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Impact of digital transformation on innovation performance: theories and practices with reference to the case of firms in the ICT sector in Saudi Arabia

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ABSTRACT

With the ongoing development of information technologies, the era of networks is gradually emerging and having a significant impact on all industries. This development compels businesses to adapt their business models to keep pace with innovation, enhance their competitive advantage, and promote healthy development. While existing research has primarily focused on the economic and environmental performance of digital transformation, few studies have directly explored the relationship between digital transformation and innovation.

From the perspective of innovation factors, our study investigated the relationship between digital transformation and innovation using data from companies in the Information and Communication Technology (ICT) sector between (2012-2023). The findings are as follows: firstly, the digital transformation of companies, measured through textual analysis methods, effectively promotes innovation. Secondly, knowledge flow, technical personnel, research and development investments, and innovation awareness play crucial mediating roles. Thirdly, digital transformation has a more substantial impact on the innovation of non-high-tech companies.

The results of this article alleviate concerns related to digital transformation, particularly in developing countries such as Saudi Arabia. They provide valuable insights and evidence to support the adoption of Industry 4.0 and foster sustainable innovation.

Keywords: Innovation performance, Digital transformation, ICT Sector, Saudi Arabia

1. Introduction

Saudi Arabia indicates a strong commitment to developing the ICT sector within the framework of Vision 2030. The transformation focuses on achieving sustainable development and diversifying the economy away from oil dependence; Key initiatives include stimulating entrepreneurship, developing technological infrastructure including 5G networks, and enhancing cybersecurity. The NEOM project also seeks to create an advanced economic zone focusing on technology and innovation. There is also a focus on enhancing education and training in technology. The Kingdom is also witnessing efforts to develop innovation and enhance foreign direct investment, which contributes to improving services and attracting job opportunities. As digital transformation continues and international cooperation is encouraged, the information and communications technology sector in the Kingdom is expected to witness further progress and development in the future.

The Saudi government has prioritized the digital transformation of various sectors, enhancing efficiency, and improving user experiences. Initiatives like NEOM, a groundbreaking economic project, showcase the Kingdom's ambition to establish an advanced technological hub. Additionally, efforts have been directed towards fostering an innovative environment, encouraging startups, and providing support for digital education and training.

Investments in digital infrastructure, including the rollout of 5G networks, contribute to establishing a robust foundation for the digital economy. The National Information Center project focuses on cybersecurity, ensuring a secure digital environment. The development of renewable energy technologies aligns with global trends toward sustainability and environmental consciousness.

The Saudi ICT sector reflects a continuous commitment to innovation and attracting foreign direct investment. The digital transformation, marked by advancements in areas like artificial intelligence and cloud computing, is evident in ongoing efforts to improve digital literacy and education. Collaboration with international partners is encouraged, fostering the exchange of expertise and joint research and development projects.

While specific recent studies are not mentioned, ongoing research likely explores the impact of these initiatives on the Kingdom's digital economy, job market, and overall technological landscape. To stay updated on the latest developments, it is advisable to explore academic institutions, research organizations, and international conferences focused on ICT and digital innovation. The global perspective involves studying the broader implications of Saudi Arabia's digital transformation within the context of worldwide technological advancements.

2. Literature Review

The emergence of digital transformation stems from the convergence between a company's personal computing environment and the profound impact of new information and communication technologies, such as mobile technology, data analytics, cloud computing, and the Internet of Things (Almaazmi, J. et al., 2020; Ardelin, L. 2020; Sebastian et al., 2017). Broadly speaking, it involves the integration of digital technologies and business processes into the digital economy (Diromualdo et al., 2018). Holistically, digital transformation encompasses the use of technology to fundamentally enhance business management, processes, and performance (Fedorova, A., Koropets, O., et Gatti, M. 2019).

However, digital transformation, also known as "digitization," remains a vague concept in current literature due to its complexity. A review of previous research allows us to consider digital transformation as a social phenomenon (Strohmeier, S. 2020) or a cultural evolution (Zaborovskaia, O., Nadezhina, O., et Avduevskaya,

E. 2020). For organizations, this complex phenomenon is built on the idea of designing new digitally integrated or digitized business models within their operational processes (Schwarzmüller, T. 2018) and (Lachmane K. et al., 2021). It represents a paradigm shift created by the digital generation, often referred to as "digitally native." In this context, businesses must adapt by modifying their business model or developing new ones.

With the advancement of digital technologies since the onset of the third industrial revolution in the 1970s, digital transformation programs worldwide have undergone several evolutionary stages. Initially, there was a transition to mechanized or electronic services with the early development of information and computer systems. This transition was followed by a shift to digital services, placing a greater emphasis on digitization over mechanization. With the rise of innovative technologies such as data science, artificial intelligence, cloud computing, the Internet of Things, cybersecurity technologies, among others, governments then moved to the stage of strategic planning for the transition to intelligent services.

This goes beyond merely providing electronic or automated government services. Instead, it encompasses the delivery of integrated intelligent government services based on technology. Furthermore, it involves the processing of vast amounts of data related to service users, with analysis and storage carried out using more available and secure systems. The goal is to enhance information and digital infrastructure, thereby strengthening a knowledge-based economy where knowledge has now become wealth in added value.

Despite the benefits of digital transformation in fostering the growth and expansion of institutions, administrative units, and businesses on a local, regional, and international scale through the use of various technological channels, several obstacles hinder this process within government institutions and businesses. Key challenges include the difficulty of prioritizing the implementation of digital transformation mechanisms, the lack of allocated budgets for these initiatives, concerns related to information security arising from the use of technologies, a shortage of qualified skills to lead these programs, as well as legal and political obstacles.

Various recent research studies have examined the role of digital transformation in developing human capital capabilities, improving the business environment, and attracting investments. For example, the OECD's 2022 study concluded that digital transformation promotes the development of human skills by providing continuous opportunities for learning and development. Meanwhile, McKinsey & Company's 2021 study highlighted its positive impact on business efficiency, innovation, and cost reduction. Additionally, PwC's 2020 study showed that digital transformation contributes to attracting investments by strengthening the competitiveness of businesses.

Previous research, such as Liang's in 2017 and John's in 2018, explored the implications of the digital economy and the digital divide in the Arab world. Liang emphasized the role of digital transformation in improving government services, expanding human knowledge, and driving economic development. On the other hand, John's study noted that, despite having indicators of digital consumption, Arab countries have not yet reached the stage of the digital economy.

Furthermore, Fernando's 2019 study examined how small entrepreneurs, despite limited capabilities, successfully underwent digital transformation by using third-party digital platforms. These comprehensive studies converge to highlight that digital transformation presents a significant opportunity for the development of human skills and the improvement of the business environment.

3. Digital transformation: a conceptual analysis

3.1. Multiple challenges

Any enterprise, despite its size and its field of activity, faces the challenge of digitization. This can be explained by two observations: (1) the nature of consumers who are connected and have expectations aligned with a mode based on the massive use of IT (mobiles, connected objects, ...); (2) the intensification of competition due to globalization and the digitalization of the economic territory. Digitization calls into question the management style, structure and culture of traditional enterprises. It exposes him to a multitude of issues that vary between organizational difficulties, the lack of digital skills, very small financial margins and the lack of support and involvement of leaders (McKinsey, 2014). For its part, Cigref (2015) revealed strategic and managerial challenges for a successful digital transformation that we summarize as follows:

Innovating Classic Business Models:

The advent of digital technology has challenged traditional approaches to developing and describing business models. The business climate is fluid, with a great risk of disappearance due to the rapid obsolescence of (IT) and the behavior of consumers favoring innovation. Consequently, cooperation and the pooling of efforts become essential and give rise to new forms of innovation adapted to this context of digital transformation: open innovation, hackathon, crowdsourcing.

Open Up And Multiply Partnerships:

Mobility and data deposits due to the massive use of information technologies and connected objects are forcing enterprises to revisit traditional modes of collaboration with all the players in their ecosystem : consumer partners, suppliers, and even competitors. Thus, these enterprises will be obliged to forge good relationships with these players in order to share opportunities and threats, to engage in the creation and sharing of value in a digital context.

Reorganize For Better Adaptation:

Any company wishing to appropriate digital uses will be required to rethink its organizational model. This requires overhauling its processes and redefining its cultural features. Digitization favors a matrix and transversal structuring, and encourages the multidisciplinarity and the multiculturality of the actors.

Secure And Control Digital Risks:

Of course, the dematerialization and automation of business operational processes have obviously reduced certain risks related to traceability and transparency. However, they create others that are digital and concern: bugs, hacking, espionage, etc. Therefore, it will be essential for these enterprises to take into account the risks of the infrastructure and the security of their information systems (cybersecurity, cyberattack) when developing their overall strategy.

Promoting An Adapted Legal Framework:

The digital transformation raises legal and regulatory questions related to intellectual property rights, security, data protection and compliance. The advents of each IT calls for an adapted regulatory

and normative framework which must take into account the contours and risks of the practices of this technology.

Anticipate Skills Needs:

The digital transformation raises the need for professions in close relationship with information systems, which professions integrate skills in modeling, business intelligence, architecture, etc. In addition, this transformation will promote the development of a generational mix of actors due to the diversity of enterprises, their cultures and their practices.

Supporting And Reinforcing Digitalization:

The digital transformation imposes new styles of leadership which clash with the old ones. These styles encourage risk taking and synchronize the action and reaction of leaders. In addition, these leaders must have leadership that allows them to align the management skills of the enterprise with its digital vision. They must know how to adapt their style to the new management rules induced by digital transformation.

3.2. Corporate Culture

The success of digital transformation is not just about technology. It supposes an organizational and cultural evolution. It involves the establishment of a transversal mindset affecting the various facets of the enterprise and its stakeholders. In other words, it is necessary to develop a corporate culture that highlights the features of the national culture and the evolution of its information systems (Oumlil, 2016). The lack of a digital culture can be seen as the main obstacle to this transformation.

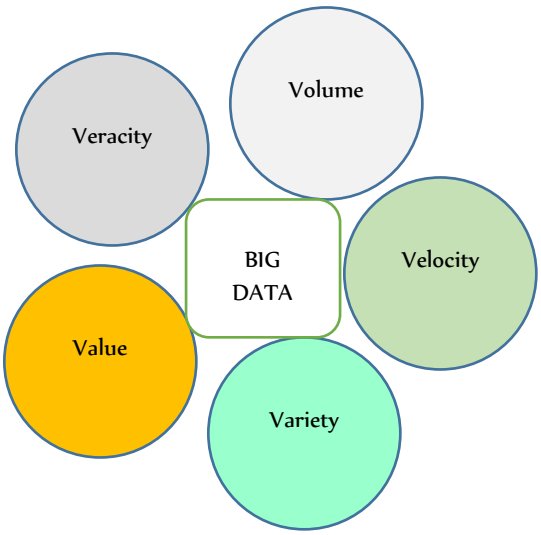
All enterprise stakeholders, employees, managers or middle management are concerned by digital transformation, and are called upon to facilitate the emergence of a multidisciplinary and transversal organization. This facilitation starts with accepting this transition. Acceptance is not limited to a simple awareness of actors on new tools or new ways of working, but must also integrate psychological, organizational and cultural aspects (Oumlil, 2016).

3.3. A Pillar of Digital Transformation

The arrival of connected and intelligent objects, the massive use of the Internet and the proliferation of smartphones and mobile applications have given birth to one of the pillars of the digital transformation(Shorooq.F et al. 2019). This pillar is behind an avalanche of often unstructured data to extract a considerable mass of strategic information for enterprises. It's the neologism: Big Data

Big Data is seen as an evolution of business intelligence (BI). The latter was limited to structured data based on Data warehouses. Whereas Big Data refers to a gigantic mass of data in the business ecosystem. This data, structured and unstructured, relates to consumer opinions on social networks, data retrieved from online services, internal enterprise data, and even personal customer data (Silva, E. et al. 2018).

In addition, understanding Big Data requires knowledge of its dimensions. Rampini. A, (2024) identified five main dimensions (Figure 1): (1) Volume, which concerns the mass of data produced by devices connected to fixed and mobile computer networks (smartphones, tablets, computers and smart objects); (2) Velocity, which refers to the speed of data generation and processing by mobilizing powerful and tailor-made calculation and analysis tools; (3) Variety, which shows that data can take various forms that vary between text, voice, log files, geolocation data, images, web analytics...; (4) Value, which is the contributions and benefits of using Big Data to the business; and finally (5) Veracity, which concerns the reliability and credibility of data. It alludes to the quality of this data necessary for an authentic functioning of Big Data.



Source: Rampini, A. (2024)

Figure 1: Dimensions of big data

Big Data constitutes a new technological paradigm which offers a recent dimension to the leaders in the management of their companies in real time. It is also a lever for growth and value creation that is firmly established in the business landscape of tomorrow. It carries with it the seeds of a digital transformation affecting all players in the value chain. In addition, it offers an innovative approach to the collection, storage and processing of all kinds of data.

4. The development of the information technology sector in Saudi Arabia

Saudi Arabia is paying great attention to developing the ICT sector as part of Vision 2030. The goal of this vision is to transform and diversify the national economy away from its main dependence on oil. Some of the efforts and initiatives taken by the Kingdom to promote the development of the ICT sector include:

- Vision 2030: Vision 2030 is the Kingdom's strategic plan to achieve economic diversification and promote innovation and technology.
- NEOM Project: It is a giant project that aims to create a special economic zone focusing on technology, innovation and sustainability.
- Stimulating entrepreneurship and innovation: Entrepreneurship was encouraged and support was provided to technology start-ups.
- Infrastructure development: Significant investment has been made in developing technological infrastructure, such as 5G networks and providing fast internet services.
- Education and Training: Education curricula have been updated to include ICT topics, and training in this field has been enhanced.
- National Information Center: The project to establish the National Information Center was launched to enhance cybersecurity and develop cloud computing capabilities.

These efforts reflect the Kingdom's commitment to promoting innovation and developing the digital economy. It is important to follow developments to obtain the latest information about the development of the ICT sector in Saudi Arabia.

Through the continued implementation of Vision 2030 and the Kingdom's commitment to achieving sustainable development in the field of technology and innovation, further developments could include:

- Digital transformation projects: The Kingdom is witnessing the continuation of digital transformation projects in the government and private sectors, which enhances the effectiveness of services and contributes to improving the user experience.
- Promoting foreign investment: Continuous efforts to attract foreign direct investment in the technology sector, which contributes to technology transfer and job opportunities.
- Developing the innovation industry: Fostering the innovative environment by providing more spaces for work and interaction between companies and pioneers in the field of technology.
- Enhancing cybersecurity: Great attention is paid to combating cyberthreats and enhancing cybersecurity for individuals and institutions.
- Renewable Energy Development: Investment in renewable energy technology and artificial intelligence to improve the sustainability of digital infrastructure.
- Promoting digital education: developing digital education programs and using technology to enhance the quality of education and develop digital skills.
- Encouraging international cooperation: Cooperating with international partners in the field of technology to exchange experiences and cooperate in research and development projects.

It is worth noting that digital transformation is an ongoing process, and therefore more initiatives and developments can be expected in this sector in the future.

5. Methodology

5.1. Study sample

Our study sample is made up of a panel of 19 economic activities in the ICT sector covering 1350 companies, over a period of 11 years (2012-2023). The final sample covers 1350 companies, which corresponds to 14850 observations. In our empirical analysis, we use the Data stream database to calculate financial information in addition to the information available on company websites. Data on company monitoring performance comes from General Authority of Statistics.

5.2. Description and measurement of study variables

The study variables include seven variables: 2 dependent variables (dt. innovation, dt.ap), 5 dependent variables (GII, GDP, Productivity, GNI, Innovation Performance), in addition to 2 control variables (company size (CSize) and liquidity ratio (Liqu)).

Our starting point in the multivariate analysis was the following equation model for the estimation of Quality Innovation and Innovation performance:

Model(1):

$$Y_{i,t} = \beta_0 + \beta_1 Y_{i,t} + \beta_2 Innovation_{i,t} + \beta_3 GDP_{i,t} + \beta_4 GII_{i,t} + \beta_5 Ln(Productivity)_{i,t} + year\ fixed\ effect_{i,t} + firm\ fixed\ effect_{i,t} + \epsilon_{i,t}$$

Where $Y_{i,t}$ a dependent variable including Innovation quality and Innovation performance.

To examine the impact of Transformation digital on the relationship between innovation quality and Innovation performance relationship, we extend the previous analysis and include an interaction effect between (innovation quality)*(Innovation performance). Specifically, our main regression was as follows:

Model(2):

$$Y_{i,t} = \beta_0 + \beta_1 Y_{i,t} + \beta_2 CSize_{i,t} + \beta_3 (innovation\ quality) * (Innovation\ performance)_{i,t} + \beta_4 GII_{i,t} + \beta_5 Ln(Productivity)_{i,t} + year\ fixed\ effect_{i,t} + firm\ fixed\ effect_{i,t} + \epsilon_{i,t}$$

6. Results and Discussion

Descriptive statistics and correlation matrix

Table 2 show that the mean, maximum, and minimum values for the first proxy of innovation performance (dtap) are: [46.53, 69.33, 0], and 445 respectively. This means that most Saudi firms are in a low-quality innovation stage and prefer the quantitative level of innovation. Similarly, the mean (36.33), the minimum (0) and the maximum (350) value of innovation performance (dtinv) confirm that Saudi companies are in a low quality of innovation.

Table 3 reports the results of the correlation matrix of the quantity of innovation and the quality of innovation. As we can see, the correlation coefficients are both less than 0.7, which indicates that there is no multicollinearity in our model.

Table 4 presents the results of the impact of digital transformation on innovation performance in Saudi Arabian companies over the period 2012-2023.

Table 1: shows the number and percentage of the study sample distributed according to the different activities to which it belongs.

Economic Activity	No. of establishments
Manufacture of electronic components and boards	20
Manufacture of computers and peripheral equipment	9
Manufacture of communication equipment	29
Manufacture of consumer electronics	11
Manufacture of magnetic and optical media	8
Wholesale of computers, computer peripheral equipment and software	35
Wholesale of electronic and telecommunications equipment and parts	36
Software publishing	253
Wired telecommunications activities	170
Wireless telecommunications activities	35
Satellite telecommunications activities	13
Other telecommunications activities	279
Computer programming activities	35
Computer consultancy and computer facilities management activities	23
Other information technology and computer service activities	153
Data processing, hosting and related activities	115
Web portals	131
Repair of computers and peripheral equipment	41
Repair of communication equipment	29
Total	1350

Source: General Authority for Statistics

The results show that the coefficient of lagged of innovation quantity (dtap) is significantly positive. Taking models (1) and (2), the impact of lag one of innovation quantity is 1.12 at the 1% significant level and the impact on lag one of the innovation quality is 1.08 at the 1% significant level. Besides, the impact of digital transformation on innovation performance is positive and significant at 1% level. A rise in digital transformation by 1% is seen to increase innovation quantity by 3.18% and innovation quality by 3.48%.

The impact of productivity on innovation performance is negative and significant at 1% level. This results indicates that a 1% increase in worker productivity reduce innovation quantity and quality by 4.31% and 7.38% respectively.

Concerning the control variables, the results show that economic growth impact positively the innovation quality but reduce innovation quality. However, the variable GII affect negatively and significant at 5% the innovation quantities. This means that an increase in GII reduce the innovation quantities.

The anticipated impact of digital transformation on the Information and Communication Technology (ICT) sector in Saudi Arabia is poised to be transformative, aligning with the nation's Vision 2030 initiative. This ambitious plan seeks to diversify the economy, reduce dependence on oil, and position Saudi Arabia as a global technology and innovation hub.

As the digital transformation unfolds, several key predictions emerge regarding its effects on the Saudi ICT sector. Firstly, there is a strong expectation of heightened efficiency across various industries. The integration of advanced technologies, such as artificial intelligence, machine learning, and data analytics, is anticipated to streamline processes, enhance productivity, and optimize resource allocation.

Table 2. Descriptive statistics

variable	Mean	Std. dev.	Min	Max
dtap	46.53	69.33	0	445
dtinv	36.88	56.77	0	350
innovation	11.76	2.11	7.43	18.36
Ln(produ)	5.74	0.73	4.44	7.17
GDP	3.93	3.88	-4.34	10.99
GII	25.60	6.84	12.4	33.4

Source: Author

Table 3. Correlation matrix

	dtap	dtinv	innovation	Ln(produ)	GDP	GII
dtap	1					
dtinv	0.98	1				
innovation	0.60	0.59	1			
Ln(produ)	0.05	0.03	0.38	1		
GDP	-0.16	-0.17	-0.08	-0.07	1	
GII	0.42	0.41	0.16	0.11	-0.58	1

Source: Author

Table 4. Results of estimation: GMM system

	Model 1	Model 2
	Coefficient (p-value)	Coefficient (p-value)
$dtap_{t-1}$	1.12*** (0.000)	-
$Dtinv_{t-1}$	-	1.08*** (0.000)
$innovation$	3.18*** (0.000)	3.48*** (0.000)
$Ln(produ)$	-4.31*** (0.000)	-7.48*** (0.000)
GDP	0.14*** (0.000)	-0.56*** (0.000)
GII	-0.08*** (0.000)	0.01 (0.33)
Cst	-6.25** (0.011)	7.83*** (0.009)
AR(1)	0.029	0.046
AR(2)	0.225	0.883
Sargan	14.90	18.76
Prob > chi2	0.82	0.60

Source: Author

The proliferation of digital technologies is likely to spur innovation and entrepreneurship. With a focus on fostering an environment conducive to startups and technological advancements, Saudi Arabia aims to nurture a culture of creativity and ingenuity within the ICT sector. This, in turn, is predicted to attract local and international talent, fostering a vibrant ecosystem of digital innovation.

The implementation of 5G networks stands out as a significant catalyst for change. The widespread deployment of 5G is expected to revolutionize communication, providing ultra-fast and reliable connectivity. This will pave the way for the Internet of Things (IoT), smart cities, and a range of applications that demand high-speed, low-latency connections, further propelling the ICT sector forward.

Cybersecurity is a paramount concern in the digital age, and Saudi Arabia is anticipated to prioritize robust measures to safeguard its digital infrastructure. As the ICT sector becomes increasingly interconnected, efforts to enhance cybersecurity are predicted to be integral to sustaining growth and ensuring the secure operation of digital services.

Furthermore, digital transformation is likely to redefine the skills required in the job market. An emphasis on digital literacy and specialized technical skills will be essential to navigate the evolving landscape of the ICT sector. Educational initiatives and training programs are expected to play a crucial role in preparing the workforce for the demands of a digitally-driven economy.

In conclusion, the anticipated effects of digital transformation on the ICT sector in Saudi Arabia encompass enhanced efficiency, increased innovation, advanced connectivity through 5G, reinforced cybersecurity measures, and a shift in workforce skills. As these

predictions materialize, Saudi Arabia is poised to emerge as a dynamic player in the global digital landscape, contributing significantly to the evolution of the ICT sector on both regional and international scales.

7. Conclusion and Recommendations

Digital transformation has had a significant impact on the innovation performance of companies in the information and communications technology (ICT) sector in Saudi Arabia. This major development has affected various aspects, positively influencing the way these companies operate and innovate.

Firstly, the transition to digital processes has improved the operational efficiency of companies in the ICT sector in SA. Automation of tasks, use of emerging technologies such as artificial intelligence and the Internet of Things have helped streamline operations, thereby reducing production times and associated costs.

In addition, digital transformation has fostered a culture of innovation within these companies. The availability of real-time data, the ease of collaboration through digital platforms, and the ability to quickly analyze information have enabled research and development teams to respond more quickly to market trends and changing customer needs.

Companies in the ICT sector in KSA have also benefited from digital transformation by strengthening their capacity to create innovative products and services. Emerging technologies have opened up new opportunities, enabling businesses to design solutions that are smarter, more agile and better suited to local and global market needs.

However, it is important to note that digital transformation has also presented challenges, such as the need to train staff on new technologies, ensure data security and quickly adapt to changes in the digital landscape. Nonetheless, overall, the impact of digital transformation on the innovation performance of ICT sector companies in KSA is positive, positioning them favorably to respond to changing market demands and remain globally competitive.

As digital transformation accelerates globally, ICT innovation capabilities are attracting attention as the core of business competitiveness. However, ICT technologies evolve more quickly than other technologies, and it is difficult to predict their performance due to the great uncertainty in the characteristics of innovation.

With the continuous development of information technology, the network era is gradually coming and has a great impact on all industries, forcing the business model of enterprises to keep pace with innovation, so as to improve the competitive advantage of enterprises, and promote the healthy development of enterprises.

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