The Role of Cost Stickiness on the Relationship Between Digital Transformation and Operational Performance in Egyptian Manufacturing Firms

Nancy Mohamed Mahmoud Ahmed
Associate Professor- Accounting Department- Faculty of Commerce- Cairo University
Nancy_m_mahmoud@foc.cu.edu.eg

Abstract

Purpose: This study examines the effects of digital transformation on cost stickiness and organizations' operational performance measured by workforce productivity, asset efficiency, and working capital efficiency. The moderating impact of cost stickiness on the relationship between digital transformation and operational performance is then investigated.

Method: The secondary data used in this empirical study was gathered from the financial statements of a sizable sample of Egyptian manufacturing companies listed on the Egyptian Stock Exchange during the period between 2018 and 2022. Multivariate regression analysis is employed to assess the research models.

Findings: The findings reveal that the influence of digital transformation on cost stickiness is insignificant. Digital transformation significantly and positively affects operational performance regarding workforce productivity, and physical assets efficiency. In addition, no moderating impact of cost stickiness on the relationship between digital transformation and operational performance is found.

Originality: This study uses empirical research to examine the operational consequences of digital transformation, which will assist in expanding digital transformation applications in Egyptian manufacturing companies.

Keywords: Digital Transformation (DT), Cost Stickiness (CS), Operational Performance (OP), Manufacturing Companies, Egypt.

JEL Classification: O33, D24, L25

1. Introduction:

In recent decades, firms have been under pressure to change to meet intensive global competition and customers' demands due to the new digital technologies. Social media, mobile technology, cloud computing, big data analytics, artificial intelligence, and blockchain are among the technologies that have been rapidly gaining ground. Therefore, firms frequently engage in "digital transformation (DT)". These new technologies change the way businesses operate and generate value (Kutzner et al., 2018 and Jardak and Hamad, 2022), leading to a significant impact on innovation (Wen et al., 2022), and corporate performance (Chouaibi et al., 2022). As a result, developed nations have developed re-manufacturing strategies to increase their global manufacturing competitiveness through adopting digital technologies. However, digitalization has resulted in a radical transformation in the manufacturing sector's technological era. Because applying digital technologies to production processes is complex, it not only creates opportunities for businesses but also challenges (Wen et al., 2022).

DT skills drive companies' sustained growth. As the value chain is restructured, an increasing number of businesses are starting to employ digital technology to achieve production and developmental benefits, and build sustainable DT capabilities (Yu et al., 2022). Therefore, it is crucial to understand how to set up an action mechanism for a sustainable competitive advantage to be able to create a DT efficiently and effectively.

Jianrong, et al. (2017) stated that product development, manufacturing efficiency, and customer service may all be improved due to the deep integration of digitalization and industrialization that altered traditional production and operations management techniques. However, due to the companies' existing manufacturing practices, finding and executing a digital business model may lead companies to face difficulties and constraints. Companies must deal with these difficulties by compromising between traditional and digital business practices, by starting with minor changes before progressively converting their conventional manufacturing procedures to digital ones (Zhou et al., 2018).

Therefore, the term "Digital transformation" describes the process through which a business connects different stakeholders—such as technology providers, supply chains, service providers, and customers—to achieve a digital manufacturing process with a short cycle and multi-function operations.

With the continuous support of Egyptian government policies, the digital economy has expanded to play a major role in the exceptional development of Egypt's economy. As the microstructure of the macro-economy, companies are essential to the expansion and transformation of the macro-digital economy. The DT is progressively being reflected in modifications to particular production behaviors. DT is a methodical procedure that makes use of complex digital technology to boost the efficacy of data flow, optimize resource allocation, and ultimately raise corporate competitiveness (Peng and Tao, 2022).

Egypt's real economy is mostly composed of the manufacturing sector. For many years, Egypt has encouraged industrial businesses to go digital (Kamel, 2021b). DT could help manufacturing enterprises improve the efficiency of their manufacturing processes and successfully respond to market-diversified demand (Rayna and Striukova, 2016). Despite these benefits, many companies may be reluctant to quickly implement DT, due to their fear of earnings decline (Haddud et al., 2017). In addition, DT requires investments in manpower, material, and financial resources (Kamble et al., 2018). Hajli et al. (2015) found that only a small number of businesses may benefit from the economic advantages brought by DT, but they did not identify which businesses can gain from it. Therefore, the key to this process is effective cost management.

Firms' cost management behaviors can be accurately described by cost stickiness (CS), which measures the economic effects driven by managers' intentional adjustments of resource input in business activities. CS is defined as “the change rate of the cost being more significant when the business volume increases than when the business volume decreases” (Anderson et al., 2003). Wu et al. (2020) argued that the integration of traditional production methods with the Internet would help in managing costs effectively and allocate resources efficiently. Accordingly, organizations’ cost management practices would necessarily reflect DT behaviors to some extent. Therefore, this paper is concerned with studying the relationship between DT, CS, and OP. In other words, this study is trying to answer the question “Can DT reduce CS and aid Egyptian manufacturing companies in improving their OP?".

To answer this question, this study creates a framework to investigate the effect of DT on CS and OP, in addition to the moderating role of CS in the association between DT and OP. To ascertain whether the DT of manufacturing organizations may enhance their OP, this study provides insight into Egyptian manufacturing enterprises. Therefore, the main objective of this study is to encourage more Egyptian manufacturing companies to speed up their DT progress and support the high-quality development of Egypt's economy by demonstrating to them how DT can greatly improve their performance.

This paper contributes to the literature in the following: First, to the best of the researcher's knowledge, this study is the first study that examines the relationship between CS and DT in Egypt, adding to the body of knowledge in this area. Second, this study uses empirical research to examine the operational consequences of DT, which will assist in expanding DT applications in Egyptian manufacturing companies. Third, from a methodology standpoint, this study offers a reference for narrowing the current methodological gap. Most earlier studies focused on the interview or survey approach (Wu et al., 2020; Zhu and Luo, 2023), however, this study uses the text analysis method to assess a firm's DT processes and its effects on various OP aspects. The objectivity and applicability of this study can be somewhat improved using the newly developed text analysis technique, which is based on reliable published annual reports. Finally, this study investigates how CS could moderate the relationship between DT and OP.

The structure of this paper is as follows: In the next section, section 2, the study's literature review and development of research hypotheses are presented. The research methodology is presented in section 3. The findings of the data analysis and discussion of the results are covered in section 4. Section 5 summarizes the study’s conclusions, recommendations, and suggestions for future research.

2. Literature Review and Hypotheses Development:

2.1 Digital Transformation Status in Egypt:

Manufacturing companies in Egypt are increasingly embracing DT. Many firms are realizing the advantages of implementing digital technology to increase their competitiveness, production, and efficiency. DT is a key element in enhancing organizations' effectiveness. Therefore, the Egyptian Ministry of Communication and Information Technology (MCIT) is working to speed up Egypt's DT to establish a powerful digital economy and accomplish a digital society. This could be achieved through the capabilities of Information and Communication Technology (ICT) to provide social justice, freedom, and prosperity for everyone (Elgohary, 2022). The digital economy is regarded as one of the fundamental components of the global economy, and Egypt Vision 2030 targets DT as a strategic objective to fulfill development goals and strengthen Egypt's presence in that economy (Metawa, 2022).

Kamel (2021a) stated that Egypt's Vision 2030 is divided into three main aspects: first, the economic aspect focuses on the inclusive of development, transparency, and maximization of government effectiveness. Second, the social aspect concentrates on areas of human resources investments, such as continuous social justice, health, culture, and learning. Third, the environmental aspect concentrates on environmental and urban development. The ICT sector is a crucial component of Egypt's Vision 2030 and is closely related to the three aspects in such a way that it significantly helps in achieving the desired results.

Consequently, Egypt's DT initiative emphasizes establishing smart cities and communities, investing in human resources, fostering a business-friendly environment, and promoting digital entrepreneurship to promote advanced technology (Elgohary, 2022). In addition, Egypt has made significant investments in creating its national infostructure and infrastructure to adequately implement ICT for the economy's development and expansion, as well as to improve the Egyptian economy, both globally and regionally (Kamel, 2021a).

The economy and the private sector must build the infostructure and infrastructure required to support DT. The continuous enhancement of the infostructure and infrastructure is critical to managing the digital platform expansion, which has been shown since March 2020 (Kamel (2021b). According to the International Telecommunication Union (2018), digital infrastructure is: " at the center of the ecosystem of the digital economy, including the digital elements of competitiveness, factors of production and industries, production processes, the connectivity of digital services, and the proliferation of more digitalized households".

Additionally, digital technologies have a significant impact on the Egyptian industrial sector by transforming and enhancing business processes. The implementation of appropriate DT enables manufacturing companies to improve their overall performance and increase their competitiveness by generating new business models, digital services, products, and solutions; generating additional revenue; and completing real-time quality control. Additionally, the availability of technical systems and data helps manufacturing firms better understand their production distribution, clients, consumption, and solutions, as well as their target markets and customers (Elgohary, 2022).

One of the main forces behind the DT of Egyptian manufacturing companies is the government's efforts to automate the manufacturing sector and improve its economic contribution to the nation. The "Egypt Vision 2030" plan, which seeks to convert Egypt into a knowledge-based economy, is only one of the efforts the government has made to expand the use of digital technology in manufacturing. Furthermore, the Egyptian Ministry of Trade and Industry began the industrial sector's digitalization process five years ago. To promote DT in manufacturing companies, the Industrial Modernization Centre (IMC) has introduced the "Digital Transformation and Technology Support Program Action Plan 2019-2020". Furthermore, the Engineering Export Council of Egypt (EEC) implements the "Egypt Exports through Product Innovation (EEPI)" initiative, which has been funded by the European Union (Kamel, 2021b).

Manufacturing companies in Egypt have gained from DT in several ways, including higher operational effectiveness, better product quality, and competitiveness. For example, some businesses have implemented predictive maintenance programs to identify and prevent manufacturing problems before they affect production or cause downtime seed. Others have implemented automation techniques, helping them reduce labor costs and increase productivity and efficiency.

However, Elgohari (2022) concluded that despite all the Egyptian efforts conducted in the DT area, Egypt is still in its early stages and has low ICT investments. This could be justified due to data privacy and security problems, lack of digital skills among the workforce, and inadequate infrastructure, in addition to the internet speed and use rate, which are still lower than the global rate.

Overall, Egypt has made a real effort to encourage DT in recent years to build a digital economy and make the country a regional center for innovation and technology. Therefore, industrial companies must progressively invest in DT to remain competitive in the international market. These firms may enhance their operations, maximize productivity, and provide better customer services by implementing digital technology. However, many industrial firms continue to employ traditional equipment and production techniques that are not digitally optimized. This may restrict their ability to compete globally and gain from the advantages of industry. It would need focused regulations and incentives, as well as initiatives to encourage a digitalization culture and offer training and assistance for employees, to persuade these businesses to use digital technology.

2.2 Digital Transformation and Cost Stickiness

Conventional cost behavior analysis showed that the variable cost will vary proportionally with the change in the level of output of the company`. In the discipline of corporate cost management, Noreen and Soderstrom (1997) discussed that the amount of increase in costs when a company’s output level increases is higher than the amount of decrease when the output level declines. "Cost Stickiness" is the term used by Anderson et al. (2003) to describe this phenomenon. Three factors were outlined by Banker and Byzalov (2014) as the reasons for CS: adjustment costs, optimistic management expectations, and agency problems.

Adjustment costs refer to the costs incurred by firms to make adjustments to their operations as a result of changes in output or demand. These costs increase with the increase in the firms’ operations, however, companies may find it difficult or expensive to lower these costs in case of decreasing firms' activities, causing CS. One of the factors that may cause adjustment costs is DT. Although DT might have many advantages, it may lead to an increase in firms' costs. Companies may need to develop new IT infrastructure, acquire personnel with specific expertise, or re-train current personnel to utilize advanced software. To utilize the new technology, businesses may also need to alter their organizational structures and business processes. For many businesses, especially smaller ones or those with fewer resources, these adjustment costs could be a substantial obstacle to DT. However, Chen and Xu (2023) revealed that DT helps to lower adjustment costs, which prevents CS. This could be achieved when companies focus more on resource "use" rather than resources "ownership". In addition, DT can enhance management's willingness to minimize unused capacity, which lowers adjustment costs. Reducing adjustment costs leads to lowering firm CS.

Optimistic management expectations refer to the tendency of managers to be excessively hopeful about potential future sales, which leads them to postpone cost-reduction actions in the hopes that sales would increase, therefore, CS would emerge (Banker et al., 2011). Optimistic management expectations can also have an impact on DT. Managers may spend more resources on new technology and procedures without fully taking into account the related costs and consequences because they have excessively high expectations about the advantages of DT. Managers may think that using the new technology would result in considerable cost savings and revenue growth without taking into account the costs needed to do so. CS may emerge in companies that are not willing to reduce their investments in DT, even if it becomes obvious that the anticipated advantages cannot occur. This may result in a scenario where costs continue to rise despite declining revenues. On the other hand, Chen (2022) found that when digitalization accelerates, management could obtain market information more quickly, analyze it with the aid of prediction models and analysis tools, predict future sales and demand accurately in light of the market information, consequently make accurate decisions regarding the investment, disposal, and retention of enterprise resources, which undoubtedly lowers the management's optimistic expectations.

From the agency problem standpoint, top management would act in their self-interest when altering resource investments, deviating from the best way to allocate resources. According to the agency problem analysis framework, management tends to over-invest in resources when a company's output volume grows and refuses to do so when business volume declines, which leads to CS (Chen et al., 2012). Agency costs might arise when managers execute DT projects that are not in line with the companies' long-term objectives. Even if these projects may not improve firms' sustainable long-term benefits, managers may be motivated to undertake DT initiatives to build their reputation or generate short-term rewards. This may lead to CS since businesses may continue to spend more on DT projects even if the results are less than anticipated or the projects are more costly than they are worth. This may result in a scenario where costs continue to rise despite flat or declining revenues. However, Chen (2023) claimed that DT helps reduce agency costs by improving information disclosure quality and transmission efficacy and supporting the creation of a corporate governance framework based on data mining, analysis, and application. Therefore, management would base cost-control and investment decisions on quantitative data analysis instead of subjective opinions to eliminate discretion and resolve the principal-agent issue.

Based on the above discussion, two points of view were presented. The first viewpoint suggests that DT may introduce additional causes of CS. Firms may need to invest in new skills and competencies to fully achieve the advantages of DT, as the costs of deploying and maintaining new technology might be significant, hence, increasing CS. The other viewpoint argued that DT could have the potential to minimize CS by enabling firms to be more flexible and responsive to changes in demand. Firms may instantly adjust their computer capabilities up or down in response to changes in demand by implementing cloud computing, which eliminates the need for physical infrastructure and related expenditures. Therefore, the following hypothesis is developed:

H_1: Digital transformation significantly reduces cost stickiness in Egyptian manufacturing companies.

2.3 Digital Transformation and Operational Performance

Companies invest in digitalization to gain a competitive advantage and accomplish superior results by transforming to the new competitive dynamics driven mostly by new technology. Since improving organizational performance is the primary objective of all firms, studies related to performance improvement have emerged as a key problem in management research. Tseng and Lee (2014) agreed that performance is the assessment of an organization's operations based on past performance or the potential for future growth. OP is one of several factors that could be used to evaluate the success of DT. DT in the manufacturing process enables firms to increase operational and managerial effectiveness (Zhang et al., 2023). Manufacturing companies need to be highly flexible in their operations as they utilize a variety of production techniques to create a wide range of products. Frey and Osborne (2017) found that Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and Manufacturing Execution Systems (MES) are examples of digital technologies that manufacturing companies implementing DT could use to increase the effectiveness of resource information integration. These digital techniques improve production processes through the use of data logic, speeding the process from production to data processing to management to management feedback to production (Nambisan et al., 2017). When these data are used rapidly and effectively, the result could be an optimized, automated production process, with reduced labor, information, and time-related costs.

In addition, DT helps companies to better serve their customers by increasing the sales channels for current products and improving customer relationship management, which would lead to reduced operational costs and increased sales rates (Frey and Osborne, 2017). Shao and Lin (2002) proved that DT improves manufacturing process technical efficiency, which in turn enhances productivity and results in improvements in OP. In the same context, Osei-Bryson and Ko (2004) empirically demonstrated that investing in a DT process would lower the companies' production costs, which would enhance their OP. Furthermore, DT helps enterprises enhance their OP by developing new goods or services, enhancing their quality, and lowering costs and the market risks associated with product or service innovations (Yu et al., 2022).

Moreover, Tian et al., (2023) used a fixed-effect model with a large sample of Chinese manufacturing enterprises from 2016 to 2020 to show that DT strategies have significant and advantageous effects on all three dimensions of firms' operational efficiency, workforce productivity, physical asset efficiency, and working capital efficiency. However, Tian et al. (2023) revealed that companies should be aware that the benefits of digitalization will almost certainly exceed the initial costs. However, they may meet several challenges, including high costs, difficult operational structure adjustments, and a lack of skilled digital workers during their transformation initiatives. In this situation, companies can quickly enable their successful integration into production and operations by implementing some transferable and imitable digital approaches or practices.

Based on the above theoretical considerations and the results of the previous empirical studies, the following hypothesis and sub-hypotheses are developed:

H_2: Digital transformation significantly improves the operational performance of Egyptian manufacturing companies.

H_{2a}: Digital transformation significantly improves the workforce productivity of Egyptian manufacturing companies.

H_{2b}: Digital transformation significantly improves the physical assets efficiency of Egyptian manufacturing companies.

H_{2c}: Digital transformation significantly improves the working capital efficiency of Egyptian manufacturing companies.

2.4 Digital Transformation, Cost Stickiness, and Operational Performance

When activity levels fluctuate, costs may tend to be more resistant to variation, a phenomenon known as CS. This situation may have a significant impact on the association between DT and OP. However, to the best of the researcher's knowledge, no study has explored how CS could moderate the relationship between DT and OP. The effects of DT on activity levels, such as increases in productivity or alterations in consumer behavior, might have an impact on costs. However, sticky costs cannot change as promptly as activity levels change, which could have an impact on OP.

When a firm invests in digital technologies to enhance productivity, but its costs are sticky, it cannot notice the OP improvements that were anticipated. Likewise, if a firm faces a decrease in demand in response to changes in client behavior, and its costs are sticky, its profitability may drop significantly. Therefore, CS could moderate the association between DT and OP by determining how changes in activity levels are converted into changes in costs, and eventually into OP. Manufacturing companies may be ready to maximize the potential benefits of DT and enhance their OP if they are aware of CS and take action to eliminate it. Based on the above discussion, the following hypothesis and sub-hypotheses are developed:

H_3: Cost stickiness moderates the relationship between digital transformation and the operational performance of Egyptian manufacturing companies.

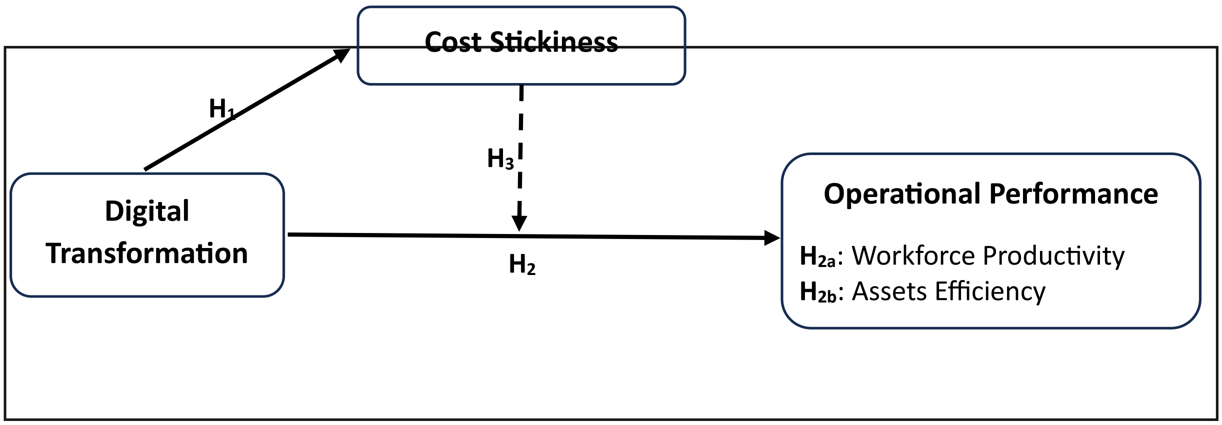
H_{3a}: Cost stickiness moderates the relationship between digital transformation and workforce productivity of Egyptian manufacturing companies.

H_{3b}: Cost stickiness moderates the relationship between digital transformation and physical assets efficiency of Egyptian manufacturing companies.

H_{3c}: Cost stickiness moderates the relationship between digital transformation and the working capital efficiency of Egyptian manufacturing companies.

2.5 Research Framework

The framework shown in Figure 1 is a practice-based framework created from businesses' DT literature, and it covers a range of actions that may have an impact on a business's operational performance. To further demonstrate the potential influencing process, the moderating effect of CS is studied. A visual illustration of the theoretical framework applied in this study is shown in Figure1. The framework's logic reflects the hypotheses developed in the previous section.



3. Research Methodology

3.1 Data Collection and Sample Size

The study sample comprised manufacturing companies that were listed on the Egyptian stock exchange from 2018 to 2022. This period is selected as before 2018, Egyptian companies hardly ever employed digital technologies. However, despite the fast advancement of digital technologies, such as cloud computing, the deep and direct integration of digital and traditional economies started to happen around 2018 when the Ministry of Communications and Information Technology (MCIT) created the country's 2030 ICT strategy “Digital Egypt” in 2017 (Kamel, 2021b).

Additionally, particular data from the year 2017 are used as CS was measured using the logarithm of costs in year t divided by costs in year t-1. The study's sample did not include the following firms: (1) Information technology and communication firms; (2) Firms whose primary activity is software development; (3) Financial sector companies; and (4) Companies with missing variables data. Finally, 338 sample observations and 59 sample firms were gathered. The published annual financial reports obtained from The Egyptian Company for Information Dissemination (EGID), Mubasher, and the listed companies’ websites are the main sources of data related to DT, CS, and OP.

3.2 Variables Measurements

The independent variable, digital transformation *(DT)*, is quantified using a proxy measure developed through the following three phases. First, the annual reports of listed companies in EGX 100 of the Egyptian Exchange Market published between 2018–2022 are manually screened to extract digital keywords by browsing Mubasher's website and the websites of the sample firms. The DT keywords, extracted from Chen and Xu (2023) and Rahman and Ziru (2023), consist of "Artificial Intelligence (AI) Technology", "Big Data Technology", "Blockchain", and "Cloud Computing". Second, a text analysis of the annual reports of sample companies is carried out to determine the existence of keywords associated with digital transformation. Third, the degree of DT of companies is proxied as a dummy variable of value "0" if no digitalization keyword was found, and of value "1" if the annual reports of a given company contain any digitalization keyword.

The moderating variable, cost stickiness *(CS)*, is measured using the Anderson et al. (2003) model. CS is measured by computing the log change in Sales, General, and Administrative costs ($SG\&A_{i,t)}$ between years t and t_{-1} as follows:

$$\boldsymbol{CS_{it} = log\ (SG\&A_{i,t}/\ SG\&A_{i,t-1})}$$

where:

CS= CS of firm i in period t

SG&A = Sales, General, and Administrative costs of firm i

The dependent variable, operational performance *(OP)*, is measured using three proxy measures that were extracted from Tian et al (2023). These proxies include workforce productivity *(PRO)*, physical assets efficiency *(AE)*, and working capital efficiency *(WCE)*. These three proxies are measured by calculating the ratio of operating income a company generates, from its main activities and operating activities, to its workforce, fixed assets, and working capital, respectively.

In addition, various control variables are included to eliminate any potential bias. Firm size *(SIZE)* is included to minimize the effects of firms' characteristics. To control for possible consequences of firm-level economic factors on firms' OP, financial leverage (LEV) is used as a control variable (Chen and Xu, 2023). Table (1) summarizes the measurements for the research variables.

Table (1): Variables Measurements and Proxies

Variables	Proxies	Measures	Data Source
Digital Transformation *(DT)*	DT practices	Dummy Variable (0= No keyword of DT is found, while 1= DT keyword is found in the annual reports)	Annual Reports
Cost Stickiness *(CS)*	Anderson et al. (2003) model	log ($SG\&A_{i,t}$/ $SG\&A_{i,t-1}$)	Financial Statements
Operational Performance *(OP)*	Workforce Productivity *(PR)*	The ratio of operating income / no. of employees	Financial Statements
	Physical Assets Efficiency *(AE)*	The ratio of operating income / average fixed assets	Financial Statements
	Working Capital Efficiency *(WCE)*	The ratio of operating income / average working capital	Financial Statements
Control Variables	Firm Size *(SIZE)*	The log of the year-end total assets	Financial Statements
	Leverage *(LEV)*	The ratio of total debts / total assets	Financial Statements

3.3 Research Models

To investigate the research hypotheses that were previously discussed in section 2, seven models are created. The first model is created to study how DT directly affects CS. Since they might affect this relationship, firm size, and financial leverage are included as control variables in the first model.

$$CS_{it} = \alpha + \beta_1 DT_{it} + \beta_2 SIZE_{it} + \beta_3 Lev_{it} + \varepsilon_{it} \text{.........} \textbf{Model (1)}$$

The second, third, and fourth models are created to examine the direct effect of DT on OP metrics, i.e. workforce productivity, physical assets efficiency, and working capital efficiency. Firm size and financial leverage are included as control variables.

$$PRO_{it} = \alpha + \beta_1 DT_{it} + \beta_2 SIZE_{it} + \beta_3 Lev_{it} + \varepsilon_{it} \text{...} \textbf{Model (2)}$$

$$AE_{it} = \alpha + \beta_1 DT_{it} + \beta_2 SIZE_{it} + \beta_3 Lev_{it} + \varepsilon_{it} \text{......} \textbf{Model (3)}$$

$$WCE_{it} = \alpha + \beta_1 DT_{it} + \beta_2 SIZE_{it} + \beta_3 Lev_{it} + \varepsilon_{it} \text{...} \textbf{Model (4)}$$

In addition to the control variables, firm size, and financial leverage, the fifth, sixth, and seventh models are created to examine the moderating role of CS on the relationship between DT and OP metrics, i.e. workforce productivity, physical assets efficiency, and working capital efficiency.

$$PRO_{it} = \alpha + \beta_1 DT_{it} * CS_{it} + \beta_2 SIZE_{it} + \beta_3 LEV_{it} + \varepsilon_{it} \textbf{Model (5)}$$

$$AE_{it} = \alpha + \beta_1 DT_{it} * CS_{it} + \beta_2 SIZE_{it} + \beta_3 LEV_{it} + \varepsilon_{it} \textbf{Model (6)}$$

$$WCE_{it} = \alpha + \beta_1 DT_{it} * CS_{it} + \beta_2 SIZE_{it} + \beta_3 LEV_{it} + \varepsilon_{it} \textbf{Model (7)}$$

4. Research Findings and Discussion of the Results

The following statistical techniques were used to evaluate the data collected for this study using the SPSS 24 statistical software. The mean, median, range, standard deviation, minimum, and maximum values are first calculated by descriptive analysis. Second, the strength and direction of the linear relationship between the research variables are analyzed using Pearson's correlation. Third, regression modeling was used to test the study hypotheses.

4.1 Descriptive Statistics

The descriptive statistics of this study variables are presented in Table 2, except for DT as it is a dummy variable. As shown in Table 2, CS ranges between (-2.86) and (1.2703), with mean and median values of (0.0304) and (0.0414) respectively, which means that the degree of CS is relatively low, and costs tend to be more flexible and responsive to changes in sales or activity levels. Workforce productivity, the first proxy measure for OP ranges from (-1612.5922), to (7350.3257), with mean and median values of (96.7348) and (17.0939) respectively, meaning that workforce productivity is high and effective. Physical assets efficiency, the second proxy measure for OP ranges between (-1.5896) and (4.1902) with mean and median values of (23.9049024) and (0.0530) respectively, meaning that the sample companies' assets are relatively inefficiently used. Working capital efficiency, the third proxy measure for OP ranges from (-153.8462) to (2.7346) with mean and median values of (-0.3684) and (0.2176) respectively, showing that the sample companies are facing liquidity problems because current liabilities exceed their current assets.

Table (2): Descriptive Statistics

	Mean	Median	Standard Deviation	Minimum	Maximum
Cost Stickiness	0.0304	0.0414	0.3173	-2.8600	1.2703
Operational Performance (Workforce Productivity)	96.7348	17.0939	641.1214	-1612.5922	7350.3257
Operational Performance (Physical Assets Efficiency)	0.1315	0.0530	0.5501	-1.5896	4.1902
Operational Performance (Working Capital Efficiency)	-0.3684	0.2176	10.6660	-153.8462	2.7346
Firm Size	5.9944	6.0299	0.7681	4.6326	7.7398
Financial Leverage	0.5436	0.4465	0.5952	0.0070	5.1635

In addition, the mean and the median values of firm size are (5.9944) and (6.0299) respectively. The sample firms represent all Egyptian businesses that are active in the market since their sizes range from (4.6326) to (7.7398). Furthermore, around 54% of Egyptian enterprises use debt to finance their operations, according to the mean financial leverage shown in Table (2).

4.2 Pearson Correlation Test

The Pearson correlation matrix is constructed to ascertain the direction and strength of the correlation between the study's variables. The results of a two-tailed significance test using Pearson Correlation are presented in Table (3). Table 3's results showed the most correlated variables with DT are workforce productivity (*PRO*), physical assets efficiency (*AE*), and firm size (*SIZE*), significant at the 0.01 level. The Pearson coefficients indicate that the relationship between DT and workforce productivity, physical assets efficiency, and firm size is a positive relation.

Table (3): Pearson's Correlation Matrix

		DT	***CS***	***PRO***	***AE***	***WCE***	***SIZE***	***LEV***
DT	Pearson Correlation	1						
	Sig. (2-tailed)							
CS	Pearson Correlation	0.075	1					
	Sig. (2-tailed)	0.211						
PRO	Pearson Correlation	**0.182****	-0.015	1				
	Sig. (2-tailed)	**0.002**	0.805					
AE	Pearson Correlation	**0.192****	-0.001	**0.327****	1			
	Sig. (2-tailed)	**0.001**	0.989	**0.000**				
WCE	Pearson Correlation	0.063	0.003	-0.015	0.019	1		
	Sig. (2-tailed)	0.299	0.955	0.800	0.748			
SIZE	Pearson Correlation	**0.362****	0.083	**0.206****	**0.207****	-0.015	1	
	Sig. (2-tailed)	**0.000**	0.170	**0.001**	**0.001**	0.803		
LEV	Pearson Correlation	0.049	0.080	-0.041	**-0.312****	0.002	**0.123***	1
	Sig. (2-tailed)	0.411	0.183	0.498	**0.000**	0.977	**0.041**	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

4.3 Regression Analysis and Discussion of Results

Multivariate regression analysis is employed to assess the seven research models. The direct relationship between DT and CS is examined in the first model. The second, third, and fourth models examine how DT could affect the three proxies of OP, workforce productivity, physical assets efficiency, and working capital efficiency. The fifth, sixth, and seventh models examine how CS could moderate the relationship between DT and a company's OP using the three proxy measures of OP, workforce productivity, physical assets efficiency, and working capital efficiency.

Results of the Relation between Digital Transformation and Cost Stickiness

In the first model, the impact of DT on CS is examined. Table 4 shows the regression analysis findings. The first research model's multiple regression analysis reveals that it accounts for 14% of the variation in firm CS. The results in Table 4 demonstrate that the influence of DT on CS is insignificant. This is consistent with Chen (2022), and Chen and Xu (2023) findings that the digital revolution has a decelerating effect on how sticky costs are in manufacturing businesses.

Table 4: Multiple regression model of the relationship between digital transformation and cost stickiness

Panel A: Model (1) summary					
Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error**	
1	0.374	0.140	0.030	3.1682	
Panel B: Coefficients [a]					
Independent variables	**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
	B	**Standard Error**	**Beta**		
Constant	-0.140	0.155		-0.899	0.369
Digital Transformation	-0.034	0.042	0.052	0.805	0.422
Firm Size	0.023	0.027	0.055	0.852	0.395
Financial Leverage	0.038	0.032	0.071	1.169	0.243

[a] Dependent Variable: Cost Stickiness

The results reveal that DT may not directly resolve the problem of CS. This may be justified due to the complex and outdated manufacturing systems in the Egyptian industries that do not respond easily to digitalization. In addition, several external factors, such as market conditions, legal requirements, or supplier pricing, may have an impact on CS. Hence, the influence of DT on CS may be limited since it may not directly address these external factors. Therefore, the first hypothesis which states that "*Digital transformation significantly reduces cost stickiness in Egyptian manufacturing companies*" is rejected.

Results of the Relation between Digital Transformation and Operational Performance

In the second, third, and fourth models, the direct effect of DT on OP, using the three proxy measures of OP, is tested. Table 5 reports the results of the regression analysis.

The second model's multiple regression analysis shows that it accounts for 6% only of the variation in firm workforce productivity. The results in Table 5 demonstrate that the influence of DT on workforce productivity is significant. This is in line with the findings of Shao and Lin (2002) and Tian et al. (2023), who demonstrated that the implementation of DT enhances workers' productivity, and improves OP. This reveals that the digitalization process helps Egyptian manufacturing enterprises improve their workforce productivity by automating their production process, generating real-time data and analytics, empowering workers, and encouraging continuous learning. Therefore, the first sub-hypothesis of the second hypothesis, which states that: *"Digital transformation significantly improves the workforce productivity of Egyptian manufacturing companies"* is accepted.

Table 5: Multiple regression model of the relationship between digital transformation and operational performance

Panel A: Model (2) summary					
Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error**	
2	0.245	0.060	0.050	624.956	
Panel B: Coefficients [a]					
Independent variables	**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
	B	**Standard Error**	**Beta**		
Constant	-773.355	306.806		-2.521	0.012
Digital Transformation	161.968	82.665	0.123	1.959	**0.051**
Firm Size	141.258	52.854	0.169	2.673	**0.008**
Financial Leverage	-72.866	63.573	-0.068	-1.146	0.253
[a] Dependent Variable: Workforce Productivity					
Panel A: Model (3) summary					
Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error**	
3	0.418	0.175	0.166	0.503	
Panel B: Coefficients [b]					
Independent variables	**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
	B	**Standard Error**	**Beta**		
Constant	-0.613	0.246		-2.487	0.013
Digital Transformation	0.154	0.066	0.137	2.324	**0.021**
Firm Size	0.143	0.042	0.200	3.370	**0.001**
Financial Leverage	-0.317	0.051	-0.343	-6.208	**0.000**
[b] Dependent Variable: Physical Assets Efficiency					
Panel A: Model (4) summary					
Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error**	
4	0.245	0.06	0.05	10.694	
Panel B: Coefficients [c]					
Independent variables	**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
	B	**Standard Error**	**Beta**		
Constant	2.561	5.252		0.488	0.626
Digital Transformation	1.706	1.412	0.078	1.208	0.228
Firm Size	-0.605	0.904	-0.044	-0.669	0.504
Financial Leverage	0.057	1.088	0.003	0.053	0.958

[c] Dependent Variable: Working Capital Efficiency

The third model's multiple regression analysis shows that it accounts for 17.6% of the variation in firm physical assets efficiency. The results in Table 5 demonstrate that the influence of DT on asset efficiency is significant. This is consistent with Tian et al. (2023), who found that the implementation of DT improves physical assets efficiency. This shows that utilizing digital technology may improve assets' performance, decrease downtime, cut costs, and increase the value received from physical assets. Therefore, the second sub-hypothesis of the second hypothesis, which states that: *"Digital transformation significantly improves the physical assets efficiency of Egyptian manufacturing companies"* is accepted.

Table 5's results show that model 4 is not significant since the model has a low R-square value of 0.06. the results show that DT has no impact on the third proxy measure of OP, working capital efficiency. This could be justified due to the costs associated with implementing DT initiatives related to the acquisition of software systems, training employees, and redesigning processes. These additional costs may draw out the companies's working capital in the short run, offsetting any gains achieved due to DT. Hence, the third sub-hypothesis of the second hypothesis, which states that: *"Digital transformation significantly improves the working capital efficiency of Egyptian manufacturing companies"* is rejected.

Based on the results of the three multiple regression models, 2,3, and 4; the second hypothesis that states that: *"Digital transformation significantly improves the operational performance of Egyptian manufacturing companies"* is accepted.

Results of the Relation between Digital Transformation, Cost Stickiness, and Operational Performance

In the fifth, sixth, and seventh models, the moderating effect of CS on the relationship between DT and OP, using the three proxy measures of OP, is tested. Table 6 reports the results of the regression analysis.

Table 6's results show that models 5 and 7 are not significant since the two models have a low R-square value of 0.048 and 0.001 respectively. The results of the three models presented in Table 6 failed to find any moderating impact of CS on the relationship between DT and OP. CS could affect financial performance (Dang, 2018), but it may not have an impact on the relationship between DT and OP, because this relationship might be motivated by other drivers such as process improvements, technology adoption, and organizational structure. These factors are not directly related to CS. This could justify the absence of the moderating effect of CS on the relationship between DT and OP. Therefore, the third hypothesis which states that: *"Cost stickiness moderates the relationship between digital transformation and the operational performance of Egyptian manufacturing companies"* is rejected.

Table 6: Multiple regression model of the relationship between digital transformation and operational performance

Panel A: Model (5) summary					
Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error**	
5	0.220	0.048	0.038	628.886	
Panel B: Coefficients [a]					
Independent variables	**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
	B	**Standard Error**	**Beta**		
Constant	-945.653	197.920		-3.174	0.002
Digital Transformation * Cost Stickiness	-153.331	245.866	-0.037	-0.624	0.533
Firm Size	181.040	49.744	0.217	3.639	0.000
Financial Leverage	-71.656	63.976	-0.067	-1.120	0.264
[a] Dependent Variable: Workforce Productivity					
Panel A: Model (6) summary					
Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error**	
6	0.401	0.161	0.152	0.507	
Panel B: Coefficients [b]					
Independent variables	**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
	B	**Standard Error**	**Beta**		
Constant	-0.753	0.240		-3.139	0.002
Digital Transformation * Cost Stickiness	0.174	0.198	0.049	0.880	0.380
Firm Size	0.176	0.040	0.245	4.386	0.000
Financial Leverage	-0.317	0.052	-0.343	-6.153	0.000
[b] Dependent Variable: Assets Efficiency					
Panel A: Model (7) summary					
Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error**	
7	0.026	0.001	-0.010	10.721	
Panel B: Coefficients [c]					
Independent variables	**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
	B	**Standard Error**	**Beta**		
Constant	0.988	5.086		0.194	0.846
Digital Transformation * Cost Stickiness	1.489	4.191	0.022	0.355	0.723
Firm Size	-0.237	0.849	-0.017	-0.280	0.780
Financial Leverage	0.060	1.091	0.003	0.055	0.956

[c] Dependent Variable: Working Capital Efficiency

5. Conclusion, Recommendations, and Future Research

The growth and proliferation of information technology have led to an extraordinary rate of integration of digital technologies into company operations and production. This study examines the effects of DT on CS and organizations' OP from the perspectives of workforce productivity, asset efficiency, and working capital efficiency. The moderating impact of CS on the relationship between DT and OP is then investigated. This investigation is based on a large sample of Egyptian manufacturing companies in the period from 2018 to 2022.

The study found that DT significantly and positively affects OP in terms of workforce productivity, and physical assets efficiency. Therefore, Egyptian manufacturing enterprises can benefit from DT in several ways, including automating their production process, generating real-time data and analytics, empowering workers, and encouraging continuous learning. In addition, utilizing digital technology may improve assets' performance, decrease downtime, cut costs, and increase the value received from physical assets.

However, digitalization is not always a solution to every business problem, particularly the problem of CS. CS refers to the situation when costs do not reduce proportionally to a decline in revenues or activity levels. There are several reasons why CS may not be directly addressed by DT:

1. The infrastructure and processes of many Egyptian enterprises are complex and out-of-date, making it difficult for them to adopt digital technologies. The costs and efforts involved in replacing or updating existing systems may restrict the immediate cost-saving effects of DT.
2. Changes to organizational structure, staff responsibilities, and business processes are frequently necessary as a result of DT. The achievement of cost savings may be slowed down by resistance to change and the need for training and skills improvement.
3. While digital technology can automate some businesses and simplify manufacturing processes, it can be expensive to implement. Investing in hardware, software, data infrastructure, and cybersecurity systems before reaping the long-term benefits can result in temporary cost increases.
4. CS may be influenced by other external factors, such as market conditions, regulatory requirements, or supply prices. The effect of DT on CS may be limited because it may not directly address these external variables.

The following policies and incentives can be used to promote digitalization in Egyptian traditional industries. First, the Egyptian government can offer financial incentives, such as tax exemptions, to companies that invest in digital technologies. This can reduce the costs associated with upgrading services and equipment. Second, employees could access support and training to help them develop the skills they need to use digital technology effectively. Programs that encourage digital literacy and education about technology, such as precision agriculture or digital commerce, fall into this category Third, the Egyptian government can collaborate with the private sector to develop and adopt digital technologies in existing and traditional projects. This allows the costs and risks of DT to be shared among different stakeholders. Finally, more investment is needed in the R&D of digital technologies, specially designed to meet the requirements of traditional Egyptian industries. Overall, promoting digitization in conventional industries will require a comprehensive approach, combining these policies and incentives, with efforts to overcome other barriers of DT, such as digital disconnections and cybersecurity concerns.

The DT process is comprehensive and multifaceted, although it can help reduce costs through improved automation. A comprehensive approach to organizational, cultural, and business issues in addition to technology is crucial for addressing CS. Therefore, manufacturing companies should plan and manage their digital efforts to mitigate CS risks in DT. This can be done by focusing on high-profit areas while minimizing costs. In addition, manufacturing companies need to ensure that their employees have the skills and knowledge they need to use new technology by focusing on training and development. Finally, to maximize the benefits of DT, companies should continuously analyze and monitor the cost-benefit impact of their digital activities, and make adjustments as necessary.

In addition, Egyptian firms could take various actions to mitigate the consequences of CS. These may include redesigning cost structures more appropriately and investing in tools and processes that can increase flexibility and reduce costs. Moreover, firms can use DT to increase their OP and maintain long-term competitiveness by effectively controlling CS.

Future studies might consider testing the impact of external factors on the adoption of DT. In addition, longitudinal research might be used in future research to compare OP before and after the adoption of DT. Moreover, applying this research in other economies appears vital to further enhance the researcher’s conclusions and expand the knowledge on digitalization.

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دور لزوجة التكلفة في العلاقة بين التحول الرقمي والأداء التشغيلي بالمنشآت الصناعية المصرية

المستخلص:

هدف البحث: تهدف هذه الدراسة الى بحث آثار التحول الرقمي على لزوجة التكلفة وعلى الأداء التشغيلي للمنظمات تم قياس الأداء التشغيلي من خلال إنتاجية العاملين، كفاءة الأصول، وكفاءة رأس المال العامل. كما اهتمت الدراسة ببحث التأثير المعَّدل للزوجة التكلفة على العلاقة بين التحول الرقمي والأداء التشغيلي للمنشآت الصناعية المصرية.

المنهج البحث: تم جمع البيانات الثانوية المستخدمة في هذه الدراسة من القوائم المالية لعينة كبيرة من الشركات الصناعية المصرية المدرجة في البورصة المصرية خلال الفترة بين 2018 و2022. تم استخدام تحليل الانحدار المتعدد لاختبار نماذج البحث.

أهم النتائج: أظهرت نتائج الدراسة الى عدم وجود علاقة معنوية ذات دلالة إحصائية للتحول الرقمي على لزوجة التكلفة. كما اثبتت نتائج الدراسة الى أن التحول الرقمي له تأثير إيجابي مباشر على الأداء التشغيلي من حيث إنتاجية العاملين وكفاءة الأصول. بالإضافة إلى ذلك، لم تثبت الدراسة وجود تأثير معَّدل للزوجة التكلفة على العلاقة بين التحول الرقمي والأداء التشغيلي للمنشآت الصناعية المصرية.

الإضافة العملية: استخدمت هذه الدراسة المنهج التطبيقي لدراسة أثر تطبيق التحول الرقمي على الأداء التشغيلي للمنشأت الصناعية، والتي ستساعد في توسيع نطاق تطبيقات التحول الرقمي في الشركات الصناعية المصرية.

الكلمات المفتاحية: التحول الرقمي، لزوجة التكلفة، الأداء التشغيلي، مصر