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Digitalization and Firm Performance: Empirical Evidence from Forbes-listed Companies

Oumeima Toumia[1], Rym Mefteh[2], and Marc Cowling[3]

[1]University of Sousse, IHEC, LaREMFiQ, BP n 40 - 4054 Sousse, Tunisia. | *toumiaoumeima@yahoo.fr*
[2]University of Sousse, IHEC Sousse, Tunisia. | *rim77fr@yahoo.fr*
[3]College of Business, Law and Social Science, University of Derby, Headington Road, Headington, Oxford, Oxfordshire OX3 0BP, UK. | *mcowling@brookes.ac.uk*

Abstract

As the world goes digital, many companies have found that their performance improves when they digitize their operations. This is especially true in light of the COVID-19 pandemic, as companies must rely more on digital tools to survive. Our paper aims to examine the connection between digital competitiveness and the financial performance of 86 digital businesses at the country level before, during, and after the COVID-19 pandemic over the period 2017–2021. Unlike previous findings that relied on qualitative methods, our research relies on quantitative methods. More precisely, we empirically examine the impact of digital competitiveness (i.e., an index) on financial performance (i.e., measured by return on assets) through linear regression models and panel data regressions for three specific periods (2017-2019 pre-pandemic, 2020 pandemic, and 2021 post-pandemic). We found that COVID-19 allows firms to adopt digitalization. More specifically, comparing the three periods, we discovered that digital competitiveness positively influences business financial performance in the post-Covid era. Looking ahead to the post-Covid world, it is clear that companies must prioritize digital competitiveness to ensure their long-term success. Governments can learn important lessons from this research on how to help companies digitize.

Keywords: Digital Competitiveness, Firm Performance, COVID-19, Digitalization, Competitive Advantage.

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1 Introduction

Nowadays, companies have access to digital technologies including the Internet of Things, location-aware technology, 3D printing, Big Data analytics, cloud computing, etc. (Martínez-Caro et al., 2020). These tools enable digital transformation by transforming their activities, processes, and capabilities (Ardito et al., 2019; Correani et al., 2020; Fatorachian and Kazemi, 2018; Rajnai and Kocsis, 2018) and leading to digital competitiveness by creating long-term competitive advantages (Bessonova and Battalov, 2021; Martincevic, 2021; Rodríguez and Rodríguez, 2005) in all sectors (Granig and Hilgarter, 2022). For example, investments in digital technologies enable companies to move from traditional business models to e-business models and become more competitive (Martínez-Caro et al., 2020). Industry value chains, internal business processes, and cross-organizational interactions have been transformed by the rapid pace of digitalization (Aaldering and Song, 2021; Ghobakhloo and Iranmanesh, 2021; Holmström et al., 2019; Mention et al., 2000).

The connection between digital technology and business performance has been the subject of several studies. They concluded that the relationship between these two concepts is not always clear (Martínez-Caro et al., 2020). It is obvious that the impact of digital technologies can be very different even between companies operating in the same sector (Hsu et al., 2006). Some studies suggested that digital technology boosts performance (Eller et al., 2020; Hautala-Kankaanpää, 2022; Li et al., 2020; Martín-Peña et al., 2019) through increased efficiency and growth (Björkdahl, 2020) even throughout the coronavirus (Frederico et al., 2023; Sharma et al., 2020), while others argued that it harms performance (Jeffers et al., 2008) due to the negative effects of digitization (i.e., costs of digitization in terms of coordination and complexity) (Dąbrowska et al, 2022; Hanelt et al., 2021). However, there are also studies that suggest that the role of digital technology is weak or nonexistent (AlMulhim, 2021; Lee et al., 2022; Liang et al., 2010; Wroblewski, 2018).

The impact of digital technology on individuals, people, and society as a whole is well acknowledged (Martínez-Caro et al., 2020). More precisely, COVID-19 has accelerated the rate at which technology disruption is occurring in enterprises, and its consequences are growing (Almeida et al., 2020). Despite the fact that digitization has been a top priority for many businesses for a while now, many are only starting their processes of change (Lichtenthaler, 2021). Therefore, researchers are under pressure to show how digital competitiveness can help organizations succeed in this new environment. In fact, to assure their long-term success, companies must prioritize digital competitiveness. Our study seeks to close the information gap regarding the impact of digital competitiveness on business performance in the period before, during, and after COVID-19. Since COVID-19 led to a health crisis and accompanying economic turmoil, we decided to focus our investigation on this period. The originality of our paper lies in its methodology. To our knowledge, the use of digital competitiveness rankings to determine the impact of digital competitiveness on firm performance is a new topic. Indeed, our article examines firm performance over three time periods (i.e., before, during, and after COVID-19). As such, it has the potential to significantly advance the field by shedding light on how COVID-19 impacted business performance, highlighting the elements that contributed to businesses' success during the pandemic, and offering advice to businesses on how to be prepared for crises in the future. For our analysis, we use a database of annual data from 86 digital companies listed by Forbes for the period 2017 to 2021.

The rest of this research is structured as follows: The literature review is summarized in Section 2, along with the research hypothesis. The study methods and data collection are provided in Section 3. The findings are discussed in Section 4. The conclusion, our paper's contributions, and its limitations are all included in Section 5.

2 Literature review

Digital competitiveness and digitization are closely related. On the one hand, Gassmann et al. (2014) confirmed that digitalization is the process of transforming existing products or services into digital products or services to gain advantages over actual products or services. This process has three aspects, which are: Digital Resources, Digital Network Resources, and Digital Synchronization Skills (Luo, 2021; Sirmon et al., 2011). On the other hand, digital competitiveness refers to an economy's capacity to accept digital technology to transform governance practices and benefit businesses (i.e., productivity, innovation, and performance) and national economies (Autio et al., 2018; Granig and Hilgarter, 2022; Laitsou et al., 2020; Martincevic, 2021; Rustomjee, 2018). Ulhøi (2021) explained that digital entrepreneurship not only encompasses digital technology and entrepreneurial action but also applies a wider repertory of architectural arrangements to challenge previous notions of objects and methods of operation. In this context, Rustomjee (2018)

noted that companies may guarantee that their objectives and personnel are best positioned to achieve them by leveraging technology as an enabler. Many companies have adopted numerous digital technologies since the COVID-19 epidemic's recent breakout to accelerate the transition of their businesses into the digital sphere (Sheng et al., 2021) and enhance operational efficiency (Sharma et al., 2020). Indeed, previous studies have shown that COVID-19 significantly affects firm performance (Liu et al., 2020; McKibbin and Fernando, 2021; Toumia and Zahou-Lamti, 2022). For example, COVID-19 led to a significantly higher unemployment rate (Ozili and Arun, 2020). Martínez-Caro et al. (2020) found that digitizing companies can promote the growth of value-added activities if they adopt a digital organizational culture. Similarly, Hautala-Kankaanpää (2022) investigated the influence of digitization on company performance, utilizing digital culture and supply chain capability as moderating variables. They found that supply chain capability and digital culture mediate the link between digital platforms and operational success. For instance, they showed that companies with a strong digital culture had a positive correlation between operational performance and digital platforms (Hautala-Kankaanpää, 2022). According to Weill and Woerner (2017), companies that use digital technologies and operate within the digital ecosystem perform better than their direct rivals in terms of sales growth by about 30% and profit margins by 27%. However, Wroblewski (2018)'s study of 24 Swedish companies found no correlation between digital maturity and profitability. His result was explained by the fact that some changes caused by digital innovations are not visible in the short term. On the basis of the earlier findings, we put forth the following hypotheses:

$\mathcal{H}1$: *The firm performance is positively and significantly impacted by digital competitiveness.*

$\mathcal{H}2$: *There exists a positive relationship between digital technology and firm performance*

Despite previous literature recognizing the importance of digital competitiveness on firm performance, other factors (education, age, gender, experience ethnicity, psychological and behavioral characteristics, social and human factors, etc.) that influence firm growth have become the focus of various research efforts (Baysinger and Hoskisson, 1990; Bertrand and Schoar, 2003; Cooper et al., 1988; Robinson and Sexton, 1994). However, the results of previous research on managerial traits and firm performance are rather contradictory (Peni, 2014). Specifically, there are studies that confirmed the positive influence of gender, age, and experience on organizational performance (Baysinger and Hoskisson, 1990; Bertrand and Schoar, 2003; Brennan and McCafferty, 1997; Gupta and Mahakud, 2020), while other studies concluded that there is no correlation between chief executive officer (CEO) characteristics and organizational performance (Davis, 1979; Dezső and Ross, 2008; Huson et al., 2004; Peni, 2014). In contrast to previous research that ignored the impact of chairman characteristics on firm performance, Peni (2014) analyzed the association between CEO and chairman traits and firm performance. They reported that both gender and experience of CEOs or chairmen have a positive influence on business performance. However, the results related to CEO or chairman age are contradictory. More specifically, CEO age was shown to be positively correlated with ROA, and the firm's Tobin's Q was inversely connected with the chairman's age. Based on previous findings, we suggest the following hypothesis:

$\mathcal{H}3$: *The characteristics of the Chief Executive Officer /Chairman Performance were associated with firm performance*

Although some attempts have been made to examine the link between the CEO and chairman's responsibilities being combined or separated and business performance, this relationship is still unclear. There are conflicting findings on the effect of dual CEO and chairman roles on business performance (Peng et al., 2007). Pi and Timme (1993) suggested that companies with separate functions are more powerful than those with combined functions. This could be due to the CEO's inability to perform two functions (Lipton and Lorsch, 1992) and the conflict between the CEO's objectives and those of shareholders (Eisenhardt, 1989). However, similar to Kim et al. (2009) and Ahn et al. (2010), Peni (2014) found that CEO duality is positively correlated with return on assets. This could be due to several reasons: (1) taking on outside functions is a result of the executive's time and effort required (Peni, 2014); (2) allowing the CEO to better serve the company because they consider the success of the firm a personal challenge (Davis et al., 1997; Peni, 2014), and (3) separating these two functions could result in expenses for a new agency, including information costs associated with the CEO and chairman exchanging information. However, Gupta and Mahakud (2020) added that CEO duality boosts performance in small board banks while having no impact on explaining performance in large board banks. Motivated by previous findings of Gupta and Mahakud (2020), we put forward this hypothesis:

$\mathcal{H}4$: *CEO-chairman duality has no effect on business performance*

Other studies examined the effects of growth opportunities, firm age and size, and gross domestic product (GDP) on firm performance. They concluded that the link between these factors and company performance is very complex and has been the subject of numerous studies. Gul (1999) reported a negative link between growth possibilities and company performance. However, in contrast to Gul (1999), Hatem (2014) concluded that the growth opportunities, which are determined by the market-to-book ratio, positively affect business performance in Sweden and Switzerland. Following Hatem (2014), we suggest the following hypothesis:

$\mathcal{H}5$: *Growth opportunities positively influence the performance of firms*

De Massis et al. (2013) found that firm size has a positive effect on business performance, while firm age has no significant impact. Conheady et al. (2015) added that the large firm size negatively influences firm performance. However, Wroblewski (2018) confirmed that firm size does not affect firm performance. Therefore, we present the following hypothesis:

$\mathcal{H}6$: *Performance of a business is not impacted by its size*

While some papers (Coad et al., 2013; Hatem, 2014) found a positive and substantial relationship between firm age and business performance, other studies (Lansberg, 1983; Wu, 2013) confirmed the negative effect of firm age on business performance. So, we suggest the following hypothesis:

$\mathcal{H}7$: *Firm age has a positive impact on firm performance*

It is well documented that macroeconomic factors can influence firm performance (Peni, 2014). Pacini et al. (2017) examined the effects of macroeconomic factors on the top 100 firms in the United Kingdom and found that the success of businesses is directly and positively influenced by GDP. In contrast, Ghazali (2016) showed a significant negative impact on 101 firms listed on

the Nigerian Stock Exchange, with the exception of the financial sector. Therefore, the following hypothesis is put forward:

$\mathcal{H}8$: *Gross Domestic Product positively influences firm performance*

In the literature review of our research, we do not limit ourselves to looking at the impact of digital competitiveness on firm performance. This is because business performance is a multi-faceted phenomenon that is impacted by several variables. Therefore, we have identified a number of key factors that influence how well firms perform.

3 Methodology and data

One of the key concepts in management research is organizational performance (Richard et al., 2009). Richard et al. (2009) ascertained that the most widely used and accessible tool for assessing organizational performance are accounting measures. Among these measures, we used the ratio of accounting earnings (ROA) before interest and taxes as the dependent variable (Amran et al., 2014). We note that other accounting measures can be used, but assume that the ROA is accepted as a sufficient proxy for firm performance (Batuman et al., 2022; Richard et al., 2009): (1) the special charges do not affect the operating income used to calculate ROA, and (2) managers cannot manipulate ROA too much (Amran et al., 2014). We used a digital competitiveness rating to assess the digital competitiveness of an economy. According to IMD (2022), digital competitiveness has three main factors: (1) knowledge (the ability to find, understand, and create new technologies); (2) technology (the environment that fosters the growth of digital technologies); and (3) future readiness (the degree to which a country's readiness to benefit from the digital revolution) (Buck et al., 2013). We introduce the variable "$Competitiveness_{i,t}$" which represents a rank that encompasses the three factors (i.e., knowledge, technology, and future readiness). To determine the use and uptake of digital technologies in a country, we used the variable "$Digital_{i,t}$". This is a rank that includes digital infrastructure availability, workforce skills, and regulatory environment (IMD, 2022). Moreover, we included CEO and chairperson characteristics (i.e., age, gender, and experience) (Peni, 2014). We introduced the variable "*CEO duality*", a binary variable with a value of 1 if the CEO also serves as the chairman of the board and a value of 0 in the other case. In addition, we include the variable market-to-book ratio variable ($Growth_{i,t}$) to measure growth opportunities, the total assets logarithm variable to gauge firm size, the firm age variable (i.e., the number of years since a firm was founded) to measure firm maturity and experience (Hatem, 2014), and the real GDP growth variable to measure the overall health of an economy (Pacini et al., 2017). To respond to our research question, we used panel regression for the pre-covid period and linear regression for the covid and post-Covid periods. Thus, our two models are as follows:

Model 1: 2017-2019 Pre-Covid

$$\begin{aligned}\text{ROA}_{i,t} = {} & \beta_0 + \beta_1 \text{Competitiveness}_{i,t} + \beta_2 \text{Digital}_{i,t} + \beta_3 \text{Gender CEO}_{i,t} + \beta_4 \text{Age CEO}_{i,t} + \beta_5 \text{Experience CEO}_{i,t} \\ & + \beta_6 \text{Gender Chairman}_{i,t} + \beta_7 \text{Age Chairman}_{i,t} + \beta_8 \text{Experience chairman}_{i,t} + \beta_9 \text{CEO duality}_{i,t} \\ & + \beta_{10} \text{Growth}_{i,t} + \beta_{11} \text{Size}_{i,t} + \beta_{12} \text{Age firm}_{i,t} + \beta_{13} \text{Real GDPgrowth}_{i,t} + \varepsilon_{i,t},\ t = 1, \ldots, T\end{aligned}$$

where t=1 corresponds to 2017 and t=T corresponds to 2019.

Model 2: 2020 Covid, and 2021 after Covid

$$\text{ROA}_t = \beta_0 + \beta_1 \text{Competitiveness}_t + \beta_2 \text{Digital}_t + \beta_3 \text{Gender CEO}_t + \beta_4 \text{Age CEO}_t + \beta_5 \text{Experience CEO}_t + \beta_6 \text{Gender Chairman}_t + \beta_7 \text{Age Chairman}_t + \beta_8 \text{Experience chairman}_t + \beta_9 \text{CEO duality}_t + \beta_{10} \text{Growth}_t + \beta_{11} \text{Size}_t + \beta_{12} \text{Age firm}_t + \beta_{13} \text{Real GDPgrowth}_t + \varepsilon_t$$

Our study looks at the performance of digital companies for the period from 2017 to 2021, and our target audience is the TOP 100 digital companies according to Forbes. Considering that the digital economy is a complex and rapidly evolving ecosystem, we chose to analyze the performance of the top 100 digital companies that have a significant influence on the economy. More specifically, these companies are leaders in their field, and the information about them can help other companies improve their own performance.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev	Min	Max
	N = 430		0.0814	-0.129	0.714
$\text{ROA}_{i,t}$	n = 86	0.0988	0.0671	-0.00062	0.293
	T= 5		0.0465	-0.0690	0.5827
	N = 430		11.523	1	55
Competitiveness $_{i,t}$	n = 86	12.967	11.147	3	51.4
	T= 5		3.1113	7.7674	23.767
	N = 430		11.954	1	56
Digital $_{i,t}$	n = 86	10.451	11.763	1.4	51.8
	T= 5		2.417	2.651	18.651
	N = 430		0.1648	0	1
Gender $\text{CEO}_{i,t}$	n = 86	0.972	0.1444	0	1
	T= 5		0.0807	0.1720	1.7720
	N = 430		6.8405	33	86
Age $\text{CEO}_{i,t}$	n = 86	55.586	6.3036	35	84
	T= 5		2.7253	35.9860	67.7860
	N = 430		7.8906	1	44
Experience $\text{CEO}_{i,t}$	n = 86	8.279	7.1650	2.2	38
	T= 5		3.3768	-10.520	33.679
	N = 430		0.2253	0	1
Gender $\text{Chairman}_{i,t}$	n = 86	0.9465	0.2068	0	1
	T= 5		0.0916	0.1465	1.7465
	N = 430		8.4028	33	87
Age $\text{Chairman}_{i,t}$	n = 86	60.697	7.9620	35	85
	T= 5		2.7935	41.0976	72.8976

Variable	Obs	Mean	Std. Dev	Min	Max
	N = 430		9.1485	1	56
Experience Chairman$_{i,t}$	n = 86	8.3186	8.6124	1.8	54
	T= 5		3.1958	-9.2813	33.7186
	N = 430		0.4977	0	1
CEO Duality$_{i,t}$	n = 86	0.4465	0.4689	0	1
	T= 5		0.1727	-0.3534	1.2465
	N = 430		0.1508	-0.5243	1.9016
Growth$_{i,t}$	n = 86	0.0557	0.1267	-0.22048	0.9490
	T= 5		0.0826	-0.37861	1.0082
	N = 430		0.4805	0.0326	2.8819
Size$_{i,t}$	n = 86	1.7066	0.4298	0.6169	2.7128
	T= 5		0.2188	-0.3604	2.8425
	N = 430		41.2162	0	175
Age firm$_{i,t}$	n = 86	50.325	41.3852	2	173
	T= 5		1.4158	48.3255	52.3255
	N = 430		3.5084	-10.8	8.9
Real GDPgrowth$_{i,t}$	n = 86	1.6414	0.9702	-0.14	6.02
	T= 5		3.3728	-9.4986	8.6414

However, we only use observations for which all data are fully available in a data set. In total, we considered 86 digital companies. Our data was gathered from several databases: ROA, chief executive officer/chairman, and CEO-chairman duality characteristics, growth, age, and size of companies were collected from Zonebourse[1] and the companies' websites. Digital competitiveness and digitalization rankings were taken from IMD (International Management Development) reports. Real GDP growth was taken from the International Monetary Fund.

In Table 1, we noted that there are large differences in the competitiveness index between countries (Std. Dev = 11.147) and small differences over time within a country (Std. Dev = 3.1113). We obtained the same results for all other variables except real GDP growth. Moreover, we noted that the ROA average for our sample companies is 9.88%. This result shows the poor performance of management in generating profits from the assets of the organizations. Besides, Table 1 demonstrates that the companies are not young and have a long history (mean = 50.325).

Table 2 displays the correlation matrix and variance inflation factor (VIF). For the majority of the pairs of our explanatory variables, Table 2 demonstrates that the Pearson correlation coefficients are low. Moreover, we calculated the VIF for each variable and found that in our case, the VIFs for all the variables are less than 6. The mean VIF is 2.39. Thus, we can conclude the absence of a multicollinearity problem[2].

1. https://www.zonebourse.com/

2. Kennedy (1992) and Marquaridt (1970) asserted that a VIF larger than 10 indicates a serious multicollinearity concern.

Table 2. VIF and correlation matrix

	VIF	$ROA_{i,t}$	$Competitiveness_{i,t}$	$Digital_{i,t}$	Gender $CEO_{i,t}$	Age $CEO_{i,t}$	Experience $CEO_{i,t}$	Gender $Chairman_{i,t}$	Age $Chairman_{i,t}$	Experience $Chairman_{i,t}$	CEO $Duality_{i,t}$	$Growth_{i,t}$	$Size_{i,t}$	Age $firm_{i,t}$	Real $GDPgrowth_{i,t}$
$ROA_{i,t}$	-	1													
Competitiveness $_{i,t}$	5.38		1												
Digital $_{i,t}$	5.18		0.882*	1											
Gender $CEO_{i,t}$	1.19		0.105*	0.127*	1										
Age $CEO_{i,t}$	1.89	−0.104*	0.115*		-0.08	1									
Experience $CEO_{i,t}$	3.91					0.218*	1								
Gender $Chairman_{i,t}$	1.33	0.153*	0.117*	0.127*	0.336*		0.145*	1							
Age $Chairman_{i,t}$	2.14			-0.086	−0.119*	0.471*		−0.096*	1						
Experience $Chairman_{i,t}$	3.6					0.0945	0.830*	0.129*	0.097	1					
CEO $Duality_{i,t}$	1.83	−0.095*				0.130*	0.329*	0.09	−0.493*	0.247*	1				
$Growth_{i,t}$	1.03		−0.183*	0.206		−0.101*	0.148*			0.105*		1			
$Size_{i,t}$	1.11	−0.207*			−0.105*				-0.08		0.201*		1		
Age $firm_{i,t}$	1.39	−0.097*	0.208*	0.093		0.223*	−0.143*	−0.321*	0.143*	−0.133*		−0.152*	−0.174*	1	
Real $GDPgrowth_{i,t}$	1.03	0.100*	−0.127*												1

Note: * denotes statistical significance at a 5 % level

4 Estimation results and discussions

We used three static models (2017-2019 pre-Covid, 2020-Covid, and 2021 post-Covid) to assess the effect of digital competitiveness on company performance. The results and tests were performed using STATA version 14 software.

For the period before COVID-19, we used panel data regression. The choice between a fixed effects model and a random effects model was made using the Hausman test. According to this test, we should use the random-effects estimator instead of the fixed-effects estimator (Prob>chi2 = 0.4530 > 0.05). In fact, we used the Breusch and Pagan Lagrange random effects multiplier test to check for homoscedasticity. We found that the p-value is less than 5% (chibar2 (01) = 134.41, prob>chibar2 = 0.0000). Therefore, heteroscedasticity is present in our data. To look for serial correlation, we perform the test of Wooldridge (2002). According to this test, we accept the null hypothesis (no first-order autocorrelation, F (1, 85) = 0.017, Prob>F = 0.8967> 1%). To minimize the effects of autocorrelation and heteroskedasticity in the error term, we use the robust VCE (variance-covariance estimator), also known as the White estimator. It is considered a heteroskedasticity-consistent estimator. Table 3 displays the results for the period before COVID. As shown in Table 3, the Rho value is 0.7694, which means that the individual effects of the cross-sections are 0.7%. R^2 (within) is equal to 0.0429. So, our explanatory variables explain 4.29% of the ROA variance. The p-value of the Wald χ^2 is less than 5% (p-value Wald χ^2 = 0.0001), so the null hypothesis (i.e., the coefficients are not both equal 0) can be rejected. Our model is correctly specified.

Table 3. Regression Results: Pre-COVID (2017--2019)

Dependent variable : ROA	Panel model with random effects (robust)
Competitiveness $_{i,t}$	-0.00060462
	(0.661)
Digital$_{i,t}$	0.00079333
	(0.623)
Gender CEO$_{i,t}$	-0.02057467
	(0.305)
Age CEO$_{i,t}$	0.00028793
	(0.788)
Experience CEO$_{i,t}$	0.00157229
	(0.154)
Gender Chairman$_{i,t}$	0.05628326
	(0.065)
Age Chairman$_{i,t}$	-0.00086708
	(0.383)
Experience Chairman$_{i,t}$	-0.00132477
	(0.185)
CEO Duality$_{i,t}$	-0.0223528
	(0.131)
Growth$_{i,t}$	–0.02889436**
	(0.004)
Size$_{i,t}$	-0.02439677
	(0.073)
Age firm$_{i,t}$	-0.00016454
	(0.352)

Dependent variable : ROA	Panel model with random effects (robust)
Real GDPgrowth$_{i,t}$	0.00353802*
	(0.013)
Constant	0.15004883*
	(0.038)
Number of observations	258
Number of groups	86
Wald χ^2 (10)	40.24
Prob F	0.0001
R-sq: within	0.0429
R-sq: between	0.1251
R-sq: overall	0.1126
σ_u	0.06296151
σ_e	0.03446014
Rho	0.76949123
Rank	14

Legend: * p<0.05; ** p<0.01; *** p<0.001

For the COVID and after-COVID periods, we employed robust linear regressions to reduce the sensitivity of our regression model to outliers (i.e., data points that deviate significantly from the average are known as outliers). Table 4 presents regression results for the COVID and post-COVID periods.

Table 4. Regression Results: COVID and Post COVID

Dependent variable : ROA	Linear regression (robust) COVID (2020)	Linear regression (robust) Post-COVID (2021)
Competitiveness	0.00468728	0.00399713*
	(0.104)	(0.035)
Digital	-0.00311698	-0.00266071
	(0.224)	(0.156)
Gender CEO	–0.03717768*	–0.08990841***
	(0.015)	(0.001)
Age CEO	-0.00281897	-0.00505508
	(0.100)	(0.071)
Experience CEO	0.00203417	0.0048061***
	(0.267)	(0.000)
Gender Chairman	0.05792053*	0.03998548*
	(0.024)	(0.043)
Age Chairman	0.00012264	0.00189284
	(0.924)	(0.268)
Experience Chairman	–0.00254325*	–0.00406109**
	(0.040)	(0.001)
CEO Duality	0.00579697	0.01337186
	(0.764)	(0.510)

Dependent variable : ROA	Linear regression (robust) COVID (2020)	Linear regression (robust) Post-COVID (2021)
Growth	0.04014258	0.30692823**
	(0.646)	(0.007)
Size	−0.06181659*	-0.02969896
	(0.012)	(0.138)
Age firm	-8.153e-06	8.539e-06
	(0.971)	(0.971)
Real GDPgrowth	0.01152827	-0.00766899
	(0.051)	(0.197)
Constant	0.34124952***	0.35602502*
	(0.000)	(0.014)
Number of groups	86	86
F(13,72)	6.54	4.5
Prob F	0.000	0.000
R-squared	0.2937	0.3187
Root MSE	0.08778	0.08064
AIC	-161.67749	-176.28412
BIC	-127.31663	-141.92326
Rank	14	14

Legend: * p<0.05; ** p<0.01; *** p<0.001

Tables 3 and 4 demonstrated that there was no relationship between digital competitiveness and business performance in the pre-COVID and COVID periods. However, digital competitiveness positively affects firm performance after the COVID-19 pandemic (P-value = 0.035 < 5%). Thus, digital competitiveness and enterprise performance have a complicated relationship. During the coronavirus, many industries suffered from not being prepared to implement digital technologies (Patra and Datta, 2021). However, in this recessionary period (i.e., COVID-19), companies may prioritize cost savings and cut down on spending on digital technology. This may explain the fact that neither digital competitiveness nor digital technology had any noticeable effects on the performance of enterprises in the two periods (pre-Covid and Covid) (see Tables 3 and 4). In fact, we found that COVID-19 forced companies to review the way they operate. In this context, Xiong et al. (2021) noted that COVID-19 provides a window of opportunity for the digital sector and its applications. Managers must thus focus on the benefits of digital transformation and the barriers that may prevent it (i.e., poor infrastructure, limited resources, and capital). They must support the post-COVID-19 digital transformation if they want their companies to grow sustainably. More specifically, digital transformation improves efficiency, minimizes costs, and breeds innovation (Bai et al., 2021). Indeed, we found that the rank of digital technology was not significant for all models. In fact, digital technology rank and digital competitiveness rank measure different things. A nation's level of adoption and exploration of digital technologies is measured by its digital technology rank (IMD, 2022), while a nation's ability and willlingness to adopt and explore digital technologies is measured by its level of digital competitiveness (Laitsou et al., 2020; Martincevic, 2021). That's why a nation may rank low in digital technology but have high digital competitiveness. This may be due to a lack of investment opportunities in infrastructure, despite the country's strong government and education system.

Indeed, we discovered that the market-to-book ratio can have a negative (before COVID-19), positive (after COVID-19), or no impact on company performance (COVID-19). A negative correlation between development opportunities and firm performance was found by Gul (1999). This is due to the increased probability that the company will suffer losses in the future, which lowers the value of the stock. The lack of an effect of the market-to-book ratio can be explained by the fact that the company's future profits are not expected to be very high during the COVID period. The increased demand for products and services is a consequence of the worldwide economy's recovery from the epidemic. Therefore, companies are likely to see an increase in sales and profits. In addition, we found that real GDP growth influences firm performance positively before and after COVID-19, while there is no effect in the COVID period. Due to the abrupt and severe economic shock caused by the pandemic, which accelerated the typical relationship between GDP growth and business performance, the influence of real GDP growth on company performance is absent in the COVID-19 era. In addition, we found that the coefficient for gender CEO is statistically significant and negative, but the coefficient for gender chairman is statistically significant and positive. This is consistent with other research that found conflicting results on the link between gender and business performance. Moreover, the experience of the chairman negatively influences the performance of firms in the COVID and post-COVID period, nevertheless the CEO's experience positively impacts performance during the post-COVID period. Thus, CEOs have more experience and ideas than board chairs. Finally, the performance of the firm is negatively impacted by firm size in the COVID period (Conheady et al., 2015).

5 Conclusion

Nowadays, digital competitiveness is one of the most popular topics due to its great impact on companies and countries. Our article intends to empirically evaluate the effects of digital competitiveness at the country level in three time periods (2017-2019 pre-Covid, 2020-Covid, and 2021 post-Covid). Our study showed that competitiveness and firm performance are significantly correlated in the post-Covid period. Digital technologies have thus been instrumental in combating the harmful impacts of the COVID-19 by enabling both product and process innovation. As the world increasingly moves toward a digital landscape, companies must adapt to be competitive. Indeed, our research highlights the influence of other factors that can affect business performance.

Our paper makes many contributions. First, to our knowledge, we are among the first to use the digital competitiveness rank to examine the impact of digital competitiveness on firm performance before, during, and after the COVID period. Compared to existing methodologies, which frequently depend on subjective evaluations or proxy measures, we offer a more sophisticated and objective measure of digital competitiveness. Second, we use an empirical model to analyze how digital competitiveness affects firm performance before, during, and after COVID-19. Thus, the novelty of our work is the empirical study of a sample of 86 digital companies from several countries (i.e., United States, South Korea, China, Japan, Germany, Spain, Mexico, France, Canada, India, United Kingdom, Netherlands, Australia, Norway, South Africa, Finland, and Sweden). Third, our findings can also be instructive for practitioners, policymakers, and government. They need to be aware of the importance of digital competitiveness, as all organizations and sectors are rapidly changing due to digital technology. Therefore, managers may be effective in managing digital innovation (Granig and Hilgarter, 2022). Indeed, the crisis (i.e., COVID-19) has accelerated the rate at which technological disruption is taking place in enterprises (Almeida et al., 2020). Almeida et al. (2020) therefore stated that managers must encourage an innovative culture that includes all employees in the process in order to be ready for this challenge. As a result, embracing

digitalization may help companies emerge from the crisis and minimize the negative impact of unpredictable events such as COVID-19. For instance, practitioners should focus on developing and implementing practice digital strategies that help their companies create value and become more competitive (i.e., provide new solutions for their clients). In the same vein, businesses may concurrently support economic, ecological, and social objectives through maintaining optimal productivity in this digital world (Lichtenthaler, 2021). There are numerous examples of how companies (e.g., Walmart, Netflix, Amazon, etc.) have improved their competitiveness by using digital technologies: (1) Walmart tracks inventory, plans the best delivery routes, and bargains with suppliers using digital technologies; (2) Netflix provides consumers with online streaming of movies and television programs using digital technologies; and (3) Amazon delivers fast and reliable shipping, a large assortment of items at affordable prices, and an easy online shopping experience using digital technologies.

To rebuild the economy after a pandemic, governments could also consider providing incentives for businesses to improve their digital capabilities and skills and create an environment that fosters creativity. These incentives fall into two categories: financial incentives (e.g., grants, loans, tax benefits, awards and competitions, etc.) and non-financial incentives (e.g., access to government resources, regulatory exemptions, sponsorship initiatives, education and training programs, public-private collaborations, etc.).

Aside from these notable findings, there are some limitations that indicate the need for more research. First, our current study concentrates on the influence of digital competitiveness on large companies. Therefore, it is important to consider how digital competitiveness affects the performance of SMEs. SMEs face several obstacles, such as low resources, financing accessibility, and rivalry from bigger companies. By using digital technology, SMEs may compete more successfully and overcome these obstacles. Second, we think that further study is required to examine how digital competitiveness differs by country size and history. In particular, it would be useful to extend the research to other countries (e.g., those with lower technological capabilities). Indeed, larger nations usually possess greater financial resources to spend on infrastructure, education, and research and development—all crucial factors in maintaining digital competitiveness. Third, it is also interesting to examine the robustness of our findings in future years. This will allow researchers to discover new areas of research and create innovative solutions. Fourth, digital technology's competitive edge is expected to erode as it gets more widely used and embraced by more businesses. Thus, future studies need to pay attention to other factors (product quality, marketing, financial management, etc.) that may affect firm performance more than digital technology. Fifth, we used a quantitative study to examine the relationship between digital competitiveness and firm performance. Therefore, it is challenging to use a mixed-methods approach (i.e., integrate qualitative and quantitative data) to obtain more knowledge of the association between business performance and digital competitiveness.

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Biographies

Oumeima Toumia. Oumeima Toumia earned her Ph.D. in management (business administration) from the Higher Institute of Management of Sousse. Her teaching experience was acquired through her position as an assistant from 2016 until 2023. She published papers in high-ranking journals and participated in known international conferences. She co-authored a book titled "Perceptions of employees of technology emerging with generative pre-trained transformer-3 in organizations." Her research interests include status quo, venture capital, digital transformation, artificial intelligence, firm performance, etc.
ORCID: https://orcid.org/0000-0002-7377-6366
CRediT Statement: Conceptualization, data curation, formal analysis, investigation, methodology, project administration, validation, writing-original draft, writing-review& editing

Rym Mefteh. Rim Meftah holds a Ph.D. from Paris-Dauphine university in 2011. She joined Higher Institute of Management of Sousse (IHEC) university of Sousse, where she is currently an associate professor of management. She runs the Master « Entrepreneurship and project Management ». Her research topics include human capital management and digital transformation. She also has a special interest for entrepreneurial issues. Her work has been published in national and international journals. Institutionally engaged, she is the head of the career and skills certification center of IHEC Sousse. She is also a referent in student entrepreneurs pole PEESO university of Sousse.
ORCID: https://orcid.org/0009-0009-8756-0556
CRediT Statement: Methodology, validation, Writing-review& editing

Marc Cowling. Marc Cowling is a professor of Economics and Productivity. He is an expert on small business economics, financing of SMEs, functioning of labour markets and public policy evaluations. He is ranked in the top 6% of economists in the world by citations (H-index) according to Research Publications in Economics (REPEC, October 2022), and in the Top 2% of scientific researchers in the world by Stanford University. He works as a Head of Research and Innovation in the College of Business, Law, and Social Sciences at the University of Derby, Great Britain. He has published 100 academic peer reviewed journal articles and co-authored three books on public policy relating to unemployment, economic growth, and entrepreneurship.
ORCID: https://orcid.org/0000-0001-5731-8712
CRediT Statement: Methodology, writing-review& editing