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THE EMERGING AND DISRUPTIVE TECHNOLOGIES – A RISK-BASED APPROACH

Marin-Marian COMAN
"Nicolae Bălcescu" Land Forces Academy, Sibiu, Romania
"Lucian Blaga" University of Sibiu, Romania
coman.marian@gmail.com

Claudiu-Vasile KIFOR
"Lucian Blaga" University of Sibiu, Romania
claudiu.kifor@ulbsibiu.ro

ABSTRACT

The accelerating pace of technological advance and its emergent and disruptive trends related to new innovations and adopted technologies have a great impact on our society. The technological, geopolitical, environmental, economic, and disruptive trends are expected to reshape the evolution of businesses and how people interact with each other. Negative effects, threats, vulnerabilities, and consequences of a rapid adoption and implementation of any emerging technologies lead to specific risks which require organizations to rethink their strategy, governance and architecture of the business models. This paper aims to emphasize the adoption evolution and implementation effects of emerging and disruptive technologies that could lead to certain challenges in the majority of fields of activity. A bibliometric analysis was conducted in order to highlight the associated risks and consequences that could result from disruptive trends concerning the adoption and implementation over time of the emerging and disruptive technologies.

KEYWORDS: artificial intelligence, emerging and disruptive technologies, impact, new innovations, risk

1. Introduction

The use of technology is shaping the economic development of countries and the future of humanity by impacting the businesses, markets and also the life of citizens, changing their manner of thinking and behaving over time. Nowadays, the new innovations and the emerging and disruptive technologies (EDTs) are implemented in the majority of our daily activities. The healthcare services, space industry, the majority of economic sectors, defense and security, government or academia are just a few examples that are making use of emerging technologies in order to improve productivity or optimize the internal processes and efficiency of the entire organizational system.

The broad understanding of emerging technologies is linked to those new technical and technological innovations or appearance of a new technology on the market that could bring a potential competitive advantage in a specific activity domain. Disruptive technologies are new innovations that support the creation of new markets or can alter an existing market, displacing an earlier used technology. The emerging technologies are posing a predictable or unpredictable

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disruptive trends, impact level, associated risks, and real effects that are related to their development, maturity, market capitalization, and evolution over time.

The implementation and use of EDTs lead to new methods of economic development and governance due to its wide range of economic and social implications with major impacts and benefits expected on government, business, civil society and individuals. The adoption and implementation of EDTs in the organizational processes of any private or government entity provide specific opportunities but they also come with some ethical dilemmas, challenges, and vulnerabilities which result in risks over time. The "Top 10 Emerging Technologies 2024: How Tech Trends Shape 40+ Industries" report, published by StartUs-Insight (2024), says that "*these technologies, if wielded without care, present risks that might overshadow their immense benefits*". Indeed, some ethical dilemmas of EDTs could claim issues related to data privacy, risks associated with Artificial Intelligence (AI) like biases and fairness, job displacements, health implications due to technology use, transparency and accountability, infodemic and data weaponization issues, and even the environmental impact.

2. Conceptual Framework related to Emerging and Disruptive Technologies

The implementation of EDTs in a suitable, connected, sustainable, and resilient way in order to ensure all necessary services to citizens, local administration, commercial or industrial fields, or national defense and security domains brings new opportunities and poses risks that are related to their use over time. Figure no. 1 shows, in a broad picture, the evolution and linkages between implementation level of emerging technologies in conjunction with their impact on society and increasing level of risk over time correlated with disruptive trends of emerging technologies. One can also notice the appearance of dual-use technologies implemented in both fields, civilian and military, as a consequence of a fast development and availability of EDTs on both civilian and military markets. The disruptive trends of emerging technologies are usually linked to unpredictable negative effects and an increasing level of risks and consequences over time.

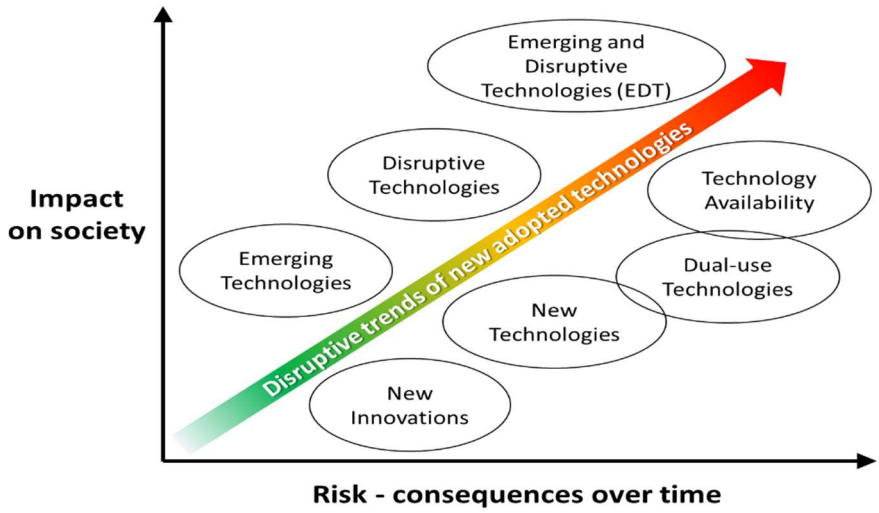

Figure no. 1: *The generic picture of impact of technology on society and increasing risk posed by EDTs implementation over time*
(Source: Authors' contribution)

In his book, "The Fourth Industrial Revolution", the world-renowned economist Klaus Schwab (2016) explains that society has an opportunity to shape the fourth industrial revolution which fundamentally alters how we live and work. The 4th industrial revolution is driven by new key technologies that are impacting the government, business, civil society and individuals and are fusing the physical, digital and biological worlds. Based on the fact that emerging technologies empower people rather than replace them, Schwab advises that humanity should "*take dramatic technological change as an invitation to reflect about who we are and how we see the world*". In "Disruptive technologies: Advances that will transform life, business, and the global economy" report, published by McKinsey & Company, Manyika et al. (2013) claim that "*not every emerging technology will alter the business or social landscape - but some truly do have the potential to disrupt the status quo, alter the way people live and work, and rearrange value pools. It is therefore critical that business and policy leaders understand which technologies will matter to them and prepare accordingly*."

In 2022, the Boston Consulting Group (BCG) conducted "Mind the Tech Gap" survey having around 2677 responders amongst which executives and key decision makers from 13 countries in order to better understand digital transformation trends. The survey concluded that a majority of company's businesses were supposed to increase their investments in digital transformation with about 60% in 2023 comparing with 2022. On one hand, this high percentage of spendings in digital transformation was planned to concentrate on internal processes and operations rather than breakthrough performance. On the other hand, 94% of companies wanted to achieve substantial and rapid impact focusing on two main areas of digital transformation: business model transformation and sustainability. This survey revealed that the top three transformative business technologies were advanced AI – 50%, Blockchain – 40%, and Internet of Things (IoT) – 39%. In addition, the experts in advanced tech – 26%, software engineers – 21%, and data scientists – 14% were considered to be the three hardest tech roles to be filled in the specific positions of companies. Also, the survey provided the top five challenges in digital transformation, such as: making the right choices among disruptive technologies, reaching scale fast with new digital solutions, recruiting talent, prioritizing investments and development, and managing the cost and uncertainty of return on investment. Furthermore, this survey has emphasized that 93% of companies have been struggling to navigate the rapidly growing landscape of disruptive new technologies.

3. Implementation Analysis of Emerging and Disruptive Technologies

This paper explores dynamic trends of interest and the associated risks posed by EDTs as a consequence of their implementation and use at a large scale. A bibliometric analysis in a well-known database was conducted in order to have a tangible investigation concerning the trends of EDTs and the specific linkages among new technologies with potential disruptive effects. The paper is also focusing on the answers to the following questions:

– Will EDTs impact and affect the society and business models over time?

– How to mitigate the risks and effects that are linked to EDTs' implementation?

In Figure no. 2 is presented the "interest over time" in the last ten years (2013-2023) concerning the evolution of EDTs, their associated risks, and the AI as a specific emerging technology with a huge disruptive potential. One can remark an increasing trend of interest in online searching for relevant information about

EDT during COVID-19 pandemic period of time. The moving restrictions of the people during the pandemic resulted in an acceleration of digitalization and implementation of new technologies in order to provide businesses continuity and support to social and government services with no disturbance. Correspondingly, the resilience was increased in the majority of activity domains like economic sectors, government services, learning environment and academia, national defense and security systems, and the daily life of citizens had also continued with no major interruptions. After the end of the pandemic, it is noticed an increasing trend (green color) of AI technology's evolution represented by the development and appearance of the well-known ChatGPT on the market, which is considered synonymous with the AI concept as a whole by majority of people. Similarly, the opportunities and vulnerabilities have been increasing and the associated risks posed by AI technology keep up with its evolution and rapid spread in many activity domains.

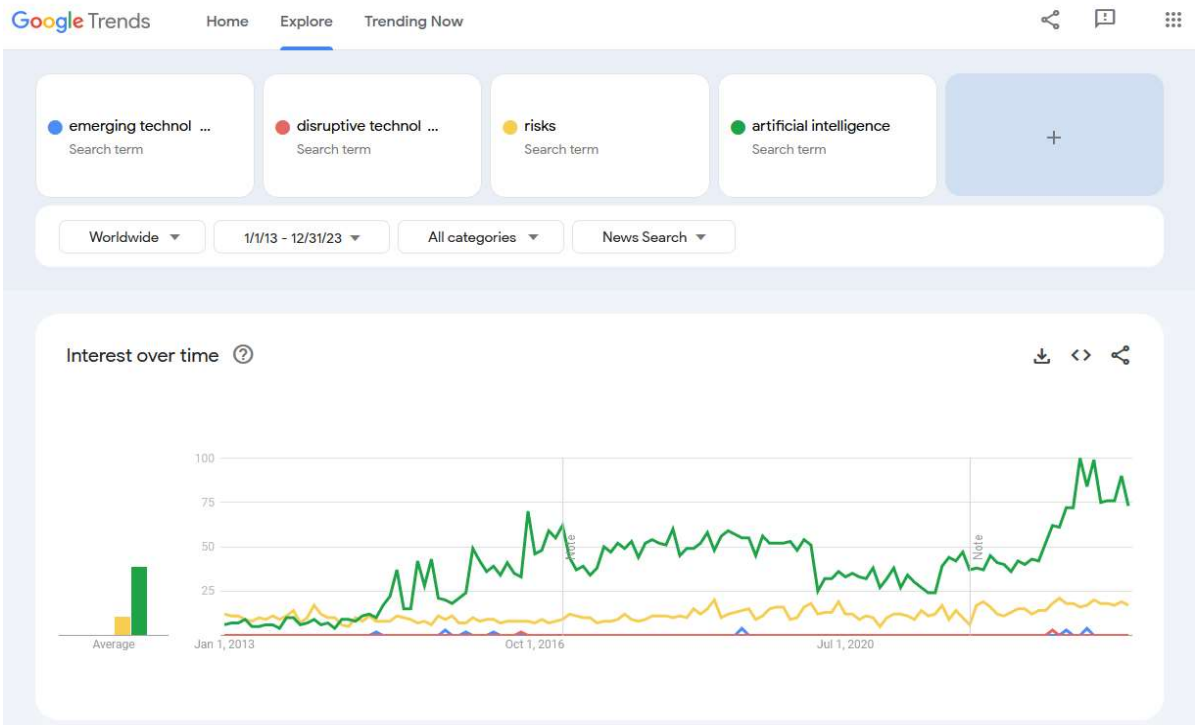

Figure no. 2: *The interest over time related to evolution of EDTs, risks, and AI*
(Source: Google Trends)

A bibliometric analysis of scholarly publications related to our topic of interest is also relevant in this context. The Web of Science (WoS) database was selected as bibliometric analysis using the following interrogation attributes: "emerging technolog*" (All Fields) OR "disruptive technolog*" (All Fields) AND "risk" (All Fields). After the interrogation of WoS database, the initial resulted bibliographic database was refined by searching the highly cited papers in the last ten years (2013-2023). The final bibliographic database has comprised of 664 papers for analyzing employing bibliometric software such as VOSviewer and Biblioshiny.

Having the emerging technologies as a central topic in the main cluster of connections, Figure no. 3 emphasizes the network analysis in scientific mapping with connections and co-occurrences of obvious keywords. Different colors are used in order

to identify the specific clusters throughout the keyword network and every node has a specific size corresponding to the topic's frequency and occurrences.

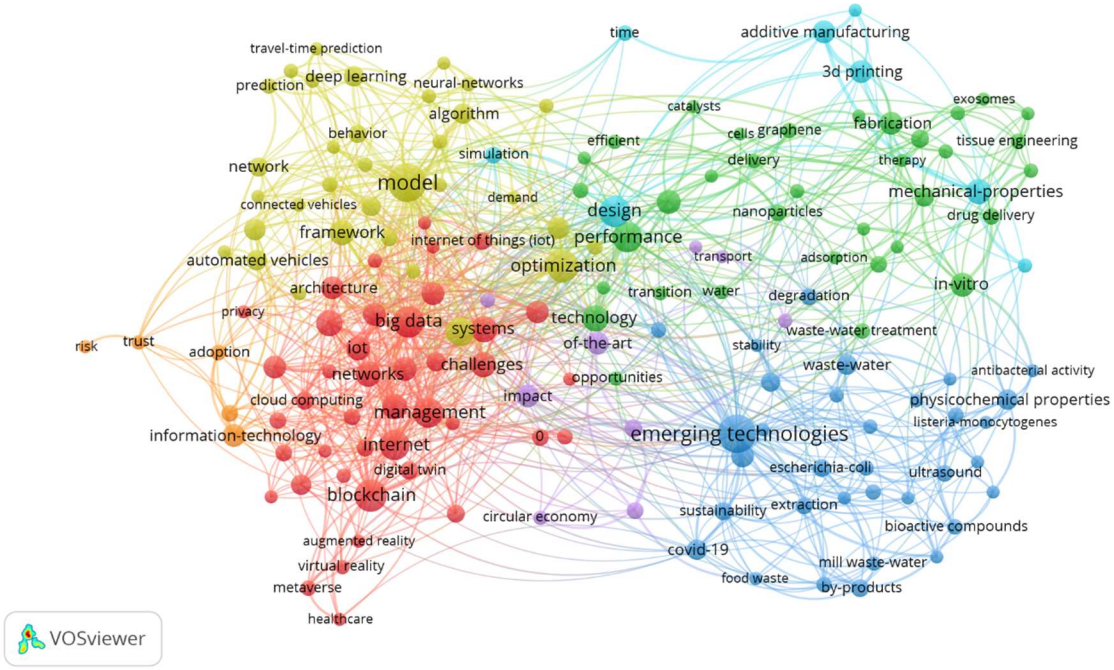

Figure no. 3: *Co-occurrence network built on the interactions among emerging technology, disruptive technology, and risk clusters*
(Source: VOSviewer)

It is noticed that the emerging technology cluster has major connectivity with clusters and topics related to big data, circular economy, blockchain, networks, AI, performance, design, optimization, model, systems, 3D printing, cloud computing, or information technology. The blue cluster (emerging technologies) has strong connections with the following topics: COVID-19, food waste and mill waste-water, bioactive components, degradation, antibacterial activity, ultrasound, stability, and sustainability. The resulted insights show a real linkage between the Google Trends analysis and the VoSviewer co-occurrence network of topics. The associated risks and consequences were based on the fact that a fast adoption of emerging technologies with disruptive effects during COVID-19 pandemic impacted to a great extent the citizens, business models, and specific services delivered to the population.

Figure no. 4 presents the Thematic Map which is split in four quadrants: Motor Themes, Basic Themes, Niche Themes, and Emerging or Declining Themes. There are three main interrelated clusters located in the upper right corner pertaining to Motor Themes quadrant (well developed and important themes for the structuring of the research field), with a high centrality and density, comprising following technology's interested topics:

Cluster red: Blockchain, AI, IoT, big data, Covid-19, deep learning, Industry 4.0, machine learning, and cloud computing;

Cluster blue: emerging technologies, food safety, sustainability, nanoparticles, cold plasma, climate change, food security, food supply chain, food waste, supply chain, and management;

Cluster green: IoT, security, 5G, wireless sensor networks, edge computing, optimization, fog computing, 6G, drones, and energy consumption.

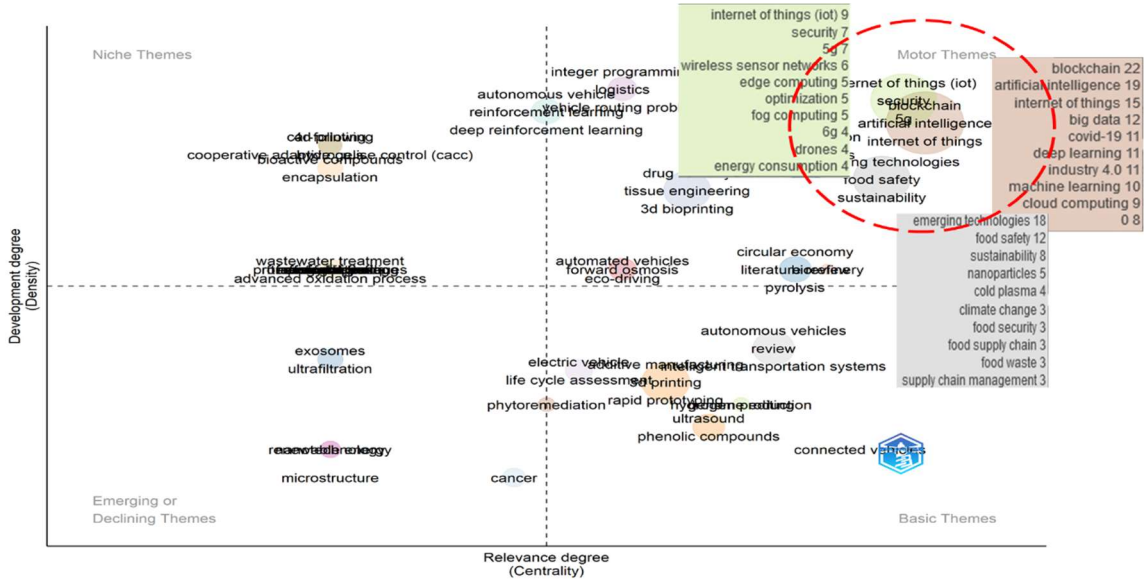

Figure no. 4: *Bibliometric Thematic Map based on the refined WoS database*
(Source: Biblioshiny)

Topics like autonomous vehicles, 3D printing, rapid prototyping, ultrasound, or phytoremediation are indicated as Basic Themes with significant density but low centrality. They are located in the lower right corner of Thematic Map implying that they are significant and not yet fully developed. In the "*Autonomous driving's future: convenient and connected*" report published by McKinsey & Company, Deichmann J. et al. (2023) argue that "*even after some setbacks that have pushed out timelines for autonomous-vehicle (AV) launches and delayed customer adoption, the mobility community still broadly agrees that autonomous driving (AD) has the potential to transform transportation, consumer behavior, and society at large.*"

As a consequence of use and rapid spread among companies and people, 3D printing technology comes also with a series of risks and specific effects linked to the following issues: emissions and air quality, biological hazards, mechanical hazards, electrical safety, fire risk, or static electricity. Not just 3D printing, as a part of additive manufacturing technology, could pose risks and negative effects as a result of its use. Other emerging technologies that will be approachable and affordable over time will have a disruptive effect on economies and will pose lots of risks after their implementation. Dickinson K. (2021) considers the following ten emerging technologies that could change and disrupt our world: 5G, IoT, serverless computing, biometrics, Augmented Reality (AR), Virtual Reality (VR), blockchain, robotics, Natural Language Processing (NLP), and quantum computing. Anand A. (2023) argues that the following ten emerging technologies and technological trends could influence the data science in the future: AI and Machine Learning (ML), IoT, blockchain technology, NLP, data visualization and storytelling, data governance and privacy, augmented analytics, edge computing and real-time analytics, data science in healthcare, and data science in education. In the "*Top 10 Emerging Technologies to Watch in 2024*", Bob A. (2024) concluded that "*the year 2024 promises to be a landmark year for emerging technologies, with advancements across various domains set to reshape our world. From AI and 5G to blockchain and quantum computing, these technologies will enable new possibilities and drive innovation across industries. As we embrace these emerging technologies, it is crucial to consider their ethical*

implications and ensure that they are developed and deployed responsibly, for the benefit of society as a whole."

4. Discussions and Conclusion

When we have to analyze the impact and the associated risks over time resulted from the implementation of new innovations and EDTs, we should understand what the main differences are between "emerging" and "disruptive" concepts. Smith T. (2022) considers that a disruptive technology is "*an innovation that significantly alters the way that consumers, industries, or businesses operate and it sweeps away the systems or habits it replaces because it has attributes that are recognizably superior*." Kelly M. & Chan A. (2022) argue that "*emerging technologies represent a major source of risk, and their complexities make those risk areas especially difficult to assess. Practitioners must consider the whole system view of the emerging technology, its use, its interplay with other technologies, and the combination of parties that could be involved*." In the "Technologies for Sustainability Systems", the PennState Department of Energy and Mineral Engineering (DEME) specifies that "*in the social and economic context, the progress towards sustainable development requires disruptions and seeks a shift in the existing paradigm*." According to DEME, the "*emerging technologies are technical innovations that breach new territory in a particular field…implementation of an emerging technology involves economic risk, but, if successful, offers a competitive advantage to a company*" and "*disruptive technologies are innovations that help create new markets and eventually go on to disrupt an existing market and value networks, displacing an earlier technology*."

The takeaways of the BCG "Mind the Tech Gap" survey (2023) portray the following reality – in order to overcome the challenges and high level of risk related to emerging technology's disruptive effects there is an urgent need for all organizations to transform and align their culture, processes, and people in accordance with the rapid evolution and implementation of emerging technologies in the majority of activities and functional fields. The Figure no. 5 portrays a broad picture of the linkage between associated risks of EDT's implementation and the resulted threats, vulnerabilities, and consequences that are related to any organization's processes and activities.

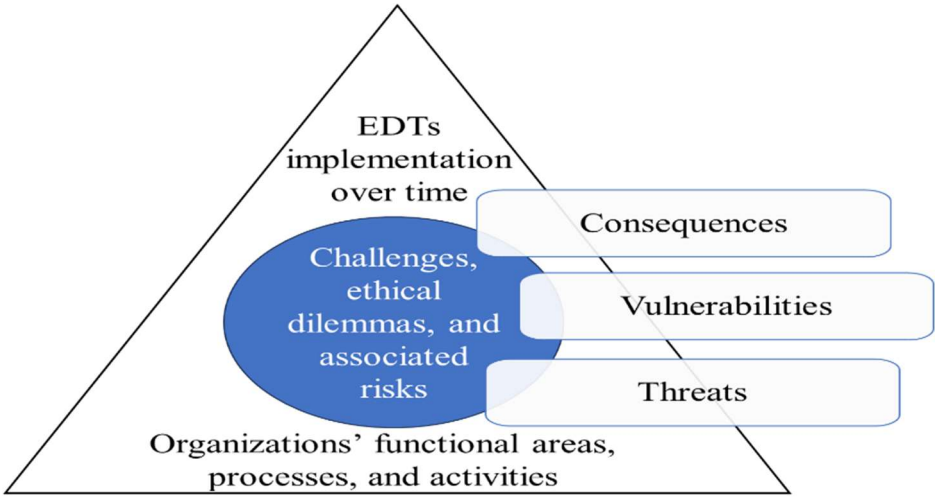

Figure no. 5: *The broad picture of threats, vulnerabilities, and consequences linked to EDTs*
(Source: Authors' contribution)

Besides the associated risks, the potential disruptive effects related to a rapid adoption and broader use of emerging technologies must be corroborated with their real implementation challenges, ethical dilemmas, and the governance process. In the "Technology Innovation Is Disrupting Risk Management", Gale M. (2017) affirms that "*there is a broader range of risks related to disruptive technology that need to be accounted for as companies adopt new innovations. Modern risk professionals need to look for solutions and alternatives that allow for innovation while balancing risk*." Risk professionals must assume a leading role in understanding, assessing, and managing the risks and opportunities of technological innovations. Analyzing the challenges throughout the investment life cycle of ETDs, Bobier et al. (2023) underscore in the "An Investor's Guide to Deep Tech" report that "*more than 80% of deep tech ventures are building physical products, which involves risks related to engineering and unit economics, as well as commercialization and scalability*."

In order to emphasize the threats, vulnerabilities, and consequences related to associated risks of EDT's implementation, the AI technology will be inherently brought into discussion. Nowadays, the AI portrays as a main technology with an economic high potential among other emerging technologies. Due to a fast widespread of ChatGPT as well as of the smart devices powered by AI starting from smartphones till smart TVs, computers or other kind of smart gadgets, probably the majority of people consider AI so easy to be developed and implemented. On a rapid developing AI market, the potential consequences of failing to account for all of the risks and the timely mitigation of their negative effects will be like a black swan over time. AI is currently one of the hottest buzzwords in the tech field due to its high potential to transform the productivity and GDP of the global economy being like a real driver for a greater product variety, with increased personalization, attractiveness and affordability over time. Scott G. (2023) argues that "*the year 2022 brought AI into the mainstream through widespread familiarity with applications of Generative Pre-Training Transformer. The most popular applications are OpenAI's DALL-E text-to-image tool and ChatGPT. The widespread fascination with ChatGPT made it synonymous with AI in the minds of most consumers. However, it represents only a small portion of the ways that AI technology is being used today*." The book "The Big Nine: How the Tech Titans and Their Thinking Machines Could Warp Humanity" written by Amy Webb (2019), a futurist and professor of strategic foresight at the New York University Stern School of Business, explores the power and potential dangers of AI, how it will impact society over time, particularly as it is developed and controlled by nine tech companies: Google, Amazon, Facebook, IBM, Microsoft, Apple, Tencent, Baidu, and Alibaba.

In broad terms, the AI technology works using large iterative processing algorithms to learn from patterns and features pertaining to the specific analyzed databases resulting in accomplishing of complex tasks such as interpreting speech, reasoning, solving problems, making decisions, or identifying patterns. Consequently, if we take into consideration a risk-based approach linked to rapidly widespread of AI technologies that power many of the tech systems and services used by many organizations and most of the people, the following legitimate raising questions could be: Can we timely identify and mitigate the vulnerabilities and risks posed by the rapidly widespread and use of AI technology? What could be the associated risks over times that are related to a fast AI technology implementation in the main activity domains?

Investments in generative AI technology have exploded in the last 2 years proving a real economic potential.

Based on the Hu K. analysis (2023), showing the comparison between the fast adoption after public launch of ChatGPT – the popular chatbot from OpenAI Company, which got its soar to 100 million users in about 2 months and the well-known TikTok platform which got its soar to 100 million users in about 9 months, it is noticed a huge interest of many companies in a fast AI implementation in most of their fields of activity.

One of the most worrying topics related to AI technology rapid implementation comes from the cyber domain and is related to the truth in an age of synthetic media. The Deloitte (2023) "Tech Trends 2024" report presents the following ideas: "*With the proliferation of AI tools, it's now easier than ever for bad actors to impersonate and deceive their targets. We're seeing deepfakes being used to get around voice and facial recognition access controls. They're also being used in phishing attempts. Security risks are multiplying with every new content-generation tool that hits the internet. However, leading organizations are responding through a mix of policies and technologies designed to identify harmful content and make their employees more aware of the risks*."

If we think about the consequences and the associated risks that are related to AI implementation over time, there are some interesting takeaways that could be inferred from the book of Amy Webb. Based on her book, Miguel de la Vega (2023) has taken into consideration the following ideas that are related to some consequences and potential risks posed by the use of AI technology: "*the algorithms that power AI can have inherent biases, leading to discrimination and perpetuating societal issues; there is a need for interdisciplinary collaboration in the development of AI, to ensure that it is developed ethically and responsibly; the development of AI has the potential to fundamentally alter the job market and workforce, causing widespread unemployment; there is a need for increased transparency and accountability in the development and deployment of AI, to ensure that it serves the interests of humanity as a whole*."

The actual framework generated by the imposed trends of Industry 4.0 as well as the fast evolution of science result in new technological developments. New innovations and technological developments are periodically reported and presented as the real change engines providing new opportunities and economic potential. Therefore, in order to reach the full potential of EDTs, every organization should have its own assessment process to evaluate the benefits of adopting the emerging technologies with potential disruptive effects. Consequently, comprehending the broad picture of risks and likely mitigation ways in order to avoid or diminish negative effects are mandatory conditions linked to a better understanding of the advantages and disadvantages of implementation of new technology over time.

In essence, the investigation of dynamic trends of interest and the associated risks posed by EDT as well as the bibliometric analysis of new innovations and emerging technologies prove the strong linkage between the implementation of new technology and its potential disruptive effects. Further research in this area could have two investigation directions: on the one hand, the relationship between the high rate of the emerging technology's development and the threats, vulnerabilities and risk consequences; on the other hand, the related effects linked to a fast adoption and use of new technology in various fields of activity as a main outcome of restrictions during COVID-19 pandemic.

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