DIGITAL INDUSTRY TRANSFORMATION - COMPLEX ANALYSIS OF TECHNOLOGIES, BENEFITS, SUCCESS FACTORS AND BARRIERS

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Abstract: Complexity of digital transformation paradigm face companies with serious challenges. This research study is settled in order to give an insight into the concept of digital transformation projects and processes, to identify initiatives, success factors, and barriers of digital transformation, as well as, to give an overview of key technologies underpinning digital transformation. As a case study a complex analysis of digital transformation industry projects is conducted. Taking into account the multidisciplinary nature of digital transformation projects and processes, a wide variety of industries in North Macedonia are included.

Key words: digital transformation, initiatives, key digital technologies, benefits, success factors, barriers.

1. INTRODUCTION

Digital transformation (DX) is innovative and principled application of digital technologies, and the strategic realignment of the organization towards the improvement of business models, industrial models, and processes and ultimately the creation of entirely new ones [1]. It is a relatively new concept and has reached high popularity among researchers and practitioners in the last couple of years [2, 3]. The importance of the topic is undisputed, and massive efforts are under way to create strategic and organizational capabilities that enable companies to successfully complete the digital transformation process [4, 5]. It is virtually impossible to escape the digital context that shapes the business realities of the early 21st century [4]. As a result of this, the universities offer courses to prepare companies for digital industry transformation [3].

The technologies underpinning digital transformation give no shortage of opportunities. Yet they were established few decades ago. Basically, the driver in the background of digital transformation comes from three focal laws. First, it is *the*

Moore's law which states that the complexity of integrated circuits doubles regularly with minimal component costs. This leads to ever faster, but also cheaper computers, which enables us to store more and more sensors, programs and applications [4, 6]. In other words, making digital staff better and cheaper. Second, *Metcalfe's law* - the effect of a telecommunications network is proportional to the square of the number of connected users of the system. It deals with connectivity, the ability of many users to access information across multiple locations. Starting with telephones, which suddenly allow people to be contacted over long distances, social media and the Internet make it possible to interact with many people at the same time. The third rule is *the Bandwidth Law*. Nielsen's Law of Internet Bandwidth states that the bandwidth of users is growing by 50% per year. This increased bandwidth ensures that the quality of our digital experiences and opportunities continues to increase and that we are able to cope better with the ever-increasing amounts of data [6].

However, an MITSloan and Deloitte study reveals that digital transformation proves to be difficult and less understood by many organizations [5]. Further research reveals that while many organizations continue to complete digital transformation projects, only one in five organizations are succeeding in realizing the true value of transformation [5]. In addition, a recent survey of directors, CEOs, and senior executives found that digital transformation risk is their number one concern in 2019. Yet 70% of all digital transformation initiatives do not reach their goals. Of the $1.3 trillion that was spent on digital transformation last year, it was estimated that $900 billion went to waste [7].

In light of this, we carried out analysis to address what can enable and what can hinder the digital transformation. Also, why organizations undergo digital transformation and what are the most used digital transformation technologies. According to literature review [1, 4, 8], we found out that digital transformation is rewriting the laws of competition. The technologies have disrupted the competition landscape [8]. At the company level, many traditional firms have been surpassed by innovative fast-growing digital entrants, and suffered as a result of this [8] (e.g., Amazon, Alphabet, Apple, and Facebook) and China (e.g. Alibaba, and JD) start to dominate numerous industries. Taking into account the multidisciplinary nature of digital transformation [8-14] we conducted complex analysis including a wide variety of industries in North Macedonia, where more than 20 top executives were involved.

2. RELATED WORK

Digital transformation is a complex, expensive and volatile endeavour in which organizations take risks in pursuit of major long term efficiency and productivity gains [5]. Digital disruption describes the ground-breaking impact of digital innovations, as opposed to sustaining and incremental changes, and highlights the urgent need to take responsive action [12]. The DNA of innovators is based on a courageous, daring mind-sets that defies convention. Or, to say it with the famous

motto of the Starship Enterprise: "*To boldly go where no man has gone before*" [4]. [12, 15] examined the motivations behind different organizations' digital transformation programs, and found many of the same drivers despite differences in industry and company size.

2.1. Initiatives and motivators for digital transformation

The driving force for digital transformation is often **market pressure**: competition, or the threat of competition. If one participant in a market successfully implements a digitally transformative project, then competitors in that market will feel compelled also to transform—or risk losing competitiveness and market share. The routes by which such competitive advantages come about range from higher process efficiencies enabling lower pricing to customers through to disruptive innovation and the implementation of a new customer proposition in the marketplace [1]. The competitive landscape is changing in many industries due to business digitalization [16]. Enterprises face threats of digital disruption from new market entrants while digitally savvy customers are demanding more from the enterprise [17].

Furthermore, digital transformation is found to often be triggered by changing **customer behaviors and expectations**. The increased use and the generative character of digital technology have led to changes in customer and end-user behaviors and expectations [12]. Digital technologies allow consumers to co-create value by designing and customizing products, perform last-mile distribution activities, and help other customers by sharing product reviews. Mobile devices have become important in today's consumer behavior and facilitate showrooming behavior, the practice of examining merchandise offline, and then buying it online. Consumers also strongly rely on apps, and new Artificial Intelligence (AI) - based technologies, like Amazon's Echo and Google Home, that are entering consumers' lives [8].

There are **network effects** at play too. The simple availability of new technologies and techniques means that enterprises can consider transforming their businesses in ways that, until now, have not been possible. One of the most significant considerations in this context is the quantity, quality and timeliness of information and the exponential growth of big data [1]. It's reshaping society [4]. The nature of technologies such as blockchain, social media, AI, cloud computing, big data analytics, etc. require a new kind of institutional infrastructure that can deal with the – often unintended and not fully understood – consequences of digitalization. The discussion about privacy, cyber security, the future of humanity or the future of work are an indication of the kind of societal challenges we need to address [4].

In all, the motivations for deploying digitally transformative solutions may be diverse [1], but they share one need (or desire) in common - to do business in a new and better way.

2.2. Key technologies underpinning digital transformation

The digital transformation technologies are mostly technologies associated with the Industry 4.0 [13], [18]. This next generation of technologies formally referenced as information and communication technologies is relying on new features which allow new services and products promising previous satisfaction level with added value which can be delivered digitally. Digital technologies related to the fourth industrial revolution whereby the way in which the technologies are intertwined - combined or separately - can bring various potential options [18].

Moreover, the list of innovations and advancements in technology that can affect digital transformation is too long and includes innovations around sensors and actuators, advancements in nanotechnology (nano robots, supercapacitor batteries, etc.). [1] provide an overview of some emerging technologies and their key usage scenarios within a digital transformation context.

The Internet of Things (IoT) - IoT is a core technology in the fourth industrial revolution. It refers to the extension and use of sensor-driven internet of things to non-consumer applications. IoT systems connect and integrate the edge with enterprise systems, business processes and analytics. Key usage scenarios include: smart manufacturing systems that optimize production and minimize unplanned shutdowns through predictive maintenance; smart infrastructure: mobilize, monitor, and manage operation of utilities, gas, water, roads, buildings, power grids, etc.

Cloud/Edge Computing - Edge technologies bring processing intelligence closer to data sources, allowing (near-)real time responsiveness and improved functionality in situations where local devices may not be continuously connected to data center resources. Storing and processing data nearer to data sources can help with regulatory compliance, including privacy and security. Redaction at the edge can reduce connectivity, data migration and bandwidth costs associated with sending data to the data center.

Big Data and Data Analytics – Big data can be defined as data sets whose size or type is beyond the ability of traditional relational databases to capture, manage and process the data with low latency. Sources of data are becoming more complex than those for traditional data because they are being driven by AI, mobile devices, social media and IoT. Big data analytics is the use of advanced analytic techniques against very large, diverse big data sets that include structured, semi-structured and unstructured data, from different sources, and in different sizes from terabytes to zettabytes [2, 19].

Artificial Intelligence (AI) - The Merriam-Webster Dictionary defines Artificial Intelligence [1] as "a branch of computer science dealing with the simulation of intelligent behavior in computers" and as "the capability of a machine to imitate intelligent human behavior". AI and analytics provide an enhanced ability to understand and learn from data; information from IoT systems provide a plethora of data that can be broken down and analyzed using AI algorithms, allowing organizations to make more informed decisions.

Human-Machine Interface (AR or VR) - Human-machine interfaces (HMIs) are combined hardware and software components that enable humans to interact with machines by inputting information to trigger outputs; they come in many forms, from simple buttons to complex graphical displays. HMI refers to novel interfaces that have yet to become mainstream in industrial settings—such as augmented reality (AR) displays in which a person's physical environment is enhanced with a visual or audio "overlay," or virtual reality (VR) headsets that enable humans to immerse themselves completely in computer-generated environments.

Cyber Security - Protecting sensitive data is one of the foundations of trustworthy systems, itself one of the underpinnings of DX. Data security is a property of being protected from unintended or unauthorized access, change or destruction ensuring availability, integrity, and confidentiality. It encompasses several adjacent and overlapping domains, such as data security, data integrity and data privacy. Data security covers a wide range of protection mechanisms such as key management, root of trust, authentication, access control, audit and monitoring.

Additive Manufacturing (3-D printing) - Additive manufacturing technology (AM) changes the way things are made by turning a digital three-dimensional design into a physical object by adding layers of material successively. Raw materials are typically plastics and other polymers, metals or ceramics and may be in the form of a liquid, powder or a sheet. One of the key usage scenarios is economical production of mass personalized products enabled by extreme flexibility of customization of manufactured goods.

Robotics - Autonomous robotic systems enhance human productivity in areas ranging from autonomous vehicles to unmanned drones and from manufacturing robotics. It allows a device to perform its tasks without requiring human control or oversight. Autonomous robotic systems are particularly beneficial in situations that require the remote operation of devices in real-time, e.g. for protecting human worker safety or avoiding hash or hazardous work environment, or applications that require greater speed and precision than humans can provide.

3. COMPLEX ANALYSIS OF DIGITAL TRANFORMATION INDUSTRY PROJECTS

For the purpose of this complex analysis of digital transfomation projects, 22 top executives across industries in North Macedonia were involved. Total six industries sectors were analyzed: Information Technology, Financials, Energy, Manufacturing, Engineering and Telecommunications. Regarding the enterprise size, 6 of the organizations are micro (less than 50 employees), 8 are small (between 50-250 employees) and 9 are large (more than 250 employees).

3.1. The applied research methodology

The respondents have been asked to complete a questionnaire sent to them by email. The questionnaire was comprised mainly of 4 questions about the use of DX

technologies, DX benefits, success factors and barriers. *Likert Scale*, rating system, as one of the best survey tools for researching opinions [20], was used in the questionnaire.

Likert-type or frequency scales use fixed choice response formats and are designed to measure attitudes or opinions. The principle is developed to measure attitudes by asking people to respond to a series of statements about a topic, in terms of the extent to which they agree with them, and so tapping into the cognitive and affective components of attitudes [20, 21]. Likert Scales have the advantage that researchers do not expect a simple yes/no answer from the respondent, but rather allow for degrees of opinion. In our research, three items were used in the scale: W(weak), M(moderate) or S(strong). Therefore quantitative data is obtained. However, the drawback is that we may not get in-depth feedback.

For results to be more accurate, we contacted our respondents to give us more comprehensive opinion about each subject. Due to the pandemic, some of the interviews were conducted online via zoom platform.

3.2. The use of digital technologies

The first probing question that we asked our respondents was '*which of the DX technologies you have used in your digital transformation projects and which of them do you think can be used in the future?*'.

We found out that the most used DX technologies are Cloud/Edge Computing, Big Data and Data Analytics, IoT and Cyber Security. Not fully leveraged DX technologies are AI, HMI, AM and Robotics (figure 1.). The reason for less used technologies is not finding the right stategy to create value from them.
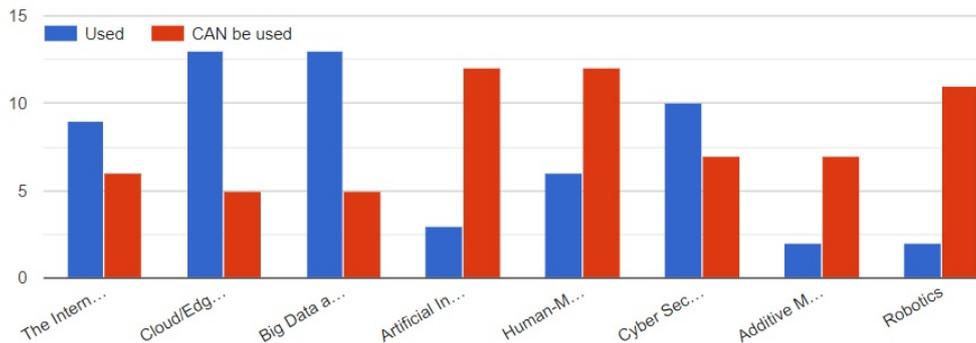

Fig. 1. The use of key technologies underpinning digital transformation - results from the complex analysis

3.3. Benefits from digital transformation

The answers from the second probing questions '*what benefits can your company get from digital transformation?*' are discussed on figure 2.
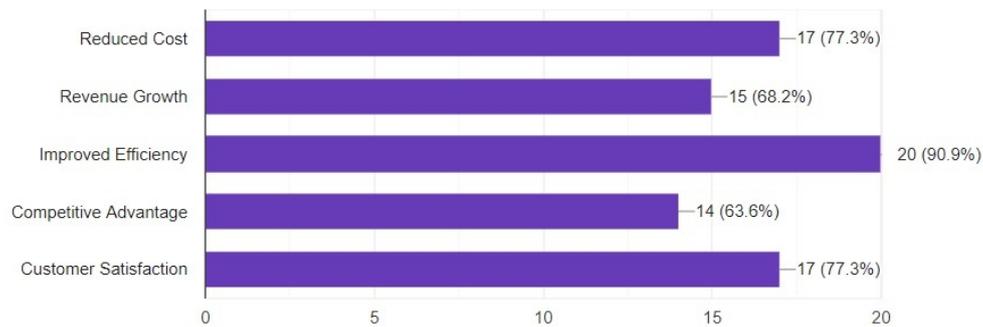
Fig. 2. Benefits from digital transformation - results from the complex analysis

The most valuable benefit from DX is *improved efficiency* of processes and business models in organizations. Also, we identify other remarkable benefits that organizations can gain from DX: *advanced corporate culture, being in touch with the latest technologies is always brilliant, building innovative solutions and products, insights through data, better overall strategy, bring new innovations to companies, simplify communication between parties/partners*.

3.4. Digital transformation success factors

The main success factors that can enable the digital transformation in organizations are *people mind-set*, *employee's engagement*, *CEO and top management abilities* and *digital assets*. While *customer involvement*, *separate business units* and *key partners* are important but cannot strongly affect the success of the DX (figure 3.).
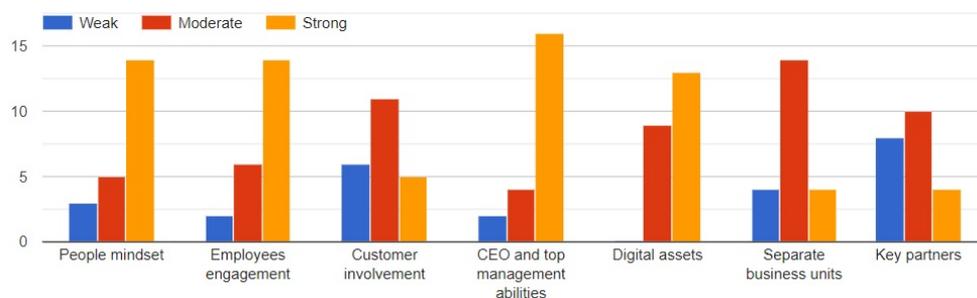

Fig. 3. Digital transformation success factors – results from the complex analysis

People mind-set - Many people have been working for years within the traditional organizational context. They have internalized cultural imperatives which are difficult to shed. Successful digital transformation require *agile mindset*. Agile teams are urged to be *entrepreneurs*, break the rules, disrupt. Finding the right balance between the entrepreneurial mind-set and the corporate setting is a major

challenge [4]. Agile mind-sets relate to fostering courage, curiosity, and a collaborative spirit as key elements of individual capabilities. People who have no guts, no curiosity, and who have a hard time to collaborate won't function well in reaching DX strategy, and they will slow down any DX success. Companies address this domain usually by offering workshops in agile methods, such as design-thinking, scrum, hackathons, and more [4].

Employee's engagement – Employees, who work on processes affected by digital transformation, need to be engaged in the changes in order for the transformation to reach its full potential. For employees to embrace the digital transformation and engage in adopting new technologies in their respective fields, it is important that managers include them as active parts of the transformation, for instance, by informing, consulting, involving, or collaborating with these internal stakeholders [12]. Digital mature enterprises need to foster a culture where employees are encouraged to take risks, innovate, be creative and create a collaborative work environment. Trying out a lot of things and learning quickly from errors can only be done if a culture of trial-and-error exists within the enterprise [16]. Changing the company culture is a real issue during digital transformation.

CEO and top management abilities - The role of strong top-down management is defined by *leadership* that steers digital transformation by setting direction and building momentum. Enterprise executives are advised to focus on employees, culture, talent and skillset. They must define clear and coherent *digital strategy* to create competitive advantage, value and customer satisfaction by leveraging digital transformation technologies [16]. Their responsibility is to foster openness to change, as well as, a willingness to accept and establish a *change-oriented mindse*t, which is essential for mastering digital transformation. Organizational values such as innovativeness, willingness to learn, tolerance of failure, risk affinity, trust, participation, cooperation, and communication outght to be emphasized [12]. One of our responders clearly said '*As a CEO, I always try to innovate, follow the current trends and future promising technologies'*.

Digital assets - Companies require digital assets, like the storage of data, information and communication infrastructure, and accompanying technologies to effectively compete in the digital era. Today's firms invest heavily in the development and acquisition of digital technologies (hardware and software) to allow for AI, Machine Learning, IoT, and Robotics. The endowments made in technologies and data provide the basic ingredients to leverage existing firm knowledge and other resources to create more value for customers [8]. Owning the right digital resource is essential for companies to successfully complete their digital transformation projects. The legacy systems slow down large organizations and create structural disadvantages is a well-known problem that remains a significant and costly challenge to progress [4].

3.5. Digital transformation barriers

The main barriers that organizations face when managing their DX transformation projects are presented on Table 1. Responders were asked to rate the barrier (weak, moderate or strong) that can affect their digital transformation success. From this research is clearly depicted that *resistance to change* is the number one concern of companies within DX. To overcome this barrier the first thing that should be done is recognize employees' fear of being replaced. When employees perceive that digital transformation could threaten their jobs, they may consciously or unconsciously resist the changes. In this case, digital transformation turns out to be ineffective. It is critical for leaders to recognize those fears and to emphasize that the digital transformation process is an opportunity for employees to upgrade their expertise to suit the marketplace of the future [7]. Participating in change processes can reduce employee resistance to the processes and in turn, enhance goal achievement and organizational commitment [12].

Table 1. Digital transformation barriers – results from the complex analysis

Barriers	Weak	Moderate	Strong
Resistance to change	0	10	12
Financial Resources	2	17	3
Existing IT Infrastructure	2	18	2
Talent Shortage	7	10	5
Risk Tolerance and Transformative Potential	6	12	4
Unknown Solutions	10	11	1
Safety Concerns	12	9	1

4. DISCUSSION

In order to overcome the main digital transformation barriers, the employees ought to be well informed about the benefits of digital industry transformation and gain the necessary skills to fully leverage the digital transformation technologies. Taking into account the results of this complex analysis and the urgency of this topic, within the Career Centre at the Faculty of Electrical Engineering and Information Technologies, we structured training course that will contribute into companies' preparation for digital industry transformation [3]. The duration of training course is 26 hours and total 4 instructors are engaged.

In the training course is given an overview of digital industry transformation. The participants will be introduced to the most commonly used technologies for digital transformation, their benefits and key usage scenarios within a digital transformation context. The design principles for Industry 4.0 scenarios (interoperability, information transparency (also virtualization or virtual entities), decentralization (also decentralized/autonomous, decisions or autonomy), real-time capability, technical assistance and service orientation (with Human-Machine Interaction) and modularity), as well as, horizontal and vertical integration in Industry 4.0 are included as course's topics. Moreover, the training course specially refers to the foreseen skills in digital project management and what means to be tech-savvy. The focus is given on data science skills, innovation, security and privacy knowledge, legal and regulatory compliance knowledge, ability to make data-driven decisions, and collaborative leadership skills. Also, the agile methodologies, agile terminology (product backlog, user story, sprint backlog, scrum, daily stand-up, sprint, the product owner, the scrum master, stakeholders, architecture owner, team members) and the agile mindset are highlighted. The recommended project team for large, medium and small companies is separately discussed. By using real examples can be practiced the necessary skills.

5. CONCLUSION

Embracing digital transformation is not straightforward. There is no 'one way fits for all'. It is a fact that every organization, every entreprise, every project is unique. The same apply for every organization's digital tranformation process. To improve the odds for success, is imperative to identify and understand the main success factors and barriers that can affect one's digital transformation. As a result of this, in many cases, the digital transformation may be successfully implemented. Defining a clear digital vision, establishing a risk-taking, innovative and proactive behaviour at all organizational level are one the main objectives that management should focus on. They ought to envision changing their business model and how their organizations can improve in the future and then organize and develop the technology that will enable that goal, rather than just finding techonology first and go back to reach business benefits.

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