observed in the case of Romania (a negative trend of the indicator is registered, with a significant decrease for 2021 compared to previous values), the Netherlands (increase in 2021 compared to 2020), Hungary (2021 compared to 2020) and Latvia (with a sharp decrease in 2021 from 2020).

Another aspect must be considered. According to a McKinsey study carried out with the Rework America Alliance, it is highlighted that, with the outbreak of the pandemic and its effects in the labour field, the large global companies have restructured the human resources management model, the poorly qualified or less educated workforce being reconsidered as a potential resource. The approach focuses on the value of the skills of this category of employees, before the academic titles they hold [20].

7. Conclusions

A very high European average of the tertiary employment rate is observed, with values starting from 77.7%. Regarding the employment rate of people with educational level 0-2, the recorded values are in 26.9% - 69.3% range.

There is already a trend of reconsideration and reevaluation of the potential of the poorly qualified labour resource, by the biggest global companies.

The EU member states with the highest DESI values are labour force receivers. Romania registers DESI values that are far from the average European values, in a negative sense: 68.80% lower in digital public services, 57.89% lower in integration of digital technologies, 32.39% lower in human capital, only in terms of connectivity approaching the European average (7.85 lower). The implementation process of the European public digitization policies in Romania must be made more efficient.

The EU member states with significant indicators regarding the intensity of employees number in knowledge economy field have also an high DESI indicators, while countries with negative critical indicators regarding the workforce present in science and technology are labour force senders and poorly DESI level.

For more in-depth future results, it should be considered how the speed of the digitization phenomenon and the degree of efficiency of the implementation of government policies related to digitization and research and development (R&D) public or foreign investments (FDI) act on the labour market and on the migratory flows of the labour force.

References

¹⁰ Source: Eurostat, author's processing

- [1] <https://dexonline.ro/definitie/digitalizare>, *DEXONLINE*, 05.12.2022
- [2] <https://www.gartner.com/en/information-technology/glossary/digitalization>, *GARTNER*, “*Gartner Glossary*.” 05.12.2022.
- [3] CEDEFOP, “Artificial or human intelligence? Cedefop briefing note, June 2019. <http://data.europa.eu/doi/10.2801/164782>.” [Online]. Available: <https://www.cedefop.europa.eu/en/publications-and-resources/publications/9140>.
- [4] <https://www2.deloitte.com/us/en/insights/topics/digital-transformation/digital-transformation-survey.html/#endnote-sup-29>, *DELOITTE*, “*Deloitte Digital Transformation 2020, Uncovering the connection between digital maturity and financial performance How digital transformation can lead to sustainable high performance*.”, 05.12.2022
- [5] <https://www2.deloitte.com/ro/ro/pages/strategy/articles/transformarea-digitala--un-proces-cu-avantaje-nu-doar-financiare.html>, *DELOITTE*, “*Transformarea digitală: un proces cu avantaje nu doar financiare*.” 05.12.2022
- [6] <https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2022>, *DESI Europa*, 05.12.2022
- [7] <https://digital-strategy.ec.europa.eu/en/policies/desi>, “*EC, The Digital Economy and Society Index (DESI)*.”, 05.12.2022
- [8] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Statistics_on_ICT_usage_and_e-commerce_introduced, *EUROSTAT*, “*Statistics on ICT usage and e-commerce introduced*.”
- [9] McKinsey & Company, “*The future of work after COVID-19, 2021*.” [Online]. Available: <https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-after-covid-19>.
- [10] N. R. Mosteanu, “*Finance Digitalization and its impact on labour market*,” *Tech. Soc. Sci. J.* (ISSN 2668-7798), [Online]. Available: [file:///C:/Users/92444272/Downloads/804-Article Text-3454-1-10-20200609 \(2\).pdf](file:///C:/Users/92444272/Downloads/804-Article%20Text-3454-1-10-20200609%20(2).pdf).
- [11] <https://www.cedefop.europa.eu/en/projects/european-skills-and-jobs-survey-esjs>, *CEDEFOP*, “*European skills and jobs survey (ESJS)*”, 05.12.2022
- [12] Factory 4.0 & Frames, “*Digitalizarea și robotizarea vor aduce peste 1 milion de locuri noi de muncă în România până în 2030 – Joburile care vor schimba viitorul*.”,
- [13] emergentresearch. <https://www.emergentresearch.org>, *Life Sciences Research An International Journal*, 05.12.2022
- [14] intuit.” <https://www.intuit.com/company/> , 05.12.2022
- [15] Kris Broda, “*Gig Economy – The Economic Backbone of the Future?*,” <https://brodmin.com/case-studies/gig-economy-case-study/>, 05.12.2022
- [16] J. Dobbs, Richard, Manyika, James and Woetzel, “*No Ordinary Disruption: The Four Global Forces Breaking All the Trends*.” McKinsey & Company, New York, 2015, [Online]. Available: <https://www.mckinsey.com/mgi/no-ordinary-disruption>.

[17] https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_808935.pdf, International Labour Organization, ILO Global Estimates on International Migrant Workers

[18] ESPON EGTC,

<https://www.espon.eu/sites/default/files/attachments/ESPON%20Policy%20Brief%20C%20Labour%20migration%20challenges.pdf>

[19] Diaz Ramirez, M., Thomas Liebig, Cécile Thoreau and Paolo Veneri. “The Integration of Migrants in OECD Regions: A First Assessment.” OECD Regional Development Working Papers, No. 2018/01. Paris: OECD Publishing. 2018., <https://doi.org/10.1787/fb089d9a-en>.

[20]

<https://www.mckinsey.com/~media/mckinsey/business%20functions/people%20and%20organizational%20performance/our%20insights/taking%20a%20skills%20based%20approach%20to%20building%20the%20future%20workforce/taking-a-skills-based-approach-to-building-the-future-workforce-vf.pdf?shouldIndex=false>)

[21] “Taking a skills-based approach to building the future workforce”
McKinsey&Rework America Alliance, 05.12.2022

FLUTTER TECHNOLOGY AND MOBILE SOFTWARE APPLICATIONS

Alexandru TĂBUȘCĂ¹

Cristina COCULESCU²

Mironela PÎRNĂU³

Abstract

Nowadays, many companies that develop mobile software applications have to develop the same application for the iOS and Android operating systems in parallel. Thus, the costs for creating the application will be higher because there have to be two teams of programmers. They have to work in parallel on the two platforms and to collaborate with each other, so that the developed application complies with requirements of design, planning and operation. The use of cross-platform frameworks allows the simultaneous development of an application for both the iOS and Android systems, generally using a platform-specific programming language, and the application code will be transposed and compiled into a dedicated code for each individual platform. Flutter technology is successfully used for the development of mobile applications, which contain a very good user interface and a technology which is simultaneously adapted to several platforms. Basically, the same code can be used for a web application that runs in a browser and can adapt itself to iOS, Android, Windows, MacOS or Linux platforms. Flutter is a development framework for front end, web development, UI, implemented by Google, being completely independent of the platform and can run both on IOS and Android systems, both as a web application and as a Windows application.

Keywords: Flutter, Dart, mobile software

JEL Classification: C88

1. Introduction

Flutter is a software development kit (SDK) created by Google under an open-source license. Initially, it was presented at the Dart Conference in 2015, and was called "Sky". It was designed as the main method of developing applications for the Fuchsia operating system (the operating system that later and gradually merged Android and ChromeOS). The latest Flutter version has three main components:

- Embedder – specific to the platform (iOS or Android)

¹ PhD Associate Professor, Romanian-American University, School of Computer Science for Business Management, tabusca.alexandru@rau.ro

² PhD Associate Professor, Romanian-American University, School of Computer Science for Business Management, coculescu.cristina@rau.ro

³ PhD Associate Professor, Titu Maiorescu University, Faculty of Informatics, mironela.pirnau@prof.utm.ro

- Engine (the Flutter rendering engine)
- Framework - the foundation library and widgets.

Applications developed in Flutter are written using the object-oriented programming language known as Dart. This programming language runs in a virtual machine written in C/C++. For choosing the programming language, Google considered the following criteria:

- developers' productivity
- using an object-oriented programming language
- predictability of the language, for a high performance but also a fast memory allocation, which is why Flutter is based on the fast and efficient allocation of small portions of memory [1-2].

A unique feature of Flutter technology is that it draws each pixel independently. Compared to React Native technology, it has internal widget collections – Cupertino for iOS and Material for Android but does not use OEM widgets [3].

Framework Dart	Material		Cupertino
	Widgets		
	Rendering		
	Animation	Painting	Gestures
	Foundation		
Engine C/C++	Dart	Skia	Text
Embedder Platform specific	Render Surface Setup	Native Plugins	Packaging
	Thread Setup	Event Loop Interop	

Fig 1. Flutter components

The rendering engine is written primarily in C/C++ and provides support for the Skia graphics library, but also links to development kits specific to both platforms, iOS and Android. In Flutter, Skia is an open source 2D graphics library that contains APIs common to a large number of hardware and software platforms.

The core library in Flutter is written in Dart and contains the core classes and functions used to build applications. Each element of the graphical interface is represented by a widget or a group of widgets.

2. Usage of Flutter Technology

To develop a Flutter application, we need to first install the software development kit (SDK) from its home web address [4] - the archive taken into account at the moment of the article elaboration is flutter_windows_3.3.8-stable.zip. The installation is done through the flutter_console.bat file inside the flutter folder. Also, to run Flutter commands in the windows console we need to add the path to the ".bat" script in the PATH system variable, see Fig 2.

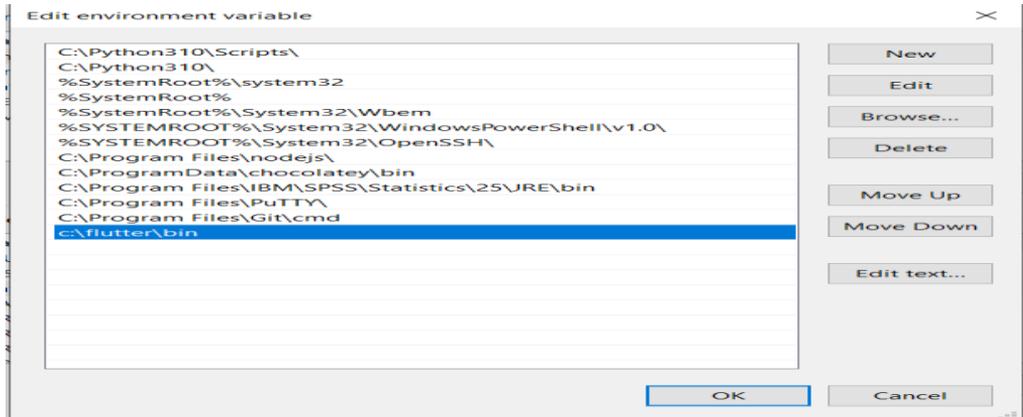


Fig 2. Adding of Flutter path

Flutter depends on the Android Visual Studio system through dependencies, so its installation becomes mandatory. The latest versions of Android SDK, Android SDK Platform-Tools and Android SD Build-Tools are installed with Android Visual Studio. Android Studio is created by Google and is an IDE used to develop Android applications [3]. In order to develop Flutter applications with Android Studio, it is necessary to install Flutter (see Fig. 3) and Dart (see Fig. 4) plugins.

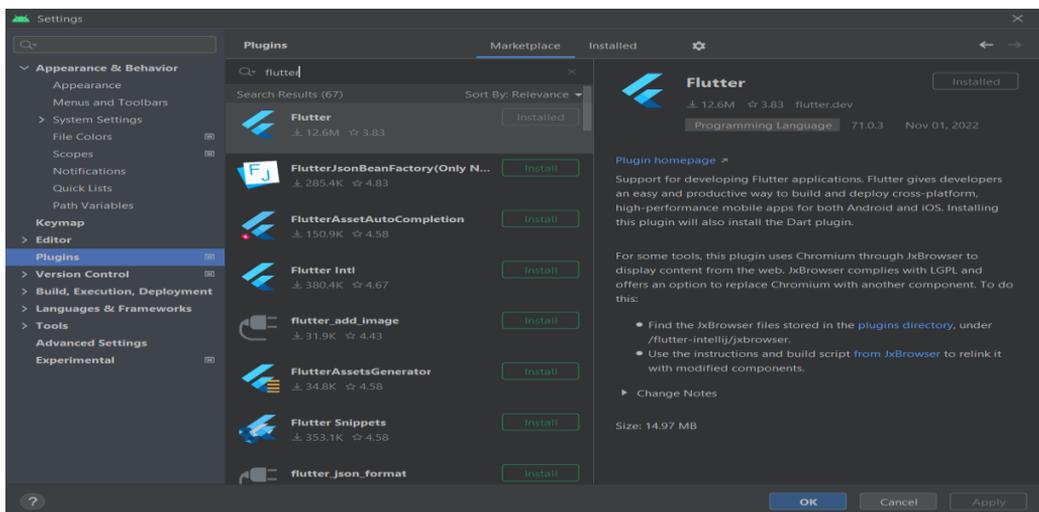


Fig. 3 Adding Flutter plugin to Android Studio

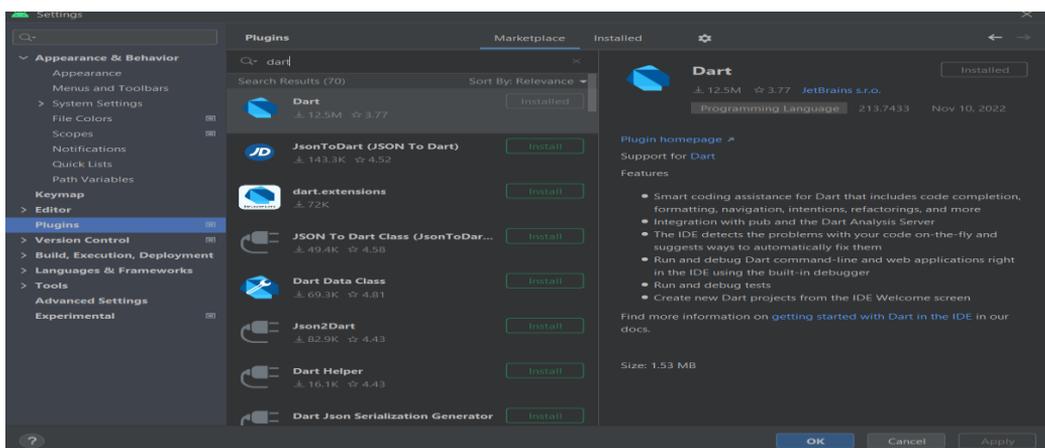


Fig. 4 Adding Dart plugin to Android Studio

After installing the Android Studio Application and adding the plugins (Fig 3. and Fig. 4.), the flutter doctor command is run in the console. This command will perform an analysis of the requirements and create a report with the information obtained, according to Fig. 5.

```
C:\Users\Mironela Pirnau>flutter doctor
Doctor summary (to see all details, run flutter doctor -v):
[✓] Flutter (Channel stable, 3.3.8, on Microsoft Windows [Version 10.0.19044.1889], locale en-US)
[!] Android toolchain - develop for Android devices (Android SDK version 33.0.0)
    X cmdline-tools component is missing
      Run `path/to/sdkmanager --install "cmdline-tools;latest"`
      See https://developer.android.com/studio/command-line for more details.
    X Android license status unknown.
      Run `flutter doctor --android-licenses` to accept the SDK licenses.
      See https://flutter.dev/docs/get-started/install/windows#android-setup for more details.
[✓] Chrome - develop for the web
[✓] Visual Studio - develop for Windows (Visual Studio Build Tools 2019 16.11.10)
[✓] Android Studio (version 2021.3)
[✓] VS Code (version 1.73.1)
[✓] Connected device (3 available)
[✓] HTTP Host Availability

! Doctor found issues in 1 category.

C:\Users\Mironela Pirnau>
```

Fig 5. Flutter doctor

With the help of the command *flutter create name_project* (see Fig 6.) a new project is created, and Flutter generates all the necessary files for a new application inside the directory where this command is run. The new directory structure created contains the files needed to generate the code in both Android and iOS.

```
C:\Users\Mironela Pirnau>flutter create flutter_project
Creating project flutter_project...
Running "flutter pub get" in flutter_project... 1,518ms
Wrote 127 files.

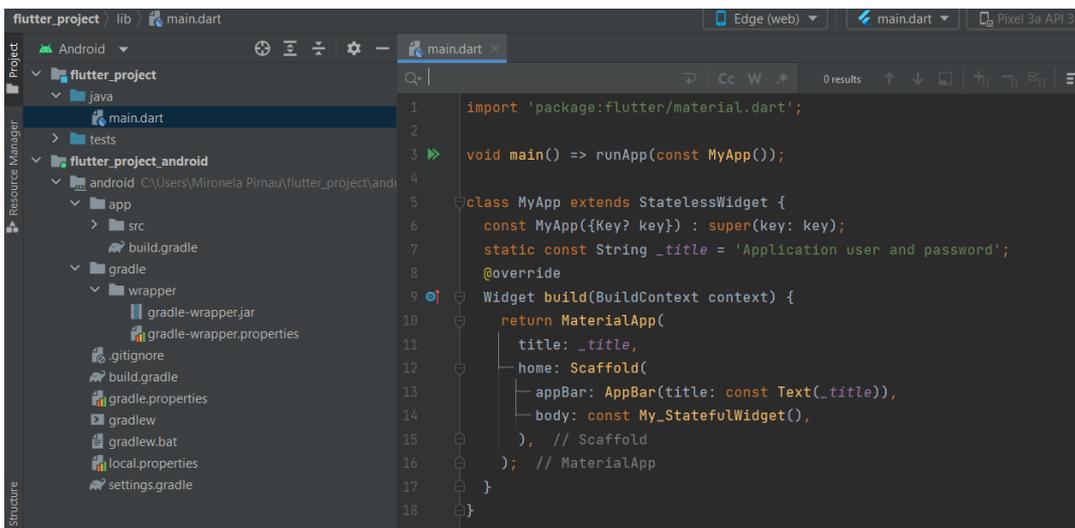
All done!
In order to run your application, type:

  $ cd flutter_project
  $ flutter run

Your application code is in flutter_project\lib\main.dart.
```

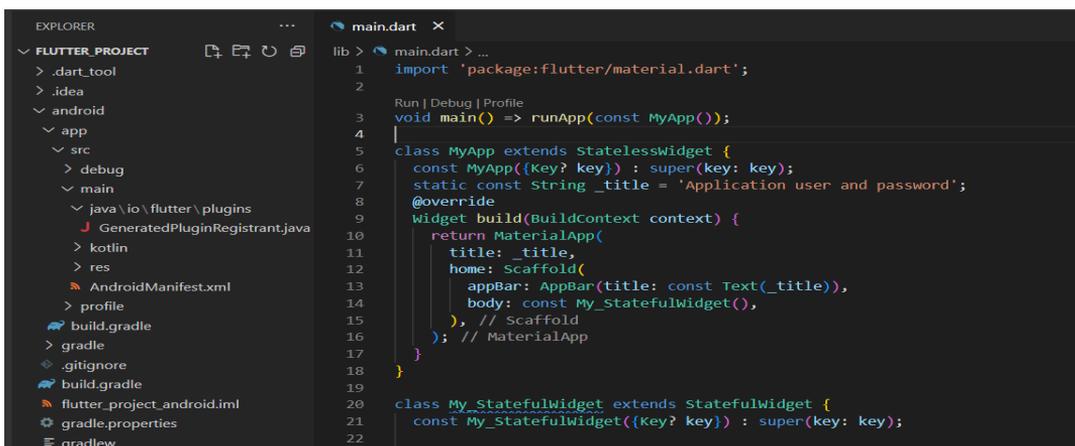
Fig. 6. Project creation within Flutter environment

The project can be open with Visual Studio Code (Fig. 7) or Android Studio (Fig. 8).



The screenshot shows the Visual Studio Code interface. On the left, the 'Project' pane displays the file structure of the Flutter project, including folders for 'flutter_project', 'flutter_project_android', and various configuration files like 'build.gradle' and 'gradlew'. The 'main.dart' file is selected and its content is shown in the editor. The code includes an import statement for 'package:flutter/material.dart', a main function that calls 'runApp(const MyApp())', and a 'MyApp' class that extends 'StatelessWidget'. The 'build' method returns a 'MaterialApp' widget with a 'Scaffold' containing an 'AppBar' and a 'My_StatefulWidget'.

Fig 7. Flutter Project opened with Visual Studio Code



The screenshot shows the Android Studio interface. The 'EXPLORER' pane on the left displays the project structure, including folders for 'FLUTTER_PROJECT', 'android', and 'app'. The 'main.dart' file is selected and its content is shown in the editor. The code is identical to the one shown in Figure 7, including the import statement, the main function, and the 'MyApp' class with its 'build' method.

Fig 8. Flutter Project opened with Android Studio

Testing the application on Android devices can be done by using a virtual machine created in Android Virtual Manager (Fig. 9) or by using a physical device connected via USB.

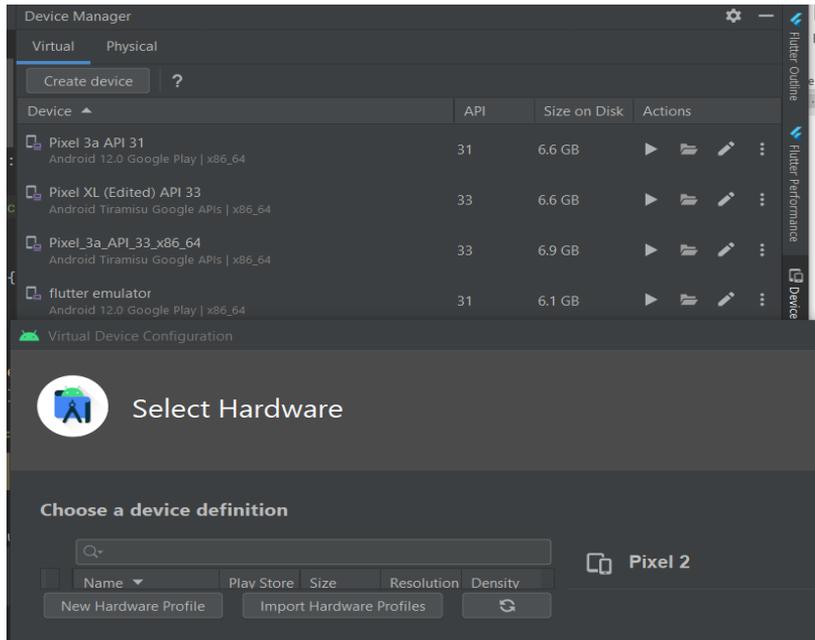


Fig 9. Create a new device within Android Virtual Manager

Android Virtual Manager is an emulation platform for devices using the Android operating system. It allows the creation of virtual machines of any version of the operating system, which will then run inside a Microsoft Windows window. Testing the application on the physical device is done by activating USB debugging in the phone's settings and connecting it using the USB cable. The user interface, after the correct running of the application, looks like in Fig 10.

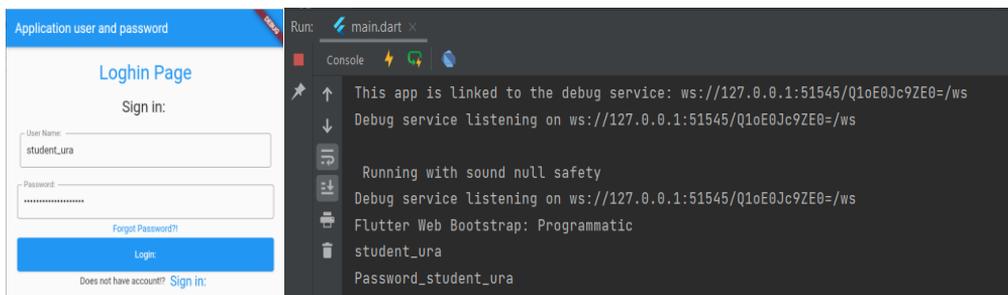


Fig 10. Interface of the current application

3. Widgets of Flutter

Each element of the graphical interface is represented by a widget or a group of widgets. In Flutter, a widget represents [3] a description of a graphical element that can be:

- a structural element: a text, an image, a shape, a button
- a styling element: font, color
- a schematic element: border, padding

Widgets form a composition-based hierarchy. Each widget is placed inside another, from which it inherits properties. There is no separate "application" object, this role being taken by the root widget. In Flutter, interaction with the user is given by updating the widget hierarchy, this is done by comparing the new widget with the old one, only the different elements being modified. Complex Widgets can also be created by combining several simple Widgets. In Flutter, the used widgets are not the native ones from the platforms the app runs on (Android or iOS) but they are specific representations, because Flutter contains a rich set of widgets, layouts and themes for each platform (such as Material Design for Android and Cupertino for iOS). In Flutter, widgets are divided into two categories:

- StatelessWidget
- StatefulWidget.

The **StatelessWidget** widgets are those widgets whose state does not change (such as for example: Text, Icon, IconButton) and do not depend on other components in the interface. A StatelessWidget widget has the role of describing part of the user interface by recursively building other widgets that form the user interface. The build process continues recursively, as shown in Fig. 11. In any Flutter application, the entry point is the *void main()* function in the *main.dart* file. This function calls, using the shorthand syntax, the *runApp* function with the constructor of the root widget class as a parameter. Flutter comes with the package called *material.dart*, which allows rapid development of an application because it contains all the basic widgets. Flutter can also import external packages that can be found at the link: <https://pub.dartlang.org/flutter>. In our case, *MyApp* is the root widget of type StatelessWidget that overrides the build method (see Fig. 11).

```
import 'package:flutter/material.dart';
void main() => runApp(const MyApp());
class MyApp extends StatelessWidget {
  const MyApp({Key? key}) : super(key: key);
  static const String _title = 'Application user and password';
  @override
  Widget build(BuildContext context) {
    return MaterialApp(
      title: _title,
      home: Scaffold(
        appBar: AppBar(title: const Text(_title)),
        body: const My_StatefulWidget(),
```

```
    ),  
  );  
}  
}
```

Fig. 11 Listing of code

Building widgets is done by implementing the build function, as shown in Fig. 12, which returns a hierarchy of widgets. When building the user interface, Flutter will recursively call the build function of each widget returned by the initial function. The structure of an application's component elements in Flutter is tree-like, where each node in the tree is represented by a widget. As these do not store location information in the tree, the concept of *BuildContext* arose. Widgets rebuild each time the app's internal state changes. To accomplish this, the *build* method is called, which receives a parameter of type *BuildContext*, where context is an instance of this class. Determining the position in which a certain widget is found in the interface, but also the position where it should end up, is done using *BuildContext*, a context that helps to position it correctly in the application stack. The child parameter is often used in Flutter widgets and represents the element or list of elements inside the widget whose parameter it is.

```
Widget build(BuildContext context) {  
  return Padding(  
    padding: const EdgeInsets.all(10),  
    child: ListView(  
      children: <Widget>[  
        Container(  
          alignment: Alignment.center,  
          padding: const EdgeInsets.all(10),  
          child: const Text(  
            'Loghin Page',  
            style: TextStyle(  
              color: Colors.blue,  
              fontWeight: FontWeight.w500,  
              fontSize: 30),  
          )),  
        Container(  
          alignment: Alignment.center,  
          padding: const EdgeInsets.all(10),  
          child: const Text(  
            'Sign in: ',  
            style: TextStyle(fontSize: 24),  
            ...));  
      ]  
    )  
  );  
}
```

Fig. 12 Listing with partial code of the *build* function

The **StatefulWidget** widgets are widgets whose state is changed by the user's interaction with the application, but also by changing other parameters of the application. Each stateful widget has an initial state that contains information about the widget. For a user-created widget to have dynamic content, it must inherit the StatefulWidget widget, according to Fig. 13.

```
class My_StatefulWidget extends StatefulWidget {  
  const My_StatefulWidget({Key? key}) : super(key: key);  
  
  @override  
  State<My_StatefulWidget> createState() => _MyStatefulWidget_State();  
}
```

Fig. 13 Listing of code

If the elements that make up a widget change their properties, so that the framework identifies the difference between the states of the widget, automatically all the elements that have undergone a change will be rendered. If in a StatefulWidget widget there are widgets that do not change their state, such as *Text*, we must use the *const* suffix before it, because the application will remove constant elements from the rendering process and thus increase its performance, according to Fig. 14.

```
class _MyStatefulWidget_State extends State<My_StatefulWidget> {  
  TextEditingController nameController = TextEditingController();  
  TextEditingController passwordController = TextEditingController();  
  @override  
  Widget build(BuildContext context) {  
    return Padding(  
      ...  
      child: const Text( 'Forgot Password?!', ), ), Container( height: 50,  
padding: const EdgeInsets.fromLTRB(10, 0, 10, 0),  
child: ElevatedButton(  
  child: const Text('Login:'),  
  ...  
  )  
  )  
}
```

Fig. 14 Listing of code

Once built, all widgets are stored in the tree that stores the logical structure of the user interface. The tree stores state in the case of stateful widgets, this being necessary because widgets cannot store relationships to the parent element or child elements. During widget

construction, Flutter avoids traversing the parent chain using *InheritedWidgets*. This widget maintains a hash table for each element, thus avoiding repeated traversal of the same widgets. This hash table only changes when a new element is inserted into the tree.

4. Dart Programming Language – main features

Dart is an optimized programming language that allows the rapid development of a solution that can be implemented on several platforms. Being a type-safe language, it uses type checking to ensure that a declared variable corresponds to the data type for which it was initialized. By using interfaces, declaring the type of a variable became optional, and declaring it in a dynamic way reverted to the dynamic reserved word, which ensures that a variable is checked and validated at runtime, when the code is executed [5]

This scenario provides the possibility for a variable to be null on declaration, by using the sound null safety paradigm. Using this paradigm at runtime, Dart performs static code analysis, thus filtering and eliminating the possibility of throwing a null exception. The technologies used by Dart for compilation offer two possibilities for running the code:

- Native Platform - for applications that are intended to run on mobile and desktop platforms
- Web Platform - for applications that run in a web browser.

For web applications, both compilation modes translate to JavaScript code. Regardless of the method used for compilation and execution, code execution needs the Dart runtime. The runtime is responsible for the following critical tasks:

- memory management
- aggressive use of the variable validation system
- isolated process management so that Dart controls the main application process in an isolated process.

Multithreaded programming in Dart is done by using *async-await*, *isolated* constructs, as well as dedicated classes, like for example *Future* and *Stream* classes. The execution of the code within an application is done inside a hybrid execution thread, which at first glance looks like a thread, and after a more detailed analysis we will find that it looks like a process. This method of abstraction is called *isolate*. In dart, each *isolate* has a single encapsulated execution thread, i.e., a safe thread.

5. Flutter vs. React

The main competing cutting-edge technologies for cross-platform development are Flutter – launched by Google in 2018 - and React Native launched in 2015 by Facebook. Although React Native supports most APIs for iOS and Android platforms, it does not provide the ability to create custom elements as Flutter does by using widgets. There are numerous statistics that show that (as of May 2021), Flutter is closing in on React Native in terms of

popularity and usage [6]. A look at the Google Trends results shows that starting from 2020, Flutter has a global search frequency above React Native. Flutter is the most popular cross-platform mobile framework used by global developers, according to a survey conducted in 2021 [7]. According to this survey, Flutter was used by about 42% of software developers. The survey also identified that 33% of mobile developers use cross-platform technologies while the rest of mobile developers use native tools. A check in google trends of user searches between Flutter and React Native technologies identified that worldwide, the interest of users' searches for Flutter technology exceeded the interest of Internet users' searches for React Native technology (see Fig. 15).

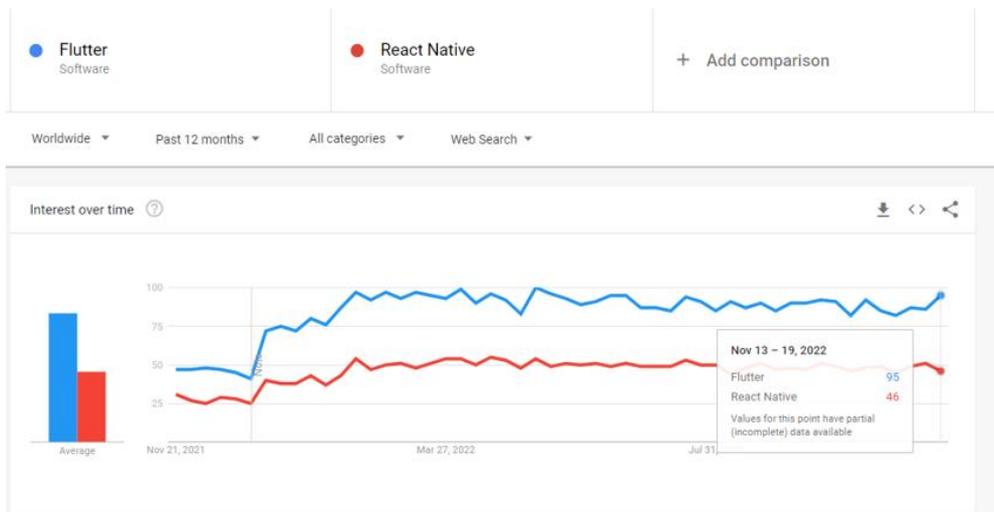


Fig. 15 Comparison of internet searches for Flutter vs React Native technology between 11/21/2021 – 11/20/2022

If we analyze user searches, but for the period 2018-2022, it can be observed that, from April 2020, the interest in Flutter exceeds the interest of searches for React Native (see Fig. 16).



Fig 16. Comparison of internet searches for Flutter vs React Native technology between 01/01/2018 – 11/20/2022

6. Conclusion

In our case-study application, discussed and partially presented in the above code-listing figures, Flutter allowed code to be written only once and compiled simultaneously for both iOS and Android. Flutter technology continues numerous facilities for the development of interactive multi-platform applications based on a complete package of tools for creating complex elements from simple elements. In Flutter any structure is a widget, including the application is represented by a widget containing the other widgets. However, the space occupied by the Flutter application is relatively large, because it is necessary to wrap the Flutter library in it. In order to be able to keep the same design, layout and widgets on mobile platforms, Flutter does not use the native elements of the mobile operating system but renders them using the Skia library. This while facilitating cross-platform development adds extra storage space occupied by the application. Flutter is fully integrated with Google services, so it makes it easy to use the Firebase Realtime Database solution for NoSQL databases. Regarding the performance of an application made in Flutter, the following factors must be taken into account:

- Speed
- Memory usage
- App size
- Energy consumption [8].

References

- [1] Napoli, M.L. *Beginning Flutter: A Hands-on Guide to App Development*; John Wiley & Sons: Hoboken, NJ, USA, 2019.
- [2] Biessek, Al., *Flutter for Beginners: An introductory guide to building cross-platform mobile applications with Flutter and Dart 2*. Packt Publishing Ltd, September 2019.
- [3] <https://docs.flutter.dev/development/ui/widgets/material> - last access: 11.2022
- [4] <https://docs.flutter.dev/get-started/install/windows> - last access: 11.2022
- [5] <https://dart.dev> - last access: 11.2022
- [6] <https://insights.stackoverflow.com/survey/2021#most-popular-technologies-misc-tech> - last access: 11.2022
- [7] <https://www.statista.com/statistics/869224/worldwide-software-developer-working-hours> - last access: 11.2022
- [8] <https://docs.flutter.dev/perf/> - last access: 11.2022

Bibliography

Sameha Rahman, <https://www.freecodecamp.org/news/https-medium-com-rahman-sameeha-whats-flutter-an-intro-to-dart> - last access: 06-12-2022

--, <https://www.javatpoint.com/flutter-dart-programming> - last access: 06-12-2022

TYAGI P, *Pragmatic Flutter*, ISBN 0367612097, Taylor & Francis Ltd. 2021

MARBURGER M, *Flutter and Dart*, ISBN 3836281465, Rheinwerk Verlag GmbH 2021

HOSSEINI P, *Flutter: Zero to App*, ISBN 1080745076, Independently Published 2019

ROSE R, *Flutter & Dart Cookbook*, ISBN 1098119517, O'Reilly Media 2022

MEILLER D, *Modern App Development with Dart and Flutter*, ISBN 3110721279, De Gruyter 2021

BELCHIN M, JUBERIAS P, *Web Programming with Dart*, ISBN 148420557X, APress 2014

PAYNE R, *Beginning App Development with Flutter*, ISBN 1484251806, APress 2019

ALESSANDRIA S, *Flutter Projects*, ISBN 1838647775, Packt Publishing Ltd. 2020

CYBERSECURITY EDUCATION – THE NEW LITERACY

Alexandru TĂBUȘCĂ¹

Gabriel GARAIȘ²

Alexandru ENĂCEANU³

Abstract

The present paper aims to underline the mandatory shift in higher education, especially, in order to include cybersecurity elements at all levels and domains of study. The nowadays almost complete reliance on electronic devices for sources of information, means of communications, utilities, research and even shopping, at some extent, bears a powerful emphasis on securing these electronic devices as best as possible. Besides the intrinsic security features and capabilities that are built into the hardware devices or programmed into different software applications, the human resources training and level of awareness towards the issue are critical. Even for students outside of the fields of study such as computer science, electronics, or informatics, at least a good level of general knowledge and awareness about cybersecurity issues like type of attacks, means of protection, basic rules of conduct regarding received files etc. becomes mandatory. The widespread knowledge about these issues, at higher education level within non-computer science related domains might exponentially increase the global level of security. The future highly skilled workforce of tomorrow would already be aware of the dangers and even able to avoid them, at least the most often encountered ones.

Keywords: cybersecurity education, electronic attacks awareness, cyber-education

JEL Classification: I21, L86

1. Introduction

For a couple of years now, the basic cybersecurity defence topic should have actually become almost a mandatory requirement, for almost all fields of education. Previously, the stage of the cybersecurity was almost reserved just for the computer science students/specialists or for self-taught “nerds”. After the virtual explosion of all kinds of electronic devices that we, the final users, use either directly (smartphones, laptops, tablets) or indirectly (cloud services, online payments, online shopping, remote meetings, etc.) throughout the day, the need for security implies the use of so many dedicated professionals in the field of cybersecurity that it is not actually possible to cover the entire market need. The first, fastest and less expensive solution is to increase the general knowledge in the field for as many as possible, to cover at least the basic and most often happening cybersecurity incidents directly at the source, without the need of a specialized and highly

¹ PhD Associate Professor, Romanian-American University, tabusca.alexandru@profesor.rau.ro

² PhD Lecturer, Romanian-American University, garais.gabriel.eugen@profesor.rau.ro

³ PhD Lecturer, Romanian-American University, alexandru.enaceanu@profesor.rau.ro

skilled cybersecurity workforce.

Moreover, during the last years there were more and more incidents that showed the critical stages that might appear in case basic cyber security issues are overlooked. Just this year, after the savage, barbarian attack of the Russian red-army hordes over a sovereign and independent neighbor, Ukraine, the cybersecurity importance increased even further. Both the barbarian attackers and the resilient defenders (with a lot of help and support from all over the world) engaged in a first wide-scale cyberwar. Both parties employed mostly the DDoS attack method to stop the access and workflows of different electronic controlled systems, such as TV stations, power companies, communication networks, services of public/private utilities companies, etc.

Even though inherently a bad situation for the cybersecurity defense, the hack managed by the well-known group of online activists commonly addressed as Anonymous was one of the first successes of the civilized world in putting the Russian population in touch with the real war their demented leaders launched. In the end, the feat was not relevant because the vast majority of the aggressor's population actually supports the war, but the hack showed that even for a seemingly powerful country it is impossible to counter 100% of the cyberattacks launched against it.



Fig. 1 Capture of Russian TV station hack broadcast showing real war images from Ukraine [1]⁴

⁴ Source <https://www.rferl.org/>

In June 2022, another cyber-attack managed to paralyze the live transmission of the Russian war-criminal leader, from the St. Petersburg economic forum. The Kremlin authorities admitted that a DDoS attack stalled the forum, which was rebooted around 100 minutes later, with the Russian war-criminal delivering its lies bundled as a speech [2]. The attack itself seems to have been on a broader scale, with the livestream video delivery delay being only the visible tip of the iceberg. Sources from the participants to the forum, corroborated with official Russian administrative staff declarations, said that electronic systems problems started earlier, with the distribution of access materials such as badges (and their verification system) and with the confirmations to the main plenary not being delivered to participants. There might also have been a local element involved, as the same sources also mention a lack on onsite wireless internet connection after the problems started to appear [3].

2. Cybersecurity Basic Attacks

We will start by introducing the most common and often encountered types of cyber-attacks that took place in 2021. The same as for the previous years, most attacks are carried out from remote locations. Especially after the pandemic that brought an exponential increase in work-from-home users, at the same time and with the same rate increasing also the permanent/temporary online (mostly internet) connections between employees' locations and company headquarters, the remote-based attacks become something almost trivial in the online environment. Among the most often encountered attacks we can mention:

Malware. At this time, specialist discern several different types of malware attacks. Malware usually refers to a dedicated code written specifically to produce harm inside an IT infrastructure element (a device, a server, a certain type of file, the whole infrastructure, etc.). These attacks can be delivered to the final victim in a multitude of forms, such as worms, spyware, adware or the feared ransomware. Several cyber-security reports sustain that, in 2021 compared to 2020, there was an increase of 800% in the malware attacks at global level. Malware attacks, even though not the very sophisticated and complex of cyber-attacks, are not only a problem for private individuals or smaller companies.

Ransomware. Ransomware is considered by the specialists as a subtype of malicious software with a particular type of attack/result. If successful, a ransomware attack effectively blocks the users within a certain IT infrastructure paradigm and does not allow them to access their systems. Unfortunately, it is a very effective cyber-attack for rendering an entire IT infrastructure useless very fast. These attacks usually encrypt the victim's data/information and demand a ransom for allowing access again. Besides the fact that, in most cases actually, even after the ransom would have been paid the attackers do not release their hold on the captured data, such an attack brings also a heavy toll in company image price. In an (in)famous attack in 2017, the WannaCry malware paralyzed more than 200000 computers with Microsoft Windows operating systems, disrupting critical services from

the fields of healthcare, finance, or communications. The National Health Service (NHS) in Great Britain was disrupted, Telefonica communications giant from Spain also paid its toll, and different banks, especially from Russia, were also disrupted. The malware seemed to have appeared at the same time in all locations and, even though not 100% sure even now, it is widely blamed on a North Korean hacking organization called Lazarus Group [4].

Phishing Attacks. Phishing is, by far, one of the most widely encountered attacks and one of the easiest to avoid by (very) basic awareness and cyber-security training. It is a type of social engineering attack, which actually convince a victim to share different critical data (usually credentials like passwords, credit cards info, user accounts, etc.). During such a cyber-attack a victim might also be convinced that it is needed to download a certain file, from a certain internet link within an email message. Besides the classic email carrier vector for phishing, we might also encounter different carriers such as SMS, other phone messages or social-media posts/messages.

DDoS. This type of attack is an evolution of the classic DoS (denial of service), which stops a victim IT infrastructure by oversaturated requests (usually meant to attack websites/web services). The need of the IT infrastructure to solve each request brings the impossibility to do it because of the huge number of fake requests, thus in fact bringing all the responses to a halt. The updated version of this cyber-attack, the DDoS (distributed denial of service) aims for the same purpose of disrupting the normal workflow of victim's IT infrastructure, but instead of sending all the flooding fake requests from one location (which actually might be very easy to overcome by just barring that one source location), it uses multiple sources for sending the fake requests. This variation, the DDoS, is much more difficult to counter, in reality being almost impossible to 100% protect against it. The infrastructure might become unusable for a while, but a professional contingency plan would render the infrastructure active again quite soon.

Credential stuffing attack. This type of attack is in fact one of the most important causes of data breaches. According to a series of research studies made by Google [5], no less than 65% of IT infrastructure users were using the same password for more than one account. The usage of the same set of credentials for multiple accounts brings an increased level or risk, as it becomes easier for an attacker to get hold of one's password and use it for multiple accounts of the same victim. In credential stuffing attacks, the credentials obtained by the cyber-attacker (usually usernames and passwords), in most cases from a data breach, are later used to obtain critical data from one of the victim's "partners" of electronic conversations (employer, bank, e-commerce websites, etc.).

Password attacks. The very often encountered password attack is the one of the oldest and easiest to carry out type of cyber-attack. It represents a common causes of data breaches, based on the users' lack of cybersecurity awareness, especially in the case of very weak passwords that become very easily exploitable. One of the US giants of

telecommunications, Verizon, published a report [6] mentioning that 61% of data breaches are due to weak passwords.

IoT weaknesses. By deploying this type of attack, the wrongdoers target a network of IoT (internet of things) devices or a single device or a specific type of devices. Due to different exploits and security breaches that are not covered by the producers/users the hackers can take control of a device and, usually, they can use it for two different types of attacks. They can either infiltrate the specific IT infrastructure the device is part of (and snoop for data, collect unauthorized information either in electronic format or even in audio/video mode) or they can take control and use it later to set up an entire army of dumb/bot devices that can further disseminate a cyber-attack in the category of DoS or DDoS. Due to the explosive expansion of IoT devices, it is most probable that the near future will bring an even greater number of attacks onto this vector.

Man-in-the-middle. This type of cyberattack is usually a much more insidious attack than the previously presented ones. The previous attacks are very visible, very soon/immediately, after the attack, as they are engineered to produce visible harm. The man-in-the-middle attack is usually used for infiltration and collecting data without authorization, within the transmission between two network points. The attacker tries to impersonate one of the two authorized parties of an electronic exchange of data (conversation) and thus can receive information such as passwords, personal data, other types of credentials, financial info etc. The results of this attack can be seen much, much later, as in a lot of cases the fake receiver of a transmission will also send the information forward, to the original destination. Such an attack can last for a long time, with an unauthorized party spying on electronic conversations and just extracting data without actually stopping the transmission process.

Cross-Site Scripting (XSS). An XSS type of cyber-attack appears if a hacker manages to inject a malicious set of code into a victim website. The malicious lines of code are usually launched as a script file, inside the victim's web browser and is responsible for acquiring unauthorized data sent by the users through the web browser.

SQL Injection. This type of attack, dissimilar to the XSS one, usually targets a database client rather than one user directly. Nevertheless, especially with the multitude of web platforms/frameworks that rely on databases for maintaining a website, (such as the omnipresent Wordpress also), the cyberattack is in fact targeting websites in a lot of cases. The logic behind this type of attack is very similar to the XSS type.

Based on estimates for the COVID-19 pandemic times, the rate of cyberattacks (of all kinds) increased by 600% between pre-pandemic and end-of-pandemic times.

A very well-known and respected specialist in the field, the publisher of Cyber Defense Magazine⁵, Gary Miliefsky, said “*Cybercrime has surpassed Drug Crime as the largest form of global thievery since 2018 and continues to grow. At Cyber Defense Magazine, we predict that Cybercrime will account for over \$12 trillion in theft and damages by 2025*”. He also concludes that “*The biggest form of cybercrime is spear phishing and remote access trojans (RATs), which are not that sophisticated at all*”.

3. Basic Response Solutions

Besides the last three types of attacks mentioned in the previous section of our paper, which require specific and technical expertise to address, all other types of attacks, all others can be avoided, at a high rate of success, by implementing only cybersecurity awareness principals that can be taught to and mastered by people not working in the IT field as their main activity.

At this time, the labour market does not offer enough highly skilled cyber-security professionals, and the situation is not possible to be addressed very soon – as such a specialist does not become available overnight, besides the basic and traditional training (computer science schools, dedicated cybersecurity programs) that might be available the person itself must be capable of understanding and efficiently employing a lot of mathematical and logical tools. Nevertheless, we consider that at least a part of the problem might be addressed by teaching skilled workers from other fields to efficiently make use of a set of basic tools and principles related to cybersecurity. Thus, by hugely enlarging the “army” that knows how to counter (lots of) cybersecurity attacks, we will correspondingly diminish the risk of important breaches of security.

The main body of cybersecurity specialists today consider that a good cyber-security posture can be attained by a company if it pays specific attention to the following cyber-defense elements [7]:

- Asset management and inventory identification
- Management of risks
- Access rights management
- Management of threats
- Security controls
- Disaster recovery and business continuity
- Management of security incidents
- Cybersecurity education, training, and awareness

All the elements above, even though their titles are seemingly very IT technical oriented, can in fact be covered at proficient enough level, by cybersecurity education implemented at non-technical study programs, within the higher education systems (and even at high school level with dedicated modifications). Students from the fields of law, sports, economics, arts, etc. can be taught the most important basic elements of cybersecurity, they can be made aware of the huge risks that a weak password, the usage of the same username

⁵ <https://www.cyberdefensemagazine.com>

and password for all websites or dismissing upgrade/updates for the security software might imply.

On the other hand, we should not forget that there are cyber-security services that only highly skilled and dedicated professionals can efficiently provide. There are services that only a professional IT engineer or dedicated cyber-forensics company can provide: pentesting, internal and external network audits, network intrusion analysis, vulnerability assessments and digital evidence preservation.

However, even in a SOHO⁶ environment, without trained cyber-security professionals, there are several things very easy to implement, that can be used against intrusions by anyone with a minimum basic cyber-security education:

- *Use antivirus and antispyware* - To gain access to data, attackers install malicious software on attacked devices, such as viruses, trojans, worms, ransomware, and spyware, without permission. Viruses can destroy sensitive data, slow down the computer, or they can take control of it. A way for computer viruses to take control of the computer is to allow spammers to send emails from someone's account. Spyware can monitor online activities, collect personal information, or create unwanted pop-up ads in your browser. It is advisable to download software only from trusted websites to avoid being infected with spyware. Antivirus solutions scan the computer and incoming emails against viruses. Sometimes, antivirus software also includes antispyware. Frequently update the antivirus to protect against the latest versions of malicious software, preferably by using the automated update options.
- *Keep the firewall enabled* - Whether it's a software firewall or a hardware firewall on a router, the firewall must be active and up to date to prevent hackers from accessing private data.
- *Manage the operating system and browser* - Hackers are always trying to take advantage of vulnerabilities in the operating systems and web browsers. To protect the computer and personal data, the computer and browser security settings must be maintained at a medium or higher level. Update computer's operating system, including web browsers, and regularly download and install the latest software patches and security updates from vendors.
- *Protect all your devices* - Your devices, whether they are computers, laptops, tablets, or smartphones, must be password protected, better yet – implement MFA⁷ if possible, to prevent unauthorized access. Stored information must be encrypted, especially if it is sensitive or confidential data. For mobile devices, store only the information you really need, in case the device is stolen or lost when you are away from home. If any of your devices is compromised, cyber-attackers can access all data through your cloud storage service provider, such as iCloud or Google Drive.
- *IoT devices* - present a higher risk of infection than other devices. While mobile, desktop and laptop platforms receive frequent software updates, most IoT devices still have the original firmware. If there are vulnerabilities in the firmware, the IoT

⁶ SOHO = small office, home office

⁷ MFA = multi-factor authentication

device will remain vulnerable. To make matters worse, IoT devices are designed to require Internet access. Most IoT devices are designed to require Internet access from the client network. The result is that IoT devices allow access to the local network and customer data. The best way to protect is for IoT devices to use an isolated network (guest SSID and/or different VLAN).

- *WIFI routers* - last but not least, update the to the latest firmware to prevent attacks such as Key Reinstallation Attacks [8]. This attack was discovered in 2017 and updated in 2018 and works against all modern protected Wi-Fi networks, so if the router manufacturer doesn't provide an updated version of firmware, it is advised to replace the router with a newer one.

4. RAU⁸ Case Study

As a case study for our idea, the Romanian-American University is currently implementing a cyber-security focused project, called "Let's Protect our Future Better! Advanced Cybersecurity". Inside the framework of the project, we have registered 23% of the applicants for internship cyber-security related internship stages that were not students of computer science programs, but actually came from other fields of study such as tourism, law, management & marketing, physical education or economic studies. Every category of students was assigned to a specifically tailored internship stages, focused on their specific field in correlation with cybersecurity elements. There were devised different activities enhancing their knowledge and skills in sub-areas such as: cyberlaw (for law students), personal data protection (for management-marketing students), data regulations and public requirements (for tourism students), protection of medical-record information (for sports and kinesiotherapy students).

The students that were involved in this project have followed a selection process, so that they were accepted into the project based on their previous background and letter of interest they attached. Each accepted student has gone through a process of professional counseling in order to be prepared for the courses in the field of cybersecurity, but also to be able to be directed to the sub-field that suits him best (cyberlaw, testing, personal data protection, software development etc.). The interest shown by the students for the activities of the project is also supported by the statistics below.

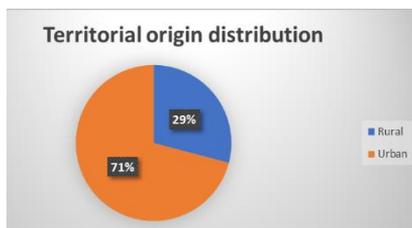


Fig. 2 Distribution of participants by domicile classification⁹

⁸ RAU – Romanian-American University, Bucharest, Romania

⁹ Source: RAU implemented project statistics, <http://practica-cybersecurity.rau.ro/>

The distribution piechart shows that most of the enrolled students come from the urban area, a result that is actually consistent with the higher number of high school and university students that come from this area, compared to the rural one.

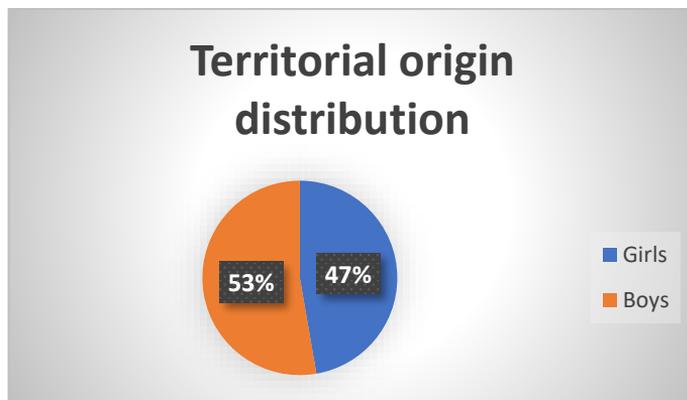


Fig. 3 Distribution of participants by sex¹⁰

It is interesting to mention that the result of the distribution by sex is almost equal between male and female participants, while the statistics for Computer Science study programs, focused on cyber-security, show a rather different distribution with around 76% of the students being males.

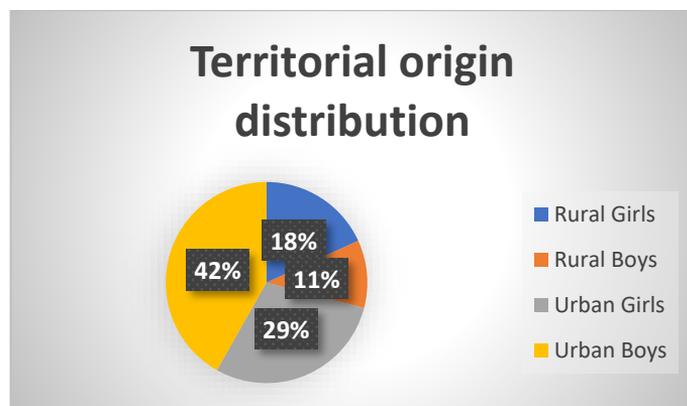


Fig. 2 The distribution of participants based on a compound territorial and sex indicator¹¹

Not surprisingly, the combined result of applying both the territorial and sex criteria shows us a majority of participants as being males from urban areas, followed by the percentage of female participants coming also from the urban areas. There is a small surprise for the last position – the lowest percentage of participants comes from rural areas and are males.

¹⁰ Source: RAU implemented project statistics, <http://practica-cybersecurity.rau.ro/>

¹¹ Source: RAU implemented project statistics, <http://practica-cybersecurity.rau.ro/>

Again, this is different from the normal Computer Science study programs focusing on cybersecurity, which have the rural & females compound category on the last position.

These statistics support the idea that basic cybersecurity education can be successfully delivered to all kind of students, regarding not only the fields of study they come from, but also their distribution based on type of origin (urban/rural) and sex (female/male).

5. Conclusions

At the end of the internship stages, the successful graduation of the programs was at an excellent level, with 100% successful internships for the non-computer science students. This figure also adds to our idea that short-term, specific-field of study, trainings for higher education students, in the area of cybersecurity, can prove very successful. These trained students will act as a multiplier and forward the spread of good-practices to their colleagues and (future) employers, thus increasing the all-around level of cyber-security defense even without the use of highly skilled, highly trained and highly expensive, cyber-security professionals.

Of course, the dedicated professionals are and will always be needed, as more complex and technically-subtle cyber-attacks are not even visible, let alone mitigated, by the above-mentioned category of “light-cyber-security” specialists.

References

- [1] <https://www.rferl.org/a/russian-tv-hacked-ukraine-anonymous/31740663.html> - Radio Free Europe Radio Liberty; last access: June 18, 2022
- [2] <https://www.darkreading.com/attacks-breaches/ddos-attacks-delay-putin-speech-russian-economic-forum> - Dark Reading; last access: June 18, 2022
- [3] <https://www.bloomberg.com/news/articles/2022-06-17/kremlin-says-cyberattack-delays-putin-s-forum-speech-by-1-hour> - Bloomberg Europe Edition; last access June 18, 2022
- [4] <https://www.malwarebytes.com/wannacry> - last access: June 19, 2022
- [5] <https://www.infosecurity-magazine.com/blogs/your-employees-reusing-passwords/> - last access: June 19, 2022
- [6] <https://www.verizon.com/business/resources/reports/dbir/2022/master-guide/> - last access: June 18, 2022
- [7] Tăbușcă, A., Tăbușcă S., Basic Cyber Defence Education for Everyone, Journal of Information Systems & Operations Management, Vol. 16.1, Bucharest, pp 253-263, May 2022
- [8] <https://papers.mathyvanhoef.com/ccs2018.pdf> - Release the Kraken: New KRACKs in the 802.11 Standard - last access: June 19, 2022

TESTING THE GENERALIZATION OF AUTOMATED REAL ESTATE PROPERTY EVALUATION MODELS

Eric TZIMAS¹

Manolis KRITIKOS²

Abstract

The goal of this paper is to analyze the implementation of an automation valuation model in real estate and provide insight regarding its behavior when faced with real world data. An automated valuation model was implemented using two different datasets from Ames Iowa and Athens Greece. The models implemented were a KNeighborsRegressor, a GradientBoostingRegressor, a DecisionTreeRegressor, a Random Forest Regressor, a Stacked Regressor, and a Neural Network. The best scoring model for both datasets was the Random Forest Regressor. Two different methods were used for the evaluation of the above models. These methods include testing using twenty percent of the starting dataset and testing using a custom dataset created by authorized property appraisers. In both techniques, the models scored similarly, with only a three percent difference in accuracy, showcasing the rigidity and robustness of the valuation model when faced with external and quality assured data.

Keywords: Machine learning, real estate, property evaluation, price prediction

JEL Classification: R320 Other Spatial Production and Pricing Analysis

1. Introduction

The real estate sector which is divided into residential real estate, commercial real estate, and industrial real estate, stands as one of the biggest markets in the world and according to recent studies, the residential market was approximated at more than \$33,8 trillion [1]. This specific market has been widely affected by the uprising of big data in the last years. Businesses use large volumes of records to assess the state of the mortgage industry and to assess insurance risk. Property evaluations have also played a major role in assessing price trends and geographical fluctuations. Businesses can assess financial risks and pinpoint high yielding investments [2]. Residential property prediction has lately been a topic of interest for scientists since it is a component of critical financial decisions for potential buyers as well as real estate brokers. Individuals and investors want to invest in the housing sector and observe the fluctuations in the real estate market, while these trends also tend to mirror the economic state of any developing country [3]. Due to the latest advances in Big Data technologies as well as Statistics and Machine Learning, real estate property predictions has become a valid field of study where those issues can be resolved by applying deep learning or machine learning algorithms on real transaction data. Application

¹ CTO-Co-Founder Hobsido, Athens, email: errikos.tzimas@gmail.com

² Management Science Laboratory, Athens University of Economics and Business, kmn@aub.gr

of big data techniques in the real estate field can be divided into two categories, forecasting the house price index and real estate price prediction [4]. Mass appraisal is now widely used by real estate companies all around the world for business decisions and the most important asset of this system is the automated valuation model [5].

The first step for creating a machine learning estimator is the collection of data. The real transactional data is hard to find and collect. Scraping techniques can be used, but then arises the problem of duplicate entries, when data is integrated from multiple sources [5]. These duplications can disrupt the training of the algorithm by indicating that these duplicate values have more importance. If duplicates exist in training and testing datasets it can bias the prediction towards these false, duplicate entries [6].

Additionally, it is difficult to collect sufficient data regarding the features of the house, as well as location data and macro variables like mean neighborhood income rate [5]. Data Selection plays a big role in the final accuracy of residential real estate price prediction models as well as the various ETL techniques that should be used to face the problem of automated estimation. The three strongest indicators of a house's price come from durability, heterogeneity, and spatial fixity. Durability of a property indicates the duration of which a house can keep its price due to good construction and a good aging process in the market. Heterogeneity stems from all the factors that differentiate one property from another such as numbers of bathrooms or bedrooms. Spatial fixity refers to the location of the property. The five aspects of locations are the distance from the analyzed property, the socioeconomic character of the location, the natural traits of a location and the local government that prevails in the area. Some basic macroeconomic factors that should be taken into consideration in conjunction with real transaction data is the GDP of a country, the GNP, and the consumer price index [7].

Analyzing this problem at scale, it should be noted that integration of heterogeneous data from different sources should be considered as the source of information for a scalable system. Building a robust model requires data in high velocity and volume to keep up with fluctuation in market prices and updates in the real estate sector as well as evaluating the constantly changing macroeconomic features of a country. A rise in the real estate market can be attributed to the increasing income of the inhabitants of a certain area, but this can change over time. Careful analysis has led us to the conclusion that the factors that indicate a real estate property's price can change over time [3].

The information needed to provide accurate real estate pricing predictions is mostly derived from quantitative and qualitative data. Thus, it is important to include enough of both feature classes in the analyzed dataset. Quantitative data consists of macroeconomic factors like GDP per country, Business Cycles, and unemployment metrics. Qualitative metrics are composed from building styles and living environment, but it has been proven to be scarce in availability and various problems seem to arise in the collection of these attributes [8]. In his analysis of random forest models for the mass appraisal of residential property in South Korea, Jengei Hong used the following variable groups to train the model, Structural attributes, Neighborhood attributes, Locational attributes, and Macro variables. These variables comprise a succinct template for a basic model as they sufficiently fulfill the prerequisites for macroeconomic features as well as estate features. These variables can also address the durability of the property, in regard to the construction year, the macro

variables (transaction period, land price fluctuation etc.). Regarding heterogeneity the chosen features might not be sufficient [9].

Identifying the correct dataset or after extracting and loading from various data sources the data should be explored and visualized to study its characteristics, something that can critically affect the model's success. All different parameters and relations should be investigated and evaluated, and tests should be run to identify possible outliers or invalid values [10]. After visualization, data pre-processing must take place. Data should be cleaned, and the outliers should be removed. The outliers could be removed using the interquartile range technique [8].

Regarding missing values, we use the values of the records with the most closely related features or, if dealing with categorical features with uneven distribution, replace null values with the most highly frequent category [11]. Additionally, numerical values can be replaced by the mean of the feature [12]. For models that do not directly work with categorical variables, categorical variables should be transformed using one-hot encoding. This method transforms n categories into n new binary features [12]. The variables could also be scaled on a scale of 1-5 based on a table of assumption connected with the significance of each variable to cover the set of features that is the most valuable [7]. Finally, data can be normalized by subtracting the mean value of each feature and dividing it with its standard deviation. This technique can speed up learning and lead to more accurate predictions [12].

2. Proposed methodology

The aim of this prototype is to assess the efficacy of a real estate prediction model and its robustness when faced with high variance data. The tools used for this prototype are Python and specifically the Pandas library, for data exploration, data cleaning, model creation and model performance assessment. Specifically for the creation of machine learning models the Sci-kit python library was used. For visualization matplotlib and seaborn libraries were used. The models are going to be tested using two different datasets from different countries and cities, containing different amounts of records. These two datasets are going to be opposite in terms of shape, meaning that the first one is going to contain a good amount of features while being small in record size and the second one is going to contain a large number of records with a limited feature size. Various techniques are going to be tested in terms of data pre-processing and model tuning but only the most successful techniques are going to be presented. Finally, the prototype is going to be tested, using 20% of the starting dataset, and using real world estimations done by human appraisers to test its generalization and rigidity.

The datasets used are two vastly different sets of real transactional data from different countries and cities. The first dataset comes from the website kaggle.com and it contains a wide range of characteristics for each property in Ames, Iowa for houses sold between 2006 and 2010. This dataset contains a small number of records but with many features. Namely, 1460 house transactions with 78 features per record.

The second dataset comes from multiple website listings in Athens Greece. It contains 69.823 records of website listings with 27 features for each record. The dataset is composed only of apartment records and the features mostly describe the aspects of the property.

Beginning with data exploration on the Ames housing dataset, each continuous feature of its records was analyzed regarding the count of occurrences in the dataset, the mean, the standard deviation, the range, the maximum and minimum values and the 25th, 50th and 75th percentiles. The mean sale price for the dataset is 180.921 dollars. The frequency of the houses compared to a continuous variable was visualized to comprehend the various distributions of our records. In Figure 1, the frequency of the records fitted into different bins based on their sale price is presented, most properties are priced between 100.000 and 150.000 Euros.

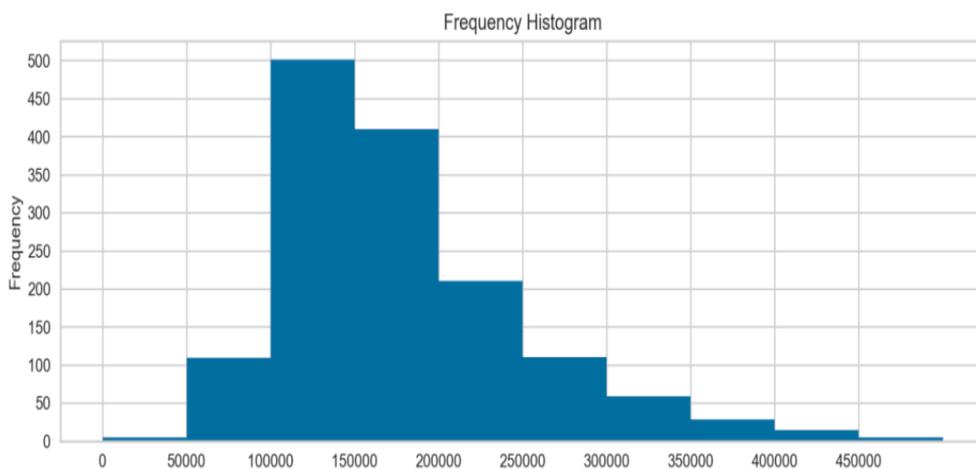


Figure 1. Frequency of properties based on price range for Ames dataset

The features of the dataset were segmented based on their type. The columns containing categorical features were factorized to deal only with numerical values from now on. To deal with null values, all empty values were replaced with the mode of the feature, if the feature was categorical, or the mean of the feature if it was continuous. Furthermore, as proposed in international literature, the categorical features were transformed using one-hot encoding. This means that a feature like MSZoning that identifies the general zoning classification of the sale and can take values: A, C, FV, I, RH, RL, RP and RM for Agriculture, Commercial, Floating Village Residential, Industrial, Residential High Density, Residential Low Density, Residential Low-Density Park and Residential Medium Density respectively, we transpose one column with n different values to n different columns, one for each value.

3. Computational Results

In this section, the models that were implemented are going to be presented and assessed, based on Mean Absolute Error, Mean Square Error and Accuracy. Accuracy is considered as $1 - \text{MAPE}$, with MAPE the Mean Absolute Percentage Error. The algorithms used were KNeighborsRegressor, GradientBoostingRegressor, DecisionTreeRegressor, Random

Forest Regressor, Stacked Regressor, Deep Learning technique, and an Artificial Neural Network.

It should be noted that the data split for the models was 80% training data and 20% data used for testing. The first algorithm implemented was KNeighborsRegressor. The number of neighbors for each iteration was set to 20 while the metric that was used was the Euclidean. The model achieved mediocre results with an explained variance for the testing set of 0.6, a maximum error for the testing set of 501.857 dollars, a Mean Absolute Error of 32.060 dollars, r-squared of 59% and accuracy of 80.72%. The second algorithm implemented was a Decision Tree Regressor. The algorithm was tuned using the cross-validation Grid Search to increase its performance, since it was one of the highest-ranking algorithms. The criterion used was the Mean Square Error, while the trees were limited to a maximum depth of 9. Additionally, every leaf of the trees was limited to containing a minimum of 20 samples. As mentioned before, this algorithm performed sufficiently with an explained variance for testing of 0.8, a mean absolute error of 24.723 dollars, r-squared for testing 80% and an accuracy of 85.18%. In the Figure 2, the distribution of records with their residuals is depicted.

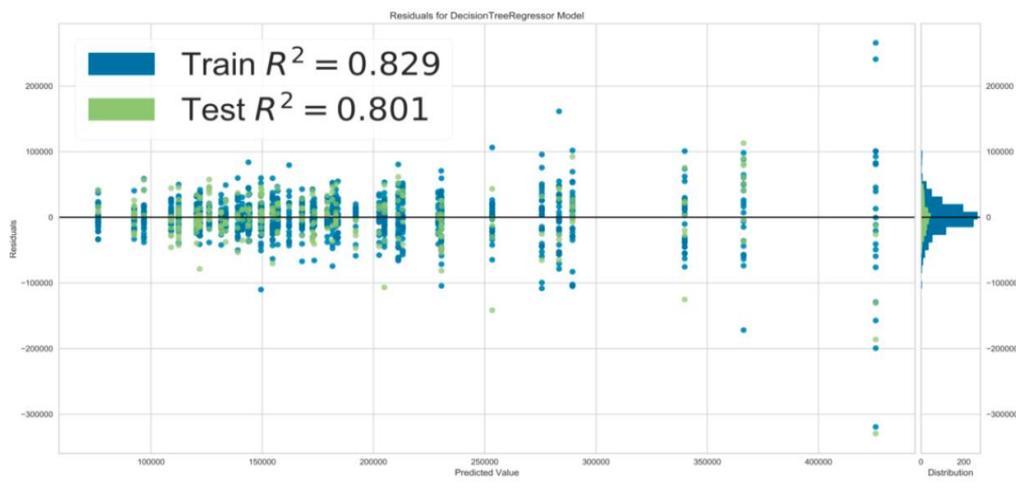


Figure 2. Price distribution and residuals for Decision Tree Regressor

The next algorithm implemented was a Gradient Boosting Regressor, improving the performance of a Decision Tree Regressor. The algorithm displayed an explained variance for testing of 0.88, a maximum error for testing 262.635 dollars, a mean absolute error for testing of 17.785 dollars, mean square error 908.281.353 dollars, r-squared of 88% and accuracy of 89.74%. These are surprisingly good results, without adding any macro - economic factors into our dataset. The predictions on the testing dataset were close to the original values, except for some properties that may be outliers. In the graph below the original and predicted price of each property is presented in blue and green respectively. Additionally, the distribution of the percentage error seems to be gravitating towards zero which indicates a good fit of the model. The graph in Figure 3 shows the frequency for the percentage error of our records, the distribution seems to gravitate towards zero, indicating a good model fit.

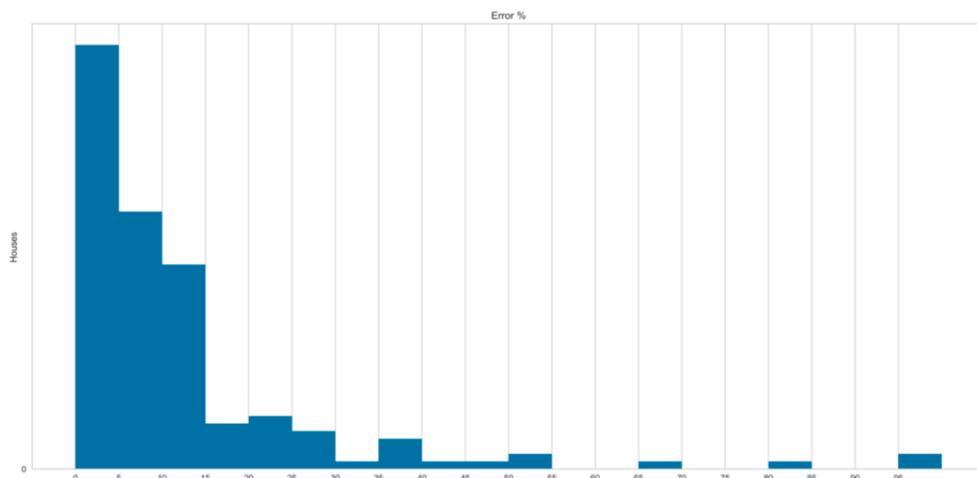


Figure 3. Frequency of properties based on Error Percentage for Gradient Boosting Regressor

The next algorithm implemented was Random Forest. The criterion used for this algorithm was mean absolute error and the number of estimators was set to 150. This algorithm achieved high performance, as expected, since this was the algorithm that the literature indicated as the most suitable for a real estate price prediction model. The algorithm achieved an explained variance for testing of 0.89, a maximum error of 221.737 dollars, a mean absolute error of 17.431 dollars, an r-squared of 0.89 and an accuracy of 89.42%.

The next model implemented was a stacked regressor, using multiple regression algorithms stacked ‘on top’ of each other. The first regressor used was a Decision Tree Regressor with the same tuning of the hyperparameters as before. Mainly, the criterion used was the Mean Square Error, while the trees were limited to a maximum depth of 9. Additionally, every leaf of the trees was limited to a minimum of 20 samples. The model produced an explained variance of 0.77, a maximum error of 396525, a mean absolute error of 26.521 dollars, r-squared of 77% and accuracy of 84.66%.

Finally, the last model implemented was an Artificial Neural Network, with three hidden layers. The input dimension was set to 96, for the 96 different features which were augmented due to the one-hot encoding. The activation function of the first and second layer was ReLU while for the last layer was linear. The loss metric for each epoch was set to mean squared error and the optimizer was Adam. The model was trained for 100 epochs because of the size of the dataset as well as to avoid overfitting.

Regarding the models trained with 69.823 apartment website listings from Athens, Greece, the same process as for the Iowa dataset was followed for the most part. Specifically, the data preparation was significantly more tedious due to the format of the data and the fact that, unlike the Iowa dataset, this dataset required extensive cleaning to be useful. It should also be noted that the addresses of the properties were transformed to coordinates. The two datasets, apart from containing a symmetrically opposite shape, were also trained to predict

different values. In the Iowa case, the property's price was the dependent variable. In this case the price per square meter is going to be the dependent variable.

The best performing algorithm for both Ames and Athens datasets using the 80/20 split as testing was Random Forest. In addition to the testing that was the 20% of our starting dataset, we outsourced 30 apartments to real estate brokers, to create a small custom testing set that will not be subjective to the seller's opinion, as it is, when sellers upload their properties on the web.

In Table 1, the results from the custom testing as well as the testing using the training data for the Random Forest Regressor for Athens are presented:

Testing	MAE	MSE	R-SQUARED	ACCURAC Y
RF model	225.2	94046.49	71%	87.02%
Custom Testing (External brokers)	MAE	MSE	R-SQUARED	ACCURAC Y
RF model	257.88	122932.36	65%	84.74%

Table 1. Random Forest Accuracy using two testing techniques

Both testing techniques proved that the Random Forest algorithm can achieve almost the same accuracy with significantly less features when faced with a sizable dataset. Although the data was collected from website listings, which reduced the quality compared to the Iowa dataset, the accuracy of the model in Athens was only 3% less than the one from Iowa. Additionally, the accuracy from the testing set produced by the real estate brokers, performed right in par with the 20% testing of our data, proving that the model generalizes its predictions, while it can be improved by tuning the algorithm using Grid Search or other tuning - boosting techniques and cleaning the data furthermore.

4. Conclusions

Data collection for transactional data can prove to be very tedious, because of this, most companies tend to collect data from websites containing property listings. The problems that arise is that data needs extensive cleaning, and the price can be subjective or plainly inaccurate. Collecting data is crucial for the training of the models as well as testing the performance of them. Thus, it is important to deal with these issues optimally. After thoroughly cleaning the data, various thresholds can be set in order to identify records that do not pertain to valid properties. The thresholds can be implemented by using limitations in different combinations of features, such as size and price. Additionally, in order to accurately assess the generalizability of the models, custom datasets should be set, by

creating pipelines that connect to various other sources of data. These sources can come from transactional data, or new appraisals implemented by brokers and not systems. This study indicated that the performance of the models increases vastly when the dataset is limited to locations that are beyond a certain density threshold. The density of a location indicates the number of properties that reside on it. Data Preprocessing is also a factor that will critically affect the performance of the automated valuation models. The random forest model seems to improve when we transform any categorical value that indicates a spatial location to a number that correlates with all other classes. The algorithm also improves when applying one-hot encoding to all categorical features. Models like the Random Forest, Gradient Boost and Decision Tree, seem to achieve good results when faced with an automated valuation problem, the Neural Network, although it performed poorly, it achieved much better results when trained with the more sizable dataset from Athens. These models can greatly improve if more data can be collected to fulfill the density of the locations, as well as the variety of the features, or by applying boosting techniques and feature selection algorithms. In very large datasets, distributed ways of handling data can be introduced, to distribute computational load across different processing nodes and increase the speed of ETL processes of a systems pipeline as well as the training of the models.

References

- [1] Depersio, G. (2021). What Are the Main Segments of the Real Estate Sector? Available at <https://www.investopedia.com/ask/answers/052715/what-are-main-segments-real-estate-sector.asp>
- [2] Treistman, H. (2020). How Big Data Is Transforming Real Estate, 1. Available at <https://brightdata.com/blog/leadership/how-big-data-is-transforming-real-estate>
- [3] Imran. (2021). Using Machine Learning Algorithms for Housing Price Prediction: The Case of Islamabad Housing Data. *Soft Computing and Machine Intelligence Journal*, 1(1), 11-23.
- [4] Mohamad, J., (2020). Heritage property valuation using machine learning algorithms Available at http://www.prrs.net/papers/Mohamad_Heritage_Property_Valuation_Using_Machine_Learning_Algorithms.pdf
- [5] Niu, J., & Niu, P. (2019). An Intelligent Automatic Valuation System for Real Estate Based on Machine Learning. *Proceedings of the International Conference on Artificial Intelligence, Information Processing and Cloud Computing*, (12), 1-6.
- [6] Bhushan Jha, S., (2020) Housing Market Prediction Problem using Different Machine Learning Algorithms: A Case Study Available at https://www.researchgate.net/publication/342302491_Housing_Market_Prediction_Problem_using_Different_Machine_Learning_Algorithms_A_Case_Study

- [7] K.C. Lam, C.Y. Yu & C.K. Lam (2009) Support vector machine and entropy based decision support system for property valuation, *Journal of Property Research*, 26(3), 213-233.
- [8] Pai, P., & Wang, W. (2020). Using Machine Learning Models and Actual Transaction Data for Predicting Real Estate Prices, 1-11. Available at <https://www.mdpi.com/2076-3417/10/17/5832/htm>
- [9] Hong, J., Choi, H., & Kim, W. (2019). A house price valuation based on the random forest approach: The mass appraisal of residential property in South Korea. *International Journal of Strategic Property Management*, 24(3), 140-152.
- [10] Louati, A. (2021). Price forecasting for real estate using machine learning: A case study on Riyadh city, 1-16. Available at <https://onlinelibrary.wiley.com/doi/abs/10.1002/cpe.6748>
- [11] Fan, C., Cui, Z., & Zhong, X. (2018). House Prices Prediction with Machine Learning Algorithms, *Proceedings of the 2018 10th International Conference on Machine Learning and Computing*, 6-10.
- [12] Yazdani, M. (2021). Machine Learning, Deep Learning, and Hedonic Methods for Real Estate Price Prediction, 1-33. Available at <https://arxiv.org/abs/2110.07151>

Bibliography

- Bhushan Jha, S., (2020) Housing Market Prediction Problem using Different Machine Learning Algorithms: A Case Study Available at https://www.researchgate.net/publication/342302491_Housing_Market_Prediction_Problem_using_Different_Machine_Learning_Algorithms_A_Case_Study
- Depersio, G. (2021). What Are the Main Segments of the Real Estate Sector? Available at <https://www.investopedia.com/ask/answers/052715/what-are-main-segments-real-estate-sector.asp>
- Fan, C., Cui, Z., & Zhong, X. (2018). House Prices Prediction with Machine Learning Algorithms, *Proceedings of the 2018 10th International Conference on Machine Learning and Computing*, 6-10.
- Treistman, H. (2020). How Big Data Is Transforming Real Estate, 1. Available at <https://brightdata.com/blog/leadership/how-big-data-is-transforming-real-estate>
- Imran. (2021). Using Machine Learning Algorithms for Housing Price Prediction: The Case of Islamabad Housing Data. *Soft Computing and Machine Intelligence Journal*, 1(1), 11-23.
- K.C. Lam, C.Y. Yu & C.K. Lam (2009) Support vector machine and entropy based decision support system for property valuation, *Journal of Property Research*, 26(3), 213-233.
- Louati, A. (2021). Price forecasting for real estate using machine learning: A case study on Riyadh city, 1-16. Available at <https://onlinelibrary.wiley.com/doi/abs/10.1002/cpe.6748>

Mohamad, J., (2020). Heritage property valuation using machine learning algorithms. Available at http://www.prrs.net/papers/Mohamad_Heritage_Property_Valuation_Using_Machine_Learning_Algorithms.pdf

Niu, J., & Niu, P. (2019). An Intelligent Automatic Valuation System for Real Estate Based on Machine Learning. *Proceedings of the International Conference on Artificial Intelligence, Information Processing and Cloud Computing*, (12), 1-6.

Pai, P., & Wang, W. (2020). Using Machine Learning Models and Actual Transaction Data for Predicting Real Estate Prices, 1-11. Available at <https://www.mdpi.com/2076-3417/10/17/5832/htm>

Hong, J., Choi, H., & Kim, W. (2019). A house price valuation based on the random forest approach: The mass appraisal of residential property in South Korea. *International Journal of Strategic Property Management*, 24(3), 140-152.

Yazdani, M. (2021). Machine Learning, Deep Learning, and Hedonic Methods for Real Estate Price Prediction, 1-33. Available at <https://arxiv.org/abs/2110.07151>

THE INFLUENCES OF COMPETITIVE VS. COLLABORATIVE APPROACH ON THE PERFORMANCE OF EMPLOYEES AND COMPANIES

Diana Apostu-CROITORU¹

Maria-Aurelia CADAR²

Iulia STANICĂ³

Costin-Anton BOIANGIU⁴

Nicolae TARBĂ⁵

Cătălin TUDOSE⁶

Abstract

Competition is an important component of all economies at some level whether it involves companies, job-seekers, or markets. Furthermore, some of the most successful companies are known for their hypercompetitive cultures that put the company's results first. However, nowadays more and more organizations are starting to embrace a distinctly collaborative approach to achieve success or goals and build successful teams. This scientific article was written to answer the following question: which approach, cooperative or competitive, has the best results in increasing the team performance? Our results lead to the fact that the collaborative approach has a higher impact on increasing the performance of companies by implementing programs that encourage teamwork and helping other colleagues grow. According to our research, the contests encourage competitiveness between employees. On the other hand, the programs increase teamwork and rewards employees based on how they have helped the team. In future work, this study could analyze the best working approach that might suit employees and companies over the years in different fields and countries, by reaching out to them.

Keywords: competitive approach, collaborative approach, employee performance, company performance, task-orientation, opportunities, cohesiveness, sub-optimal business

JEL Classification: P17, P27, P47, L25

¹ Student, University Politehnica of Bucharest, apostudiana111@gmail.com

² Student, University Politehnica of Bucharest, aureliacadar@gmail.com

³ Lecturer, PhD. Eng., University Politehnica of Bucharest, iulia.stanica@upb.ro

⁴ Professor, University Politehnica of Bucharest, costin.boiangiu@cs.pub.ro

⁵ PhD Stud., Eng., University Politehnica of Bucharest, nicolae.tarba@upb.ro

⁶ Lecturer, PhD Eng., University Politehnica of Bucharest, catalin.tudose@gmail.com

1. Introduction

Competition and collaboration often exist simultaneously in today's competitive work environments. To achieve organizational objectives for firms, employees need to collaborate in teams and projects. On the other hand, employees are equally concerned with their self-interests, increasing so the degree of competitiveness in their team.

The success of modern organizations depends on collaboration but also communication. As Edmondson and Nembhard pointed out [1], in almost every area of the economy, critical work is accomplished through collaboration. In fact, more than 50% of employees report spending a portion of their workday in collaborative groups.

On the other hand, to achieve recognition, promotions, raises, or assignments, employees compete between them. According to the analysis presented in "Top Dog: The Science of Winning and Losing" [2]: about 50% benefit from competition, 25% of people are not impacted by competition, and 25% strongly dislike competitive environments. In the article "Prosocial option increases women's entry into competition", Mary Rigdon [3] argues that competition affects differently both women and men. "We really have to ask what it is about this social incentive that drives women to compete," Rigdon says. She presents the fact that men tend to be less stressed by competition and the risks it generates and more overconfident in their abilities. Women tend to avoid a competitive environment and be conservative regarding their possibilities to impose themselves.

Independently of the gender, people are constructed in different ways: some benefit from a calm environment for high performance, and others do their best under stress. As Tjosvold [4] demonstrates, good managers balance the competitive view and the persons.

This article aims to describe the two approaches: competitive and collaborative within an organization. The article has the purpose of answering the following question: "How do these approaches affect a company externally (customers) vs internally (the employee's salary)?"

2. Previous work

It is a continuous debate between internal collaboration and competition as management techniques, as both approaches are strongly connected with organizational culture and performance. Various approaches to combining internal collaboration and competition can consequently range from exclusively internal collaboration, through a balanced mix between internal collaboration and internal competition, to exclusively internal competition.

The different management approaches can be graphically visualized below in Figure 1. Consequently, managers face the complex decision of which executive approach is the most effective.

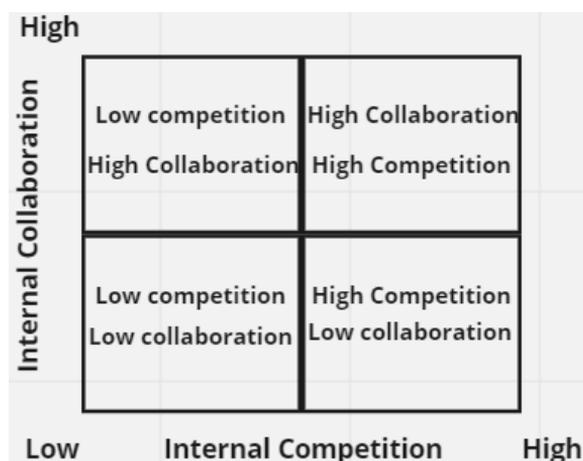


Figure 1: The management Paradox Model

2.1 Outcomes of Competition

Khoja [5] considers that there are clear benefits to supporting internal competition inside a company. In the article “Strategies for managing internal competition” [6], Birkinshaw and Khoja claim that these benefits include increased flexibility and active experimentation to keep up with the speed of environmental changes and enable strong innovation and performance inside the organization. They consider that an employee involved in competition because of a task to be executed [7] will look for improving performance in bringing the task to success.

Yet, different authors, Deutsch, Birkinshaw, Beersma, Hollenbreck, Bittner Heidermeier, [8] [9] [10] consider the negative consequences of competition inside an institution. Birkinshaw [11] argues that the competitive environments may generate higher costs as a result of overlapping within the organization and ambiguity around the strategic direction. In a later study, Tjosvold [4] enumerates several reasons for supporting competitive behavior: ego-orientation, task-orientation, extrinsic pressures, intrinsic pressures, and the wish to prevent others to benefit from success.

According to multiple studies conducted by the Harvard Business Review [12], competition can motivate employees, stimulate them to get more involved, and get better results. Competition stimulates physiological and psychological activation; the person will be ready to put more effort and seek better results. And also, if employees actively look to offer high-quality service to customers or to find ways to release new products faster, then internal competition can generate serious advantages for companies. They also claim that employees who feel anxious in competitive environments are more likely to use unethical means to get their work done. They are also less likely to be creative in their work. When a team member feels excitement in such an environment, he/she is more likely to be creative and less likely to be unethical.

Therefore, the competitive approach has positively affected salaries, increased flexibility, and highlighted employee skills, on the other hand, employees try to stand out within the organization, giving up working in a team and helping their colleagues. Although

financially and internally, employees earn higher salaries, externally, the company can lose important customers.

2.2 Outcomes of Collaboration

Beersma [7] claims that “collaboration promotes cohesiveness, trust, and supportive behavior amongst team members, which promotes performance in the organization”. Costs may be reduced by sharing resources between teams, the goals are defined and managed in a centralized manner. Through the collaborative approach, employees are determined to become more creative and vocal. Because they feel integrated into the team, they are encouraged to come up with ideas to achieve a common goal.

However, collaborative team environments shadow individual achievements or initiative, and individual performance levels vary, as Lock and Beersma said [13]. Beyerlein [14] believes that collaborative work may impact the decision capabilities and may bring disorder and repeated decisions of the same kind. These negative outcomes of the collaborative process “will result in sub-optimal business results and outcomes”.

Tracy Middleton [15] highlighted some advantages of teamwork and she claims that “great ideas don’t come from lone geniuses”. Furthermore, John J. Murphy [16] claims that “Behind every genius is a team”. Middleton also argues that “diverse perspectives help you come up with winning innovations” and when “you work in a team, you grow as an individual”. Other advantages would be that “sharing the workload eases burnout, dividing the work lets you grow your skills”, and recognition from other team members can improve your productivity.

According to Cameron Nouri [17], “a truly collaborative environment is judgment-free”. He claims that “employees should feel like their unique perspectives are valued, regardless of department or seniority level, so they’re comfortable proposing ideas, sharing feedback, and challenging the status quo, all of which moves the organization forward”.

Therefore, teamwork positively affects the company, attracting many more customers as a result of the services offered. On the other hand, for the employees, although they feel integrated and part of the team, from a financial point of view, end up being harder to notice (their salaries remain unchanged).

3. Proposed Approach

In this study, we would like to comparatively analyze the two approaches and the impact they have on employees and companies. To achieve this goal, we looked for achievement programs or contests/competitions present in companies. The participation of employees in these competitions, and also the answers given following the survey below, will reflect their preferred approach: competitive vs. collaborative.

For the collaborative approach, we followed internal programs/contests favoring teamwork and internal communication in front of the results. For example, hackathons generate actionable ideas and innovative thinking, they support collaboration and creativity. Another relevant example of presenting a collaborative approach during internal programs will be loyalty points. According to many companies which include this program in their benefits

for employees, giving loyalty points to your colleagues will increase teamwork. Assuming you are an employee who benefits from this program, you will receive some points, which you cannot use for individual purposes. These points can only be sent to a colleague who helped you or whom you respect. After collecting a large number of points, your colleague can benefit from certain items offered within the company: backpack, tablet, phone, etc. Therefore, people tend to help each other more in the team.

On the other side, to present the competitive approach, we found internal programs which promote competition between team members. For example, the internal mobility program. If you are noticed and you have exceptional results, you can be proposed for a better job, to get a promotion (to advance in the hierarchy). People who participate in this program can get a better salary, a higher status, or more benefits. Through this program, the competitive approach is promoted, because each employee pursues his personal goal. Another relevant internal contest will be finding the best idea. If you find the best idea to optimize an internal process, you will receive a prize (money, vouchers). This gives up sharing ideas within the team. Employees will become more competitive to stand out or gain benefits. Hackathons can obviously encourage the competitive side of employees, making them compete against each other.

Therefore, we created a survey to identify these internal programs/contests and the preferred approach by employees. This form examines people's preferences about how to work, what kind of programs or contests they are participating in, and how their work is influenced by these types of activities, either it helps both them and the company or it makes their productivity lower. We also tried to find out what the rewards are to see what motivates employees most to get involved in such activities. This research will provide a better understanding of whether these approaches will directly affect the companies and their employees. It's a significant environment to examine, engineers will understand how to work to get better results, how to improve their skills, and communicate with their teams.

4. Study Results

This chapter analyses the survey of our study concerning people's considerations about working competitively or collaboratively. Approximately 100 employees responded to our survey. These people are both women and men, aged between 18 and 45 years. Since the IT field has grown a lot in recent years, we have not been able to find retired people. On the other hand, this survey presents the answers of people with different positions: managers, developers, testers, and team leaders.

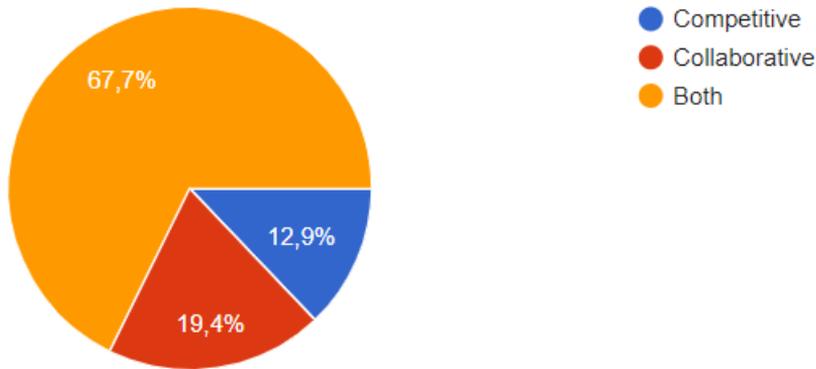


Figure 2: Do you consider yourself a competitive or a collaborative person?

As we can see in Figure 2, most employees consider themselves both competitive and collaborative persons, and a very small percentage of people (12,9%) have responded that they prefer competitive working. These results can outline that, as employees have said that they can both work competitively and collaboratively, the competitive work does not affect their collaborative work.

Figure 3 and Figure 4 reveal the fact that employees really enjoy these types of programs and activities. Almost all people have responded that they had participated in such a contest or achievement program at the company they work for. According to percentages from Figure 4, we can conclude that employees are trying to make time to participate in these programs, if not every time, at least from time to time.

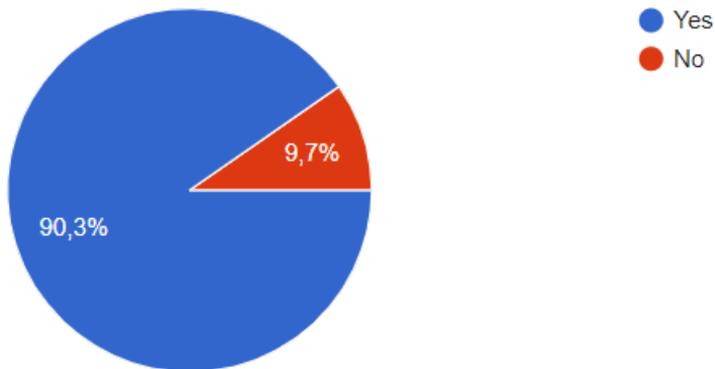


Figure 3: Have you participated in any contests/competitions or achievement programs at the company you work for?

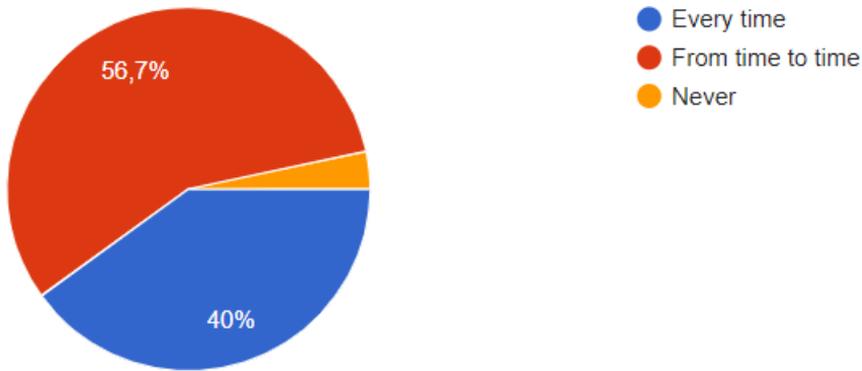


Figure 4: How often do you participate?

Figure 5 demonstrates that the prizes of these programs are mostly represented by money, so we can say that employees are more motivated to participate if they are rewarded with money. Motivation has a significant influence on the productivity of an employee. In a professional environment motivated individuals are always looking for better ways to achieve their goals, more quality-oriented more productive. According to Maslow's classical theory (A Theory of Human Motivation) [18], the energy invested by an individual is allocated according to a pyramid of individual needs. Money impacts the lower levels of Maslow's pyramid, so it's a strong motivator but not a lasting factor. Higher levels (self-esteem and reaching your full potential) give you a stronger and longer-term motivation.

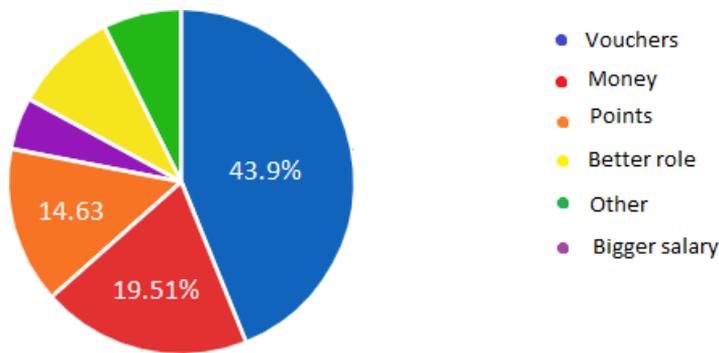


Figure 5: What kind of prizes are awarded?

We also asked them if they think these contests could affect collaborative work and what approach is most effective to make them stand out and here the opinions were divided. Employees who have participated in a contest based on independent work said that these types of activities affect collaborative work because "everyone wants to get a better job", "everyone wants to win the contest" and "if you receive money, you will want to win" and, also, they believe that "you should be a competitive person if you want to stand out". These quotes were taken from the completed survey, suggesting employees' ideas on a collaborative approach.

On the other side, the employees who have participated in programs that encourage teamwork, obviously said that these activities did not affect their collaborative work but on

the contrary, they improved and streamlined teamwork and they even claimed that “if you help your teammates, you’ll be noticed”.

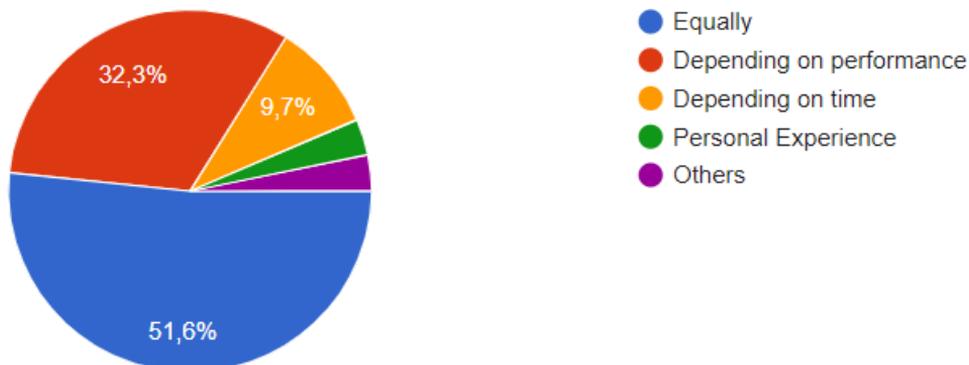


Figure 6: If you work in a team, how do you divide the tasks into it?

Figure 6 points out the fact that people tend to work in a team, sharing everything equally instead of dividing them according to their own performance. This means that most people are collaborative.

5. Conclusions

According to our research, the way of working is largely influenced by the type of activity organized by the company. Even if it’s competitive or collaborative work, the competitive work has some influence on collaborative work.

The contests that encourage competitiveness between individual employees or even between teams have a big impact on making employees less collaborative, especially on competitive people, because they think that this is the only way they can stand out, and also, the financial reward has a big influence on this aspect.

The programs that encourage teamwork and rewards employees based on how much they have helped the team and other employees and contributed to the evolution of other employees have more chances to improve teamwork and, in this way, the company can increase its performance.

According to our research, at the question “Are there any contests/competitions or achievement programs at the company you work for?”, 93.5 % of the received answers said “Yes”. This means that performant companies are frequently using programs/contests and searching for ways to apply their results within their teams. For example, collaboration is beneficial both for the company and the employees as working together and exchanging ideas, they will benefit from other people’s way of thinking and working. This favors the possibility to acquire strong knowledge and skills from other employees. If they will follow these programs that encourage teamwork, the teams will spawn more innovative ideas that increase the success of the business. On the other hand, employees can follow contests that help them to increase their personal skills. Maybe it would be better for these contests to be organized by the employees’ companies, but to take place against the opposing companies. This idea will be better because these contests can motivate some people but working in a

competitive company for a long time can produce negative workplace stresses, ethical breaches in ethics, and increased risks.

To the question “Do you consider yourself a competitive or collaborative person?”, 67.7 percent of women and men respondents, aged between 18-and 45, believe they are both competitive and collaborative. Therefore, the best solution for IT companies is: to organize contests against opposing companies but also carry out achievement programs within the company.

That being said, the companies choose these types of activities to make employees perform better and grow both personally and professionally but to be able to do this, they need to choose wisely which kind of work they want to encourage, competitive or collaborative.

6. Future work

Our analysis can be extended in future work. We would like the survey to be conducted over a longer period, gathering more answers. The participants should be given the possibility to motivate the way they answered some questions (e.g., “Do you prefer working competitively or collaboratively? Why?”, “What do you think about listening to and respecting other people’s ideas? Why?”).

This study may continue by analyzing in different countries and different cultures the consequences that contests have on individuals regarding the process of teamwork and increasing the performance of the companies and which working approach might best suit them.

Bibliography

- [1] Product Development and Learning in Project Teams: The Challenges Are the Benefits, Edmondson and Nembhard, 2009
- [2] Top Dog: The Science of Winning and Losing, Ashley Merryman, February 18, 2014
- [3] Prosocial option increases women’s entry into competition, Alessandra Cassar and Mary L. Rigdon, November 9, 2021
- [4] Tjosvold, D., Johnson, D. W., Johnson, R. T., Sun, H. (2006). Competitive motives and strategies: Understanding constructive competition. *Group Dynamics: Theory, Research and Practice*, 10, 87-99
- [5] Khoja, F. (2008). Is sibling rivalry good or bad for high technology organizations? *Journal of High Technology Management Research*, 19, 11-20
- [6] Birkinshaw, J. (2001). Strategies for managing internal competition. *California Management Review*, 44(1), 2138
- [7] Beersma, B., Hollenbeck, J. R., Humphrey, S. E., Moon, H., Conlon, D. E., Ilgen, D. R. (2003). Cooperation, Competition, and Team Performance: Toward a contingency approach. *Academy of Management Journal*, 46(5), 572-590

- [8] Bittner, J.V., Heidemeier, H. (2013). Competitive mindsets, creativity, and the role of regulatory focus. *Thinking Skills and Creativity*, 9, 59-68
- [9] Deutsch, M. (1949). A theory of cooperation and competition. *Human Relations*, 2(1), 129-152
- [10] Birkinshaw, J., Lingblad, M. (2005). Intrafirm competition and charter evolution in the multibusiness firm. *Organization Science*, 16(6), 674-686
- [11] Beersma, B., Hollenbeck, J. R., Humphrey, S. E., Moon, H., Conlon, D. E., Ilgen, D. R. (2003). Cooperation, Competition, and Team Performance: Toward a contingency approach. *Academy of Management Journal*, 46(5), 572-590
- [12] The Pros and Cons of Competition Among Employees, Anna Steinhage, Dan Cable, and Duncan Wardley, *Harvard Business Review*, March 20, 2017
- [13] Loch, C. H., Huberman, B. A., Stout, S. (2000). Status competition and performance in work groups. *Journal of Economic Behaviour and Organization*, 43(1), 35-55
- [14] Beyerlein, M. M., Freedman, S., McGee, C., Moran, L. (2003). The ten principles of collaborative organizations. *Journal of Organizational Excellence*, 22(2), 51-63
- [15] The importance of teamwork (as proven by science), Tracy Middleton, Atlassian, September 25, 2021
- [16] 10 Rules for High Performance Teamwork, John J. Murphy, August 2010
- [17] The Importance of Effective Collaboration in the Workplace (and Software Tools To Help), Pingboard Blog, Cameron Nouri, Jun 14, 2021
- [18] A Theory of Human Motivation, A. H. Maslow (1943)
- [19] Lee, C.-L., Yang, H.-J. (2011). Organization structure, competition and performance measurement systems and their joint effects on performance. *Management Accounting Research*, 22, 84–104
- [20] Costin Anton Boiangiu, Adrian Firculescu, “Teaching Software Project Management: The Competitive Approach”, *The Proceedings of Journal ISOM*, Vol. 10 No. 1, May 2016 (*Journal of Information Systems, Operations Management*)
- [21] Costin Anton Boiangiu, Ion Bucur, “Teaching Software Project Management: The Collaborative Approach”, *The Proceedings of Journal ISOM*, Vol. 10 No. 1, May 2016 (*Journal of Information Systems, Operations Management*)
- [22] Costin-Anton Boiangiu, Alexandru Constantin, Diana Deliu, Alina Mirion, Adrian Firculescu, “Balancing Competition and Collaboration in a Mixed Learning Method”, *International Journal of Education and Information Technologies*, ISSN: 2074-1316, Volume 10, 2016, pp. 51-57.

THE INVESTMENT FIELD OF COMPANIES WITHIN SOFTWARE PROJECTS

Bogdan-Costinel DRĂGHICI¹

Iulia POPA²

Ștefan-Alexandru HOISAN³

Costin-Anton BOIANGIU⁴

Mihai-Lucian VONCILĂ⁵

Nicolae TARBĂ⁶

Abstract

Software startups are new corporations with no operating history and are quick in producing newfangled technologies. Startup companies operate in extremely unsure conditions, facing aggressive markets with few resources at their disposal. These conditions in which most startups operate create many challenges for software development activities. This study aims to structure and analyze the literature on software development in startup corporations, deciding thereby the potential for technology transfer and distinguishing software development work practices reported by employees, managers, and recruiters. We analyzed the investment field of companies within software projects by obtaining their classification, ranking the principal activity fields, the main technologies in the most important projects, and the turnover and income summary. A complete study of how software development startups and companies work in a world dictated by investment is mapped and synthesized in the current article. From the reviewed primary studies, multiple engineering corporations were classified and analyzed for the present research paper. This study provides a clear vision of what it means to invest in a startup or company, during a global and epidemic crisis. The results indicate that startups choose and adapt their software engineering work practices with great regard to the constraints of the startup context.

Keywords: software project management, technology companies, software engineering, startups, investing strategies, from theory to reality

JEL Classification: L86, D25, E22, F21

¹ Student, University Politehnica of Bucharest, bogdandpm@gmail.com

² Student, University Politehnica of Bucharest, iuliajulia1999@gmail.com

³ Student, University Politehnica of Bucharest, candul12345@gmail.com

⁴ Professor, PhD Eng., University Politehnica of Bucharest, costin.boiangiu@cs.pub.ro

⁵ PhD Stud., Eng., University Politehnica of Bucharest, mihai_lucian.voncila@stud.acs.upb.ro

⁶ PhD Stud., Eng., University Politehnica of Bucharest, nicolae.tarba@upb.ro

1. Introduction

In recent years, we have observed a constant and substantial increase in the number of businesses called startups. The procedure by which a company moves from theory to reality is named a “startup”. Being a business in the first stage of its operations, it tries to discover a match between the product and the market, by adapting to the market, establishing and classifying customers by their needs and desires, and discovering the various characteristics of the product. Although most of the time everything is set up properly, and the business seems to have a chance to evolve from the initial phase, 90% of them disappear before turning 3 years old. According to a study conducted by National Business Capital [1], it is estimated that approximately only 80% of startups survive their first year of business. This number only decreases with time to 70% for the second year, 50% for the fifth year, with only 30% managing to make it past their tenth year. The most common cause is not validating the idea alongside actual clients or potential clients, to create a product intended to bring something completely new to the customer or to significantly improve what currently exists. Thus, due to low earnings or high costs, most startups do not have long-term success.

Previous studies show the evolution of these companies over time globally, among the best-known examples of great ideas of some young undergraduates that have led to outstanding companies, including Facebook, Uber, Airbnb, LinkedIn, Spotify, Pinterest, and Instagram [2,3]. Since the beginning of the decade, in Romania, there has been considerable public interest in promoting and funding startups that attempt to bring innovation, original products, and to seek, develop, and validate a scalable business model. To identify the cause of the remarkable progress of this type of organization and to find out the reason why more and more young students are among the financiers of these companies, this paper aims to explore what a startup really is for scholars at the beginning of the road, who do not have plenty entrepreneurial experience but with enthusiasm and overflowing passion for novelty. Furthermore, we have the objective to encourage readers to have the audacity to put their own ideas into practice, through the example of other successful young people across our country.

2. Background and Related Work

2.1. Background

In 2018, the news of the year in the national IT industry came from a start-up, and not from a well-known company. UiPath, now the world’s leading Robotic Process Automation (RPA) software corporation has become the first Romanian unicorn (start-up with a valuation exceeding \$1 billion) in the investment field after attracting \$153 million in funding. Founded in 2005 in Bucharest by Daniel Dines and Marius Tircă, with a team of only 10 people, the RPA platform monitors user activity to automate repetitive processes performed by employees, including customer relationship management and enterprise resource planning (ERP) software. According to the CEO of UiPath, Daniel Dines, the drivers of such growth are not technology or business strategies but building an organization of people who believe in what they do and treat each other equally. He also mentions that other ingredients of success are represented by setting a global vision, bringing the best people, and not pursuing profit. To Dines, looking at some solid principles and following

them has been more important than doing all sorts of tactics to make money. That is the reason why the entrepreneur advises new generations to become better and better, build a bigger culture, and have a well-defined idea when they decide to start their own company [4].

Bitdefender was founded in Bucharest by two mathematicians and researchers, Măriuca and Florin Talpeș. The revolution of December 1989 made the two doubt the safety of their jobs, so they decided to resign and start their own business. Thus, in 1990, Softwin was born, an IT company started with the idea of providing services to companies in Western Europe, and the first customers came from France and Germany. Subsequently, they developed their own products, including Antivirus Expert (AVX), which was rebranded as Bitdefender in 2001 [5]. At present, the company is one of the most innovative IT security software providers in the world. With more than 1600 employees and a team of more than 800 engineers and researchers, the business is valued at almost \$2 billion. Florin Talpeș claims that what makes a startup successful is a revolutionary idea, exposed courageously and meant to generate a high degree of innovation [5].

The most famous online store in Romania, eMAG, was founded in 2001 as a distributor of computer systems and office products, being founded by Radu Apostolescu, Dan Teodosescu, and Bogdan Vlad. In 2009, 51% of the company's shares were bought by Asesoft Distribution, and the general manager of eMAG became Iulian Stanciu [6]. Today, the company under new CEO, Tudor Manea, deals with the online sale of IT equipment and components, electronics, home appliances, personal care items, automotive products, sporting goods, books, home and garden products, pet shops, children's items, and more [7]. Currently, initial founder Radu Apostolescu and his wife, Monica, invest in their ophthalmology clinic that has already gained its reputation, Clario. They say that confidence in what you do, desire to learn and act, curiosity, and courage to change are the essential elements to developing a profitable business [8].

Given those cases of prosperous and rewarding corporations, the paragraphs that are going to be talked through the section 4 below have the goal to encourage people to start their own companies, through the power of the example of young students who have embarked almost on their own on the difficult and surprising road of the investment world.

2.2. Related Work

Ross et. al. [9] addresses the subject of investment within software projects related to the IT field, putting emphasis on explaining, characterizing, and dividing the IT-Investment Framework. An essential step to reach these goals was to undergo a study based on interviewing business and IT executives at over 30 US and European companies. In their study. The study led to the conclusion that investments tend to be based on two main factors, namely strategic objectives, and technology scope. The first aims to make compromises between short-term profitability and long-term growth, whilst the latter aims to highlight the main differences between the shared infrastructure and potential business solutions. Based on these observations, they conclude that companies should focus on investing in four types of investment, specifically transformation (for changing an inadequate infrastructure related to the desired business model), renewal (aimed at reducing overall costs or improving the quality of IT services), process improvement (aimed at improving

the operational performance), and experiments (finding new technologies or ideas that could benefit products or business models).

Paternoster et al. [10] describe the methodologies implemented to control the development activities of startups, whilst also performing a systematic mapping study (SMS) aimed at dealing with wide and poorly defined areas. This option was chosen despite a systematic literature review (SLR) to answer the overall research question: “*What is the state-of-art in the literature pertaining to software engineering in startups?*”. The SMS process follows a series of simple steps, starting with the definition of research questions, continuing with searching between all papers and screening the relevant ones, keywording, data extraction, mapping, and concluding with synthesis and the classification of work practices.

Berghout et al. [11] discuss the impact certain business cases can have on IT investment decisions and analyze this impact by looking at municipal e-government projects. They start with a theoretical foundation that is used to describe certain methodologies used in different business cases which are later used to propose several hypotheses that are used to predict how certain elements of a business case might affect the initial cost estimation of an investment. Based on these hypotheses, they then construct a theoretical model aimed at identifying the influence of these elements. An empirical test is performed on the model by looking at similar business cases of municipal e-government projects and how the initial cost estimates were affected. Based on the results they obtain, a framework is derived, which can be used to develop IT business cases based on certain components. Lastly, a regression analysis is performed to validate the hypotheses, as well as content analysis to determine whether a certain case contains certain elements from the proposed developmental framework.

3. Market Overview

Before diving more in-depth and starting to discuss our analysis and the methods that we used to examine the investment field within software projects and the newly founded startups we came across during our study, an overview of the current market of project management software is needed.

A tool that is used a lot, regardless of the industry, when developing a certain project is a Project Management Software (PMS). Whilst this tool is mostly aimed at project managers, it can also be used by other interested parties, such as stakeholders or clients. It provides different functionalities that aid with developing and maintaining a project, such as planning and scheduling, the management of different resources and how they change over time, up-to-date documentation, and quality management, whilst also being able to be used as an organizational framework.

In terms of net worth, the PMS market was estimated at a value of ~\$5.4 billion in 2020 [12], a value which is expected to further grow and reach a value of ~\$9.8 billion by 2026. This is mainly because most companies nowadays continue to grow, thus a complex and comprehensive solution, that can manage the portfolio of projects they might have, is required.

This gave PMS the opportunity to develop into an essential component of businesses due to the fast changes that occurred across every industry. Since most software offers

functionalities for managing resources as well as real-time updates regardless of time and place, it can be seen as a good tool to be used for reducing overall risks as well as costs associated with most projects. All these factors combined are predicted to increase the speed at which the PMS market continues to develop.

However, the main issue associated with PMS is that most software frameworks present a certain complexity and require a learning curve. This coupled with the fact that different frameworks can diverge in different directions, and the costs of setting up such a framework in a large organization, are the main factors considered to be preventing most companies, as well as clients from investing a lot of resources into PMS.

PMS has additionally advanced into a method for new product development, attributable to the rise of the Internet of Things (IoT) and the reception of Agile New Product Development (NPD), which has now converged with Project Management Software and resulted in new firms being born, such as GenSight, UMT360 and Decision Lens in the field of enterprise product manufacturing.

Another factor to be considered in the current market for PMS is held by the ongoing COVID-19 pandemic, which led to a huge impact on many businesses. Due to different requirements, and the fact that most of the world was forced to now work in an online environment, the dependency on a computerized solution that can keep track of projects increased even more and is likely to keep so even after post-pandemic.

4. Proposed approach

4.1. Survey Form

Surveys are one of the most essential ways to gather the data that organizations need. Done right, surveys can lessen risks, give insights about employees, clients, and management, and even adjust PR, advertising, and different communications programs. Done inadequately, they can derail strategies and generate misguided marketing, communications plans, and customer service.

Our target group consists of employers, entrepreneurs, or acquaintances that have/had a startup. Having mentioned that, the survey that we proposed has the main target to visualize what are the current tendencies when it comes to investing in a new business, what area attracts new investors, how entrepreneurs manage their business, the impact of project software on a line of work and to eventually forecast a possible area/idea of investment in the future by analyzing the extracted data and trying to find relevant patterns.

When requesting data, we also took into consideration the main technologies used in the most important projects ongoing inside the firm, to make a correlation between the current clients' demands and the overall propensity towards technology or another in that line of work. It's important to know how different technology is used and what purpose it serves to choose the right fit when planning a new project idea. Following this, we aimed to analyze the tools that are brought together and how they assist to solve various tasks and specific problems, reduce excess time, and help to interact and exchange information.

Besides this data, we figured that knowing the available budget for a project might allow us to have a better view of how the business owner can concentrate on cash flow, reducing

costs, improving profits, and increasing returns on investment. After all, budgeting is the basis for all business success. Besides, we concluded that by having the ability to oversee a firm's budget for various projects, together with the access to both planning and control of the finances, we would be able to have a better understanding of the type of clients a firm has or even what needs a particular client has.

Studies [13] have shown that understanding a client's budget and budget-related issues provide benefits by being able to tailor and present solutions in a way that meets a client's wants and needs, as well as reducing a lot of time and resources. It is also crucial that the budget planning is done appropriately, in order to ensure that throughout the duration of the project, the budget isn't exceeded.

We concluded the survey by asking about the overall impact that the pandemic had on the investment plan of the company, whether it was good or bad. We considered this question relevant, keeping in mind that the number of working business owners plummeted from 15.0 million in February 2020 to 11.7 million in April 2020 [14] because of COVID-19 health and economic driven demand shifts, leading to a loss of 29% from the total hours worked by all business owners, but at the same time big companies like Microsoft, Amazon.com Inc, and Alphabet Inc registered increases in share prices and were expected to exceed their sales estimates for the quarter [15].

4.2. Interviews with students

The road to success may be different and difficult from one entrepreneur to another, but all of them certainly recognize the opportunities that arise from one day to the next. According to data provided by the European Commission [16], the founder of a startup is male (82.8%), has a university degree (84.8%), is currently 38 years old, and has been 35 years since he founded the business. This highlights the fact that most founders have skills acquired through education in university (84.8%), practical knowledge, and experience. This section tells the stories of several students at the Politehnica University of Bucharest, Faculty of Automatic Control and Computer Science, having the purpose to show that "exceptions" exist: our interviewed colleagues are between 20 and 23 years old and, although they are at the beginning of the road to entrepreneurship, they are overflowing with enthusiasm, passion, and ambition.

Right in the middle of the pandemics, two freshmen come up with the educational idea of creating a platform that helps people understand the basic principles of cybersecurity by playing games: which links are safe to be clicked on, what kind of passwords we should use, why we should not download any file from the Internet. Having the goal to save corporations from data breaches and security issues in their minds, they participate in Innovation Labs 2020 [17], where they present the concepts of their idea, obtaining support from mentors and experienced businessmen. The path was clear: from idea to notion, to prototype, and finally to implementation. But unfortunately, due to other priorities in their lives, the students stopped following their dream temporarily. Cheerfully, though, they want to continue working on this solution next year, when they think they will have more free time to focus on their entrepreneurial careers.

In September 2020, an enthusiastic colleague dared to build up together a group of people who found his startup idea innovative: a marketplace concentrated on organic products,

between local producers and consumers. This thing came to his mind at the moment when he realized that healthy food is becoming rarer and rarer these days. With a team of supportive and intelligent people, the student presents the concept within an entrepreneurship program, called BrightHub, which took three months. Their first intention was to finance the project from their personal funds, attracting ulteriorly more investors. But understanding that the money needed could be more than they had, they decided to postpone the implementation for a few years to gain more experience, vision, and, not lastly, the capital. Asked if he would change a thing in the past process, the student sustains that he would improve the way the team was organized (from weekly meetings to effective discipline of members), the set of goals, and his attitude towards having his idea rejected by important investors. He also believes that a design expert would have brought a huge benefit to their plan.

In the same year, another intelligent man came up with the idea of consultancy and development tools application during a college programming course. Unlike the above examples, this man financed his corporation from his own funds. Recently, however, he has gained funding from top investors. Even if the whole startup is still at the beginning, he diligently believes that his idea will work, but he still cannot be sure in what phase the company will be in 5 years. The only thing that the young entrepreneur would change in this whole story is that they would turn to specialists from an early stage, even if they are expensive, and at the start, the budget is a problem. This model has the role of showing the fierce importance brought by the interesting way of teaching a college course by an inspirational teacher.

In June 2021, after two failed startups created in high school, a second-year student comes up with a new and braver view, due to his need to achieve new and interesting things that will also bring clear benefits for the future. At first, he presented his idea in a contest, and later at Innovation Labs. Afterward, he and his teammates started financing, but they soon received funding from some businessmen (even had important meetings with top investors like Andrei Pitiş, CEO & Founder of Simple Capital). Even if he believes that the pandemics can be negative to some companies, to his startup it wasn't the case, as his idea was a web portal. He also thinks that the future is bright for them if they find enough good investors.

Innovation Labs 2020 signifies the beginning of the road to success for many of our students. Wanting to have their own organization and to work for themselves, but not for other managers, a group of four programming enthusiasts thought of an idea to help agriculturists, who asked for something new-fashioned and more innovative to ease their labor. From here, based on their preferences and needs, they developed the concept step by step. After this long product, they came up with a functional product that could be tested and approved by users. Their project did not need initial funding, they incurred costs until the actual launch of the product. The idea turned into a tangible product, it brought them an award in the InnovationLabs 2020 Demo Day Final, namely Best Potential Award Team. The boys believe that their project was helped by the pandemic, claiming that they brought digitization to a time when all areas were in dire need of it. He considers that the pandemic was an unusually positive factor for them and that it helped them to expose the usefulness of the product much better. Their idea is for the future and the team believes that in 3-5 years they will get more customers, i.e., agricultural cooperatives that will use their application daily to digitize the production planning process. At the same time, the media appearances gave them a significant boost: on the *Telejurnal Matinal* on national television,

then they gave an interview for "Agriculture of tomorrow", for the entrepreneurship website start-up.ro. The most important television appearance, however, was on the show "I like IT" on PRO TV.

In March 2020, another team's project begins with the participation in the Innovation Labs pre-accelerator. The interviewed young woman says that she has always wanted, through the knowledge and skills acquired over time in school and college, to succeed in creating with her colleagues a solution that will really help and bring a change for the better in society. Together they created various projects, sketches, and prototypes with which they participated in a multitude of national and international competitions, but, after the completion of the competitions, our projects remained only at the idea stage. That is the reason they decided to start our own business, to identify the real needs of our customers and to take the project to a final stage, widely used.

The idea started from the identification of some problems reported by their current partners: the lack of a digitized and autonomous system for detecting the profile of truck tires. They went through several brainstorming sessions and decided what technical solutions to design and test, especially considering the optimal functionality conditions for end-users. It helped them a lot in this process of moving from idea to practice and using a Lean Business Canvas [18], with the help of which they determined what their first goals are. For a start, they held a pitch about their concept at the Innovation Labs 2020 event, during which they had the opportunity to present the entire evolution, including in the grand final. Subsequent presentations were also at the Atos IT Challenge 2021 international competition, but also at the press conference that took place after winning the grand prize at this competition.

Since the founding of this project, they have had a large transport service company with us, as partners and future customers. They support the team with industry information and constant feedback in everything we do. At the same time, they brought funding to the project, after it became a research project within the Politehnica University of Bucharest. All the presentations went very well, and the constructive feedback they received each time helped them to evolve. Even their presentations have evolved over time, moving from concept to project evolution to the first live demos of the prototype. The results obtained from these presentations were the Best Smart Mobility award offered by OMV Petrom within Innovation Labs, respectively the 1st Prize at the Atos IT Challenge [19] competition. She believes that success was guaranteed by passion, dedication, and desire to make their solution constantly improve.

Chronologically, the company started almost simultaneously with the pandemic. This made the first part of the project's evolution a little difficult, due to the passage of our meetings in an exclusively online environment. But after a while, they adapted and turned this impediment into a solution to hear even more often with their mentors and partners. They were also affected by the pandemic when they tested the prototype in the field because they had to wait for certain periods of high infection in their area to pass. But they cannot say that the pandemic caused any failure, because, even during these delays, they worked remotely on other necessary functionalities.

They dream that the robot and the company's services can be available on most truck routes, both in Romania and in the rest of Europe. In the future, they want to enter partnerships with at least 3 transport companies, and each station to be used daily by over 100 trucks. At

the same time, it intends to impose a rigorous standard regarding road safety, offering its services to the local authorities that have the duty to periodically carry out legal checks.

Consequently, the young woman states that the TV appearances below helped a lot in the development of the company: the first of them was in the ZF IT Generation show, then they went live in the grand final Innovation Labs 2020, followed by the promotion of the project in an article from startup.ro. The great prize obtained at Atos IT Challenge also brought them a multitude of appearances in the national and international press (atos.net, digital-business.ro), but also in the press conference within PUB. On this occasion, they also appeared live on the show "In front of the nation", from the Antena 3 television station, and later they were congratulated in the grand finale of the Innovation Labs 2021. Finally, in the near future, a news article about their organization will be published by the Romanian Tech Startups Association.

5. Results

To realize an adequate and comparative analysis, we decided to interpret ten answers of the respondents of our Google Form, which had the goal to identify the important aspects of the investment field of companies in software projects from Romania. Moreover, to better understand the interests, needs, and desires of young entrepreneurs from Romania, we conducted eight interviews with students from the Politehnica University of Bucharest, Faculty of Automatic Control and Computer Science, who are currently running a startup business.

The first couple of questions were intended to establish a basis regarding the place where the company was founded, and the year it was founded. Given that all these companies could be considered startups, the place where they were founded is also where they would be conducting their business. Figures 1 and 2 show the answers received when asked these questions.

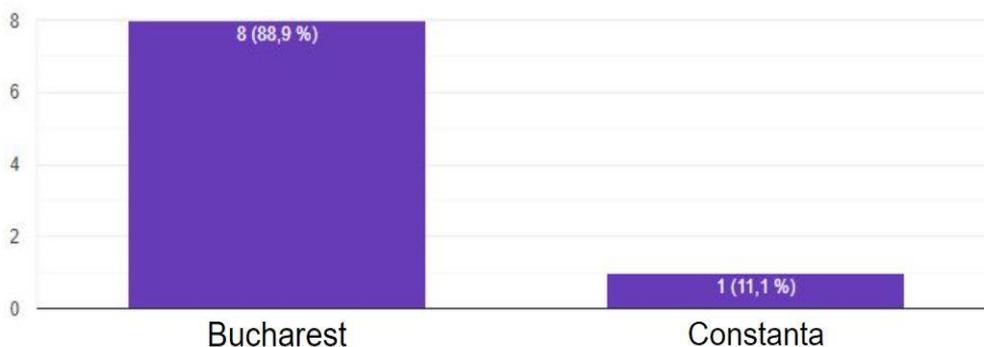


Figure 1 - The place where a corporation conducts its business

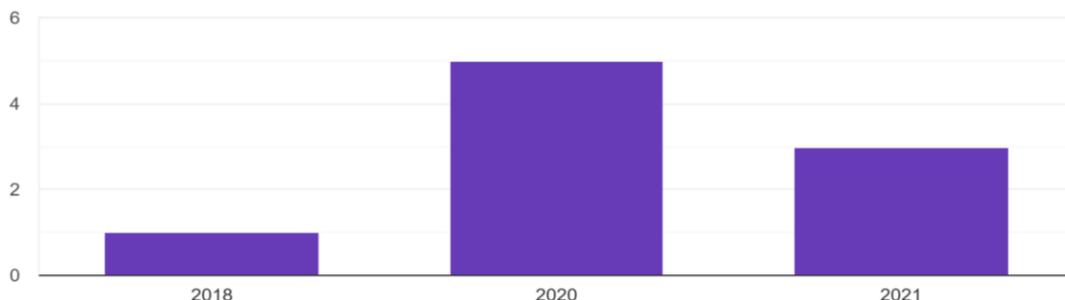


Figure 2 - The year when the company was founded

Based on the answers received to the first question we can conclude that most startups would pick a major city as a place for business. This could be because, while it is riskier to grow due to a lot of competition, the growth can also be faster due to the potential numerous clients and investors that could approach the business.

We also asked our respondents to provide a source for the information that is needed when trying to run a business. We tried to analyze how they keep up to date with the most current and accurate information, where they are taking their information from, and trying to see if there is a common ground between different companies. We let the respondents answer freely to this question and their answers are as follows:

- 44.45% revealed that their main source of information consists of dedicated websites for financial news
- 22.22% consider that their main source of information is represented by websites dedicated to startups ideas or projects involving new startups
- 11.11% use social media in order to keep up with the news
- 11.11% take their information and news from books or documentation
- 11.11% answered that their main source of information comes from following important entrepreneurs or a major media personality

Figure 3 shows some of the main fields of business of the interviewed companies.

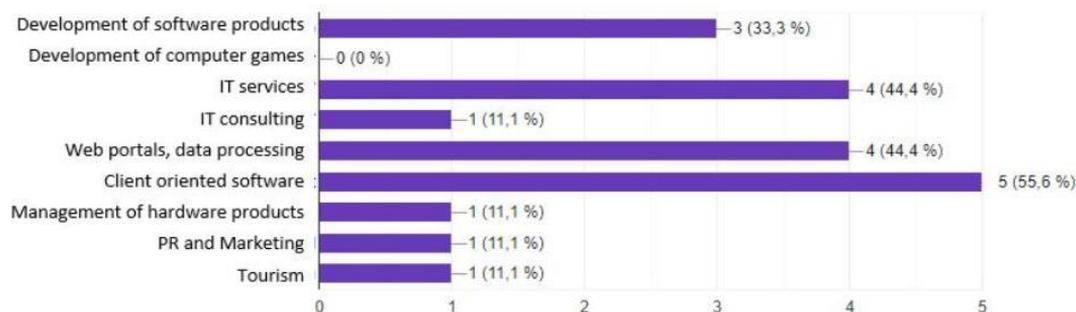


Figure 3 - The scope of the businesses

The investment field of the software projects created by the people who answered the questions is quite numerous, but most of them imply customer-oriented software:

- 55.6% - Client-oriented software
- 44.4% - IT Services and web portals, data processing, and web page administration
- 33.3% - Development of software products
- 11.1% - IT Consultancy, hardware product management, tourism, and PR & Digital marketing
- 0% - Development of computer games

Business intelligence technologies are software programs that help decision-makers - executives, managers, and analysts - make informed decisions. Here are some of the most important technologies, used by our respondents to increase the success of their companies:

When asked about the most used technologies when developing a project, the main choices were Python, C++, Blockchain, and Javascript, with others such as Golang, IPLD, and IPFS, following closely behind.

When asked about the average budget for their projects, most of the respondents wanted to keep this information private, while few of them declared that the average budget for a project is estimated at ~20.000€.

As was mentioned from the beginning, a study shows that 33% of startups fail in their first 3 years. The interviewed people, however, prove the opposite: 55.6% of the companies reported neither a gain nor a loss, while the remaining 44.4% registered considerable profit.

A 2021 [economedia.ro](#) article says that seven out of ten Romanian technology startups have been affected by the COVID-19 pandemics, according to a study initiated by the Romanian Tech Startups Association (RO TSA), in partnership with actors from the national start-up ecosystem [20].

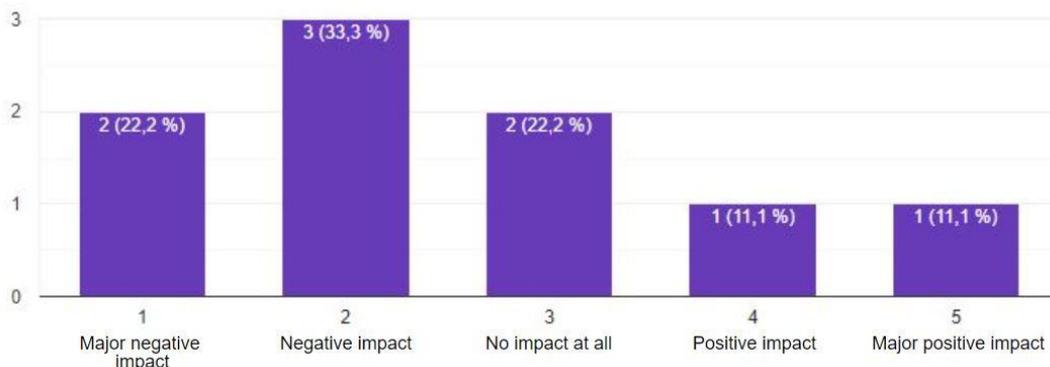


Figure 4 - COVID-19 impact on software projects

The form respondents have various opinions about how the disease influenced their projects:

- 33.3% - 2nd column - negative impact
- 22.2% - 1st column - major negative impact; 3rd column - no impact at all
- 11.1% - 4th column - positive impact; 5th column - major positive impact

6. Conclusion

This article shows that starting a business is a lot harder than most people think, but the steps of the process are similar: first, our young entrepreneurs identify an opportunity in an innovative concept; then, they suggest their ideas in front of top investors, mentors, and businessmen in competitions like Innovation Labs, Start-Up Nation or Business Plan Challenge. If their solutions present interest among entrepreneurs, they get motivation, financial support, and virtual promotion from the investors, thus obtaining a boost of energy and confidence in their project. Furthermore, the young people continue to invest time and resources in their startups, focusing on implementation and continuous development.

The reasons why they chose this path may vary: most students want to change something, making the world a better place, by improving their ideas, while some of them desire to become their own CEOs, work for themselves, and to guide other people, creating jobs for them. Another significant part of our colleagues aspires to turn their passion into profit, increase their earning potential, and become experts.

In conclusion, the current article has the objective to stimulate people to start their own business, as shown above, it offers several benefits. Each day at the office is motivating when you work for yourself and follow your passions and dreams. Moreover, you can achieve financial independence, control your lifestyle and your schedule and you'll soon become a professional in your own industry, as well as you will learn multiple skills: from HR decisions to inventory management to customer service. Starting your own business is compelling enough since each day provides new difficulties, fascinating chances, and the opportunity to pursue your passion. It certainly feels good to know that you've opted to take charge of your own destiny.

Bibliography

- [1] National Business Capital and Services. "2019 Small Business Failure Rate: Startup Statistics by Industry" Accessed Nov. 9, 2020
- [2] Robehmed, Natalie (16 December 2013). "What Is A Startup?", *Forbes*. Retrieved 30 April 2016
- [3] Riitta Katila, Eric L. Chen, and Henning Piezunka (7 June 2012). "All the right moves: How entrepreneurial firms compete effectively" (PDF). *Strategic Entrepreneurship JNL*. 6 (2): 116–132. doi:10.1002/sej.1130. Retrieved 18 May 2017

- [4] Raluca Juncu, “The first Romanian unicorn: How did a start-up launched by two Romanians in 2015 management to be valued at 1.1 billion dollars?”, *Forbes*. Retrieved 1 April 2018
- [5] Claudiu Zamfir, “Romanian company Bitdefender - possible valuation at almost \$ 2 billion”, *Startup Cafe*. Retrieved 13 December 2021
- [6] Forbes Romania, “The second unicorn: What is the story of the pioneer of the online commerce market who became the second unicorn with origins in Romania?”, *Forbes*. Retrieved 21 December 2021
- [7] Claudiu Zamfir, “eMag has a new CEO (CEO), replacing Iulian Stanciu”, *Startup Cafe*. Retrieved 29 March 2021
- [8] Monica Tanase, “How did eMAG end up being sold on a napkin corner? The story of entrepreneurs Monica and Radu Apostolescu: they survived the business crisis and now they have chosen to invest in health”, *LIFE.ro*. Retrieved 21 June 2021
- [9] Jeanne W. Ross, Cynthia M. Beath. "New approaches to IT investment." *MIT Sloan management review* (2002)
- [10] Paternoster, N., Giardino, C., Unterkalmsteiner, M., Gorschek, T., & Abrahamsson, P. (2014). “Software development in startup companies: A systematic mapping study”. *Information and Software Technology*, 56(10), 1200-1218
- [11] Berghout, Egon, and Chee-Wee Tan. "Understanding the impact of business cases on IT investment decisions: An analysis of municipal e-government projects." *Information & Management*, 50.7 (2013): 489-506
- [12] Mordor Intelligence, “Project Management Software Market - Growth, Trends, COVID-19 Impact and Forecasts (2022-2027)”
- [13] Business 2 Community - Dana Prince, “Why Knowing a Client’s Budget is Key to Sale Success”. Retrieved 26 January 2012
- [14] Fairlie, Robert. “The impact of COVID-19 on small business owners: Evidence from the first 3 months after widespread social-distancing restrictions.” *Journal of economics & management strategy*, 10.1111/jems.12400. 27 Aug. 2020, doi:10.1111/jems.12400
- [15] *Reuters* - Stephen Nellis, Akanksha Rana. “Microsoft earnings rise as pandemic boosts cloud computing, Xbox sales”. Retrieved 26 January 2021
- [16] M.Sc. Lisa Steigertahl, Prof. Dr. René Mauer, ESCP Europe Jean-Baptiste Say, Institute for Entrepreneurship, “EU Startup Monitor”, 2018 Report, Available Online: <http://startupmonitor.eu/EU-Startup-Monitor-2018-Report-WEB.pdf>, Retrieved 10 March 2022
- [17] Innovation Labs 2022, Available online: <https://www.innovationlabs.ro/>, Retrieved 10 March 2022
- [18] Lean Canvas/Leanstack, Available online: <https://leanstack.com/lean-canvas>, Retrieved 10 March 2022

- [19] Atos IT Challenge 2022, Available online: <https://www.atositchallenge.net/>, Retrieved 10 March 2022
- [20] “Study on young businesses in the country: Seven out of ten Romanian technology start-ups were affected by the pandemic”. Available online: <https://economedia.ro/study-on-young-businesses-in-the-country-seven-out-of-ten-romanian-technology-start-ups-affected-by-the-pandemic.html>, Retrieved 10 March 2022.

JOURNAL OF INFORMATION SYSTEMS & OPERATIONS MANAGEMENT
VOL. 16 No. 2 / 2022



ROMANO - AMERICANA
UNIV. DR. ION SMEDESCU

