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Digitalization and Firm Financial Performance in Healthcare: The Mediating Role of Intellectual Capital Efficiency

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Abstract: The digitalization of processes in healthcare sector firms is expected to reduce costs, improve the quality of healthcare service, customer care experience, and patient safety, and attain efficiency and efficacy in project implementation. This research investigates the impact of digitalization on the financial performance of healthcare-sector firms in the European Union. The study also examines whether a firm's intellectual capital efficiency mediates the process of digitalization's impact on a firm's financial performance. Using a sample of 965 firm observations from 2017 to 2021, we find that digitalization positively affects financial performance. Further analysis suggests that capital-employed efficiency fully mediates the relationship between digitalization and firm performance. Partial mediation is also reported for intellectual capital efficiency, human capital efficiency, and structural capital efficiency in the process of digitalization impacting firm performance. These findings provide fresh insight into how digitalization impacts a firm's financial performance, establishing intellectual capital efficiency as a mediating mechanism that may explain this impact.

Keywords: digitalization; intellectual capital; financial performance; healthcare

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1. Introduction

Firms across the globe are moving towards digitalization in order to thrive or remain competitive in the current business landscape. Digitalization refers to the use of digital technologies (e.g., big data analytics, artificial intelligence, the Internet of the things, and cloud computing) that enable connectivity, communication, and automation in the era of Industry 4.0 [1]. Digitalization has the potential to deliver major business improvements [2] such as streamlining business processes, enhancing marketing capabilities, fostering product innovation, and even altering business models [3]. The COVID-19 pandemic has further accelerated the move towards digitalization forcing firms to undergo such transformation to survive the economic downturn [4].

However, despite the potential benefits of digitalization, its actual impact on a firm's financial performance remains unclear [5]. Survey studies [2] indicate that firms struggle with creating and appropriating value from digitalization investments. The literature refers to this phenomenon as the digitalization paradox [6]. McKinsey [7] reports that worldwide most firms did not achieve the expected financial and operational benefits from their digitalization initiatives, capturing less than one-third of the value that they expected to see. As the literature points out [3], digital transformation entails increased costs not only for the investment in digital resources but also for the management and integration costs resulting from the business and organizational transformation [8]. This raises concerns about the real performance impact of implementing digitalization. Additionally, firms' behavior is affected by the broad set of political and economic institutions

within which they operate [9]. Institutional development and its quality can affect the expectations related to the digitalization of firms within a country. The European Union has developed and adopted a Digital Economy and Society Index (DESI) to measure the progress of the digital economy and society. The DESI takes into account four major dimensions that include human capital, connectivity, the integration of digital technologies by businesses, and digital public services. This study uses the integration of digital technologies dimension to capture cross-national variations in the level of firms' digitalization [10,11].

To date, the empirical works that assess the impact of digitalization on firm financial performance are relatively limited [3,5,12]. In addition, the existing studies have barely examined the mediating mechanisms through which digitalization may affect financial performance [6,12,13] and the potential moderators of this effect.

To fill this research gap, this paper examines the impact of digital transformation on firm financial performance using a sample of healthcare firms from 12 EU countries over the period 2017–2021. Notably, we hypothesize and empirically support that digitalization improves financial performance by increasing the firm's intellectual capital efficiency and particularly the human capital and structural capital efficiency [14–16].

This paper defines the healthcare sector as comprising a diverse array of industries ranging from healthcare equipment and services to pharmaceutical, biotechnologies, and life science firms (as per the global industry classification standard). All these industries are highly knowledge intensive and create value primarily based on the accumulation and use of intellectual capital [17–20]. As such, they provide an interesting setting to examine whether digitalization affects intellectual capital efficiency and whether this mediates the effect of digitalization on financial performance.

Our findings support the positive impact of digitalization on healthcare firms' financial performance as measured by return-on-assets (ROA). This result is robust to using return-on-equity (ROE) as an alternative measure of performance. In addition, we document that human capital efficiency, structural capital efficiency, and capital employed efficiency are three mediating factors for the positive impact of digitalization on a firm's financial performance.

This research makes several contributions to the literature on digitalization, intellectual capital, and firm performance. Firstly, the study assesses the impact of digitalization on the financial performance of healthcare firms in the European Union, which has not been previously explored in prior studies. The impact of digitalization at macro and micro levels is relatively underexplored and particularly important for the firm performance of the European Union as it supports shared European public health policies [21]. Thus, it fills specific gaps in the empirical literature. Secondly, this study establishes the mediating effect of intellectual capital efficiency in the relationship between digitalization and firm performance. The study also articulates the role of intellectual capital efficiency by analyzing the impact of its individual dimensions, which include human capital, structural capital, and capital employed efficiency. Thirdly, the study is conducted for the listed healthcare-sector firms that would differ from those not listed in terms of policies, procedures, and dynamics, thus resulting in different outcomes.

The remainder of this paper proceeds as follows. Section 2 reviews previous research on DT and firm financial performance and presents the theoretical foundations of our research hypotheses. Section 3 describes the research methodology. Section 4 presents and discusses our empirical findings. Section 5 concludes this study, outlining its practical implications and suggesting future research directions.

2. Theory and Hypotheses Development

2.1. Digitalization and Healthcare Firms' Financial Performance

Digitalization has dramatically affected the business landscape globally, altering the way firms develop and market their product offerings, changing consumers' expectations and behaviors, and disrupting markets and industries [22]. More and more firms worldwide embrace digital technologies as a means to sustain their competitive edge and cope with the current digital era of business. As a disruptive technological change, digitalization has the potential to deliver sustainable competitive advantages, which should ultimately lead to improved financial performance [12]. Essentially, digitalization enables firms to optimize their production process and to cope with a rapidly changing external environment more effectively, enhancing their sensing and seizing capabilities [23]. The former advantage results in lower costs, higher operational efficiency, and increased work productivity, while the latter relates to the fact that digital technologies empower firms to forecast demand more effectively, sense changing consumer needs, and adapt products accordingly. As such, digitalization is not only about improving operational efficiency but may also enable innovation in products, customer service, and business models.

The vast potential of digitalization for business development has aroused growing research attention in these last few years. Studies have examined the impact of digitalization on various organizational outcomes such as productivity [24], innovation [25], product category [26], and consumer value [27], among others. Research is also seeking to assess whether digitalization ultimately leads to improving financial performance. The available evidence is, as yet, relatively limited, but it seems to hint at a positive answer.

Studies such as Li et al. [1], Guo and Xu [3], Cheng et al. [13], and Peng and Tao [28] document a positive association between firm digitalization and financial performance in the Chinese manufacturing sector. Eremina et al. [29] focused on Baltic-listed firms and show a positive association between several financial indicators (e.g., ROE) and the level of firm digital maturity. Ribeiro-Navarrete et al. [30] examined the financial impact of digitalization in the knowledge-intensive service industry. Specifically, they found that social networks and training in digital tools enhance financial returns. Chen and Srinivasan [31] examine the financial performance of firms from non-technology industries and find that digital transformation improves the market-to-book and return-on-assets (ROA) ratios of these firms. As specifically regards the healthcare industry, Holopainen et al. [32] found a positive impact of digitalization on the financial performance (ROA) of private healthcare firms. Zhang and Qi [33] reported that digitalization has improved the organizational resilience of healthcare manufacturing firms, leading to higher firm growth during the COVID-19 pandemic. Based on the aforementioned studies, we propose our first research hypothesis (H1) as follows:

Hypothesis 1 (H1). *Digitalization improves healthcare firms' financial performance.*

2.2. The Mediating Role of Intellectual Capital Efficiency and Its Sub-Components

The existing empirical research has barely examined the mediating mechanisms through which digitalization may influence financial performance and the potential moderators of this effect. Few notable exceptions exist, however. Zeng et al. [12] provided evidence that digitalization improves a firm's financial performance by enhancing total factor productivity. Cheng et al. [13] showed that digitalization increases profitability in manufacturing firms by improving the efficiency of asset utilization to generate sales. They also found that digitalization enhances performance more for firms operating in highly competitive industries, smaller firms, and firms with fewer skilled workers. Zhai et al. [34] showed that digitalization enhances financial performance by reducing operating costs, improving operational efficiency, and fostering innovation. Peng and Tao [28] point to similar findings.

We extend this line of research and hypothesize that digitalization enhances financial performance by improving the firm's intellectual capital efficiency. To the best of our knowledge, this hypothesis has not yet been put to the empirical test.

Following Ante Pulic [14–16], we define intellectual capital efficiency as the firm's ability to efficiently use and create value from its investment in knowledge assets. Pulic argues that a firm's intellectual capital efficiency is the composite result of human capital efficiency, structural capital efficiency, and physical capital efficiency. The term human capital (HC) for Pulic is the amount of capital invested in knowledge workers (wages, salaries, and training) and, consequently, the term human capital efficiency (HCE) refers to the value created per each monetary unit invested in HC [35]. By the same token, the term structural capital efficiency (SCE) is the share of value creation obtained through the use of structural capital, which encompasses all non-human storehouses of knowledge [36]. The SCE also incorporates the value created by relational capital, the third relevant component of intellectual capital, thus respecting the working definitions of intellectual capital validated by the related literature and praxis [37]. Relational Capital refers to the sum of collaborations, partnerships, and other relationships established with external entities that allow a firm to create value [38]. The notion of intellectual capital efficiency also takes into account the efficiency of the physical and financial capital employed (CEE), based on the consideration that intellectual capital cannot create value on its own [15]. On these grounds, Pulic proposes an aggregated indicator, the value-added intellectual capital coefficient (VAIC), which intends to measure how much value added has been created within a given amount of physical and intellectual capital [14]. The details of the calculation of VAIC and its main shortcomings are discussed in the methodology section.

Healthcare firms possess vast structured and unstructured stockpiles of intellectual capital. As with all knowledge-intensive firms, the most valuable form of intellectual capital of healthcare firms is the knowledge, skills, and experiences of their leaders and professionals (human capital). The structural capital of healthcare firms includes the knowledge embedded in their organizational structure and routines, health technologies, communication tools, and all the Information Technology solutions used for healthcare services. It also includes the knowledge created through research and development activities, such as scientific research projects focused on clinical effectiveness, service delivery, and the development of patents and other research products [39]. Furthermore, healthcare firms derive knowledge-based value from the relationships with their several stakeholders such as patients, other healthcare firms, local governments, regions, voluntary organizations, universities, and research institutions [18,39]. Therefore, given the substantial presence of intellectual assets, one may argue that variations in the performance of healthcare firms may be explained, to some extent, by the firms' efficiency in managing and leveraging IC [17].

2.2.1. Digitalization and Intellectual Capital Efficiency

Recent research suggests that the digitalization trend, notably the industry 4.0 trend, generates new flows of intellectual capital that boost a firm's ability to compete in the current knowledge era of business [40].

Digitalization is altering the distribution of human and technical resources in production and the process of organizational learning, which leads to the creation, reconfiguration, and upgrade of a firm's intellectual capital. Indeed, digital transformation is playing a massive role in equating, rethinking, and redefining human resources skills and capabilities [41]. On the one hand, new technologies such as artificial intelligence are increasingly competing with human capital [42], particularly displacing low-skilled workers performing routine tasks [43]. On the other hand, digitalization raises the demand for highly skilled and highly educated workers, thus increasing the overall human capital of firms. Consequently, recruiting or equipping workers with the ability to thrive in the digital era has become a strategic business imperative [44]. The use of cyber-physical systems and data mining technologies will in fact require more 'digitally knowledgeable' people

endowed with systemic analytical skills, active learning, and a problem-solving orientation [40]. This, in turn, leads to an increase in human capital efficiency.

The potential of digitalization to promote human capital efficiency has been documented in recent studies. Song et al. [45] found that digitalization promotes labor efficiency by improving the level of human capital. Cette et al. [46] focused on big data and cloud computing technologies and showed they improve a firm's labor efficiency to a significant extent.

Digitalization has a significant impact on firms' structural capital as well. Advanced digital technologies such as the Internet of things, cloud computing, big data, and analytics enhance the firm's capabilities to gather and process information related to the manufacturing environment, thus leading to the formation of vast amounts of data and information that, through intelligent data analytics, is converted into formalized knowledge—that is, new structural capital. For instance, machine-to-machine communication and cloud computing enable the full sharing, on-demand use, and optimal allocation of information required by production, which results in greater operational efficiency (Li et al. [1]). Big data and predictive analytics may further help to gather, store, extract, and analyze valuable data and information, thus generating additional knowledge in support of the decision-making processes. Importantly, big data analytics may help organizations to capture and codify tacit knowledge and convert it into new intellectual capital, particularly in healthcare settings [47]. Overall, the enhanced information processing capabilities enabled by digital technologies contribute to the creation of new structural capital [40], which represents another key enabler to improve production efficiency and attain a competitive advantage. Based on the above discussion, we hypothesize that:

Hypothesis 2 (H2). *Digitalization promotes intellectual capital efficiency in healthcare firms.*

2.2.2. Intellectual Capital Efficiency and Firm Financial Performance

Many empirical studies have examined the effect of intellectual capital efficiency on a firm's financial performance using the VAIC methodology. Many of these studies provide evidence of a positive association between the intellectual capital coefficient and financial performance [48–51], although a few studies report a negative association [52] or no significant association at all [53,54].

Regarding the individual components of VAIC, studies have provided mixed evidence as to their role in enhancing profitability. Sardo and Serrasqueiro [55,56], Gupta et al. [50], and Nadeem et al. [49] provided evidence that all three components of VAIC have a positive impact on financial performance (ROA and ROE). Other studies, however, found that only a single component of VAIC is associated with financial performance. To name a few, Maditinos et al. [52], Joshi et al. [57], Meles et al. [48], Chowdhury et al. [58], and Zhang et al. [54] reported that only human capital efficiency has a positive impact on financial performance, while Firer and Williams [59], Mehralian et al. [53], and Tiwari [51] found a positive association only with CEE.

Some of the aforementioned studies have focused on healthcare and its subsectors. Gupta et al. [50] used a sample of Indian pharmaceutical firms and found a positive association between overall IC efficiency (VAIC) and financial performance (ROA and ROE). They also found HCE, SCE, and CEE to have a significant impact on firm profitability. Chowdhury et al. [58] and Zhang et al. [54] reported that the financial performance (ROA) of the pharmaceutical industry is predominantly driven by HCE. Vishnu and Gupta [60] focused on private hospitals and medical research centers in India and found a positive financial impact of SCE and CEE but not HCE. In contrast, Tiwari [51] found that CEE is the only VAIC component that drives the financial performance of healthcare firms (hospitals, medical equipment, clinical trials, outsourcing, and other organizations that facilitate the provision of healthcare to patients) in India.

Taken together, the reviewed literature suggests that firm digitalization may enhance the firm's efficiency in using its intellectual capital, and this in turn may improve its

financial outcomes. In other words, intellectual capital efficiency may exert a mediating effect on the association between digitalization and a firm's financial performance as depicted in Figure 1. Hence, we propose:

Hypothesis 3 (H3). *Intellectual capital efficiency (VAIC) mediates the impact of digitalization on healthcare firms' financial performance.*
Hypothesis 4 (H4). *Human capital efficiency mediates the impact of digitalization on healthcare firms' financial performance.*
Hypothesis 5 (H5). *Capital employed efficiency mediates the impact of digitalization on healthcare firms' financial performance.*
Hypothesis 6 (H6). *Structural capital efficiency mediates the impact of digitalization on healthcare firms' financial performance.*

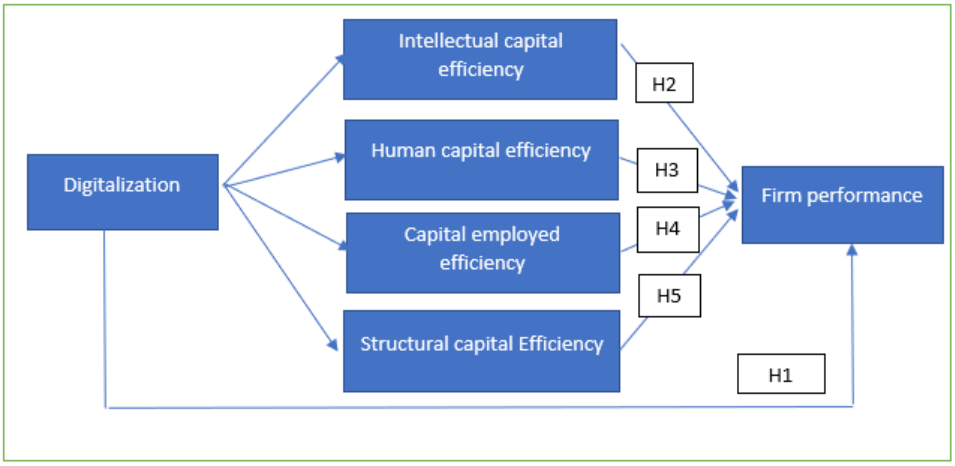

Figure 1. The research model.

3. Materials and Methods

3.1. Sample and Data Collection

We used a sample of 193 listed healthcare firms from 12 EU countries over the period 2017–2021. We defined healthcare firms according to the global industry classification standard (GICS) as including healthcare equipment and services providers, pharmaceutical firms, biotechnology firms, and related life sciences service providers.

The initial sample consisted of 206 firms, and after eliminating firms with missing data, the final sample was 193 firms.

The sample firms included in this study are from the following countries: Austria (1), Belgium (12), Denmark (12), Finland (7), France (38), Germany (5), Greece (1), Ireland (15), Netherlands (4), Slovenia (1), Spain (5), and Sweden (92). The period of study was confined to 2017 to 2021 as the reporting of the digitalization index (DESI) began in 2017 and the latest financial year data available were up to 2021 at the time of conducting this research.

3.2. Research Model

The following models are estimated in this research:

$$FirmPerf_{i,t} = \beta_0 + \beta_1 Int\_Digitech_{i,t} + \sum Controls_{i,t} + Year + \varepsilon_{i,t} \quad (1)$$

$$IntellectualCapital_{i,t} = \alpha_0 + \alpha_1 Int\_Digitech_{i,t} + \sum Controls_{i,t} + Year + \varepsilon_{i,t} \quad (2)$$

$$FirmPerf_{i,t} = \delta_0 + \delta_1 IndVariable_{i,t} + \gamma_1 IntellectualCapital_{i,t} + \sum Controls_{i,t} + Year + \varepsilon_{i,t} \quad (3)$$

where:

- FirmPerf denotes firm performance.

- Int_Digitech denotes the integration of digital technologies by businesses.
- IntellectualCapital denotes intellectual capital efficiency (VAIC), human capital efficiency (HCE), structural capital efficiency (SCE), and capital employed efficiency (CEE).
- Controls refer to the control variables.
- β_1 refers to the impact of Int_Digitech on FirmPerf.
- α_1 refers to the impact of Int_Digitech on IntellectualCapital.
- δ_1 refers to the direct impact of Int_Digitech on IntellectualCapital.
- $\delta_1 * \gamma_1$ refers to the mediating effect of IntellectualCapital in the process of Int_Digitech affecting FirmPerformance.

3.3. Variables Measurement

3.3.1. Dependent Variables

We followed previous research on digitalization that captures a firm's financial performance by ROA and ROE [6,23,34] where ROA is the net earnings to total assets and ROE is the net earnings to equity. ROA indicates how efficiently the assets have been used to generate profits. A higher ROA indicates that more profit is generated from invested capital in the form of assets. ROE measures the firm's profitability in relation to each share, thus being a valuable ratio for shareholders. ROA is widely relied upon by managers and analysts and is the primary dependent variable of this study whereas ROE is used as a robustness check as observed in prior studies [50,60–62]. According to Ferraro and Veltri [63], IC variables do not reflect a meaningful relationship with market value, thus they were not considered a firm performance measure in this study.

3.3.2. Independent Variable

The core explanatory variable is the integration of digital technologies by businesses. This variable is measured by the 'Integration of digital technology' index [64], which together with other indicators comprises the Digital Economy and Society index (DESI) developed by the European Commission in order to capture and keep track of the digital performance of its member states. This DESI dimension specifically measures the level of digitalization of firms and, in particular, the degree to which firms integrate digital technologies in their business processes from a very basic to an advanced level. These include the use of social media and electronic information sharing, but also the use of more advanced technologies such as big data analytics, cloud services, and artificial intelligence. This information was sourced from the European Union survey on ICT usage and e-commerce in businesses.

3.3.3. Mediating Variables

This study used the VAIC coefficient and its individual components (HCE, SCE, and CEE) to examine the mediating role of intellectual capital efficiency between digitalization and financial performance. Andriessen [65] and Stähle et al. [66] criticized the VAIC, arguing it has no correlation with intellectual capital but rather measures the labor and capital efficiency of a firm. In contrast, Iazzolino and Laise [35] clarified that the VAIC is not meant to measure the value of intellectual capital, but the value created by the firm's investment in intellectual capital, based on the accounting concept of value added. Thus, it should be properly understood as an accounting tool to measure value creation in a knowledge economy context. Although this method and its calculation are not free of limitations [67–69], it is widely used by researchers for its ease of use and understandability in complex quantitative analyses of intellectual capital [58].

3.3.4. Control Variables

We included a set of control variables, namely firm size, financial leverage (LEV), inflation, and gross domestic product. Firm size may affect the availability of resources to invest in digital transformation and the success of the digitalization strategy [23].

Many of the studies in the extant literature advocate that high leverage may negatively affect financial performance [12,34,70]. Finally, following previous studies [71,72], we controlled for inflation and GPD to capture the impact of the macroeconomic environment on firm performance. Our econometric model also accounts for year-fixed effects. The detailed variable definitions are presented in Table 1.

Table 1. Variable definitions.

Variable	Acronym	Definition	Source	References
Return on asset	ROA	The ratio of net earnings to total assets	S&P CapitalIQ and authors' calculation	Guo and Xu [3], Yang and Yee [23], Peng and Tao [28], [Dalwai et al. [72]
Return on equity	ROE	The ratio of net earnings to equity	S&P CapitalIQ and authors' calculation	Du and Jiang [4], Peng and Tao [28], Eremina et al. [29], Zhai et al. [34]
Digitalization	Int_digitech	The Integration of Digital Technologies Index	S&P CapitalIQ and authors' calculation	Russo [64]
Intellectual capital efficiency	VAIC	HCE + SCE + CEE	S&P CapitalIQ and authors' calculation	Pulic [14–16], Shahzad et al. [70], Dalwai and Salehi [73]
Human capital efficiency	HCE	HCE = Value added divided by personnel cost (human capital) Where: Value added = Net income + personnel costs + interest + taxes + depreciation & amortizations	S&P CapitalIQ and authors' calculation	Pulic [14–16], Shahzad et al. [70], Dalwai and Salehi [73]
Structural capital efficiency	SCE	SCE = Value added divided by structural capital, Where: Structural capital = value added minus human capital	S&P CapitalIQ and authors' calculation	Pulic [14–16], Shahzad et al. [70], , Dalwai and Salehi [73]
Capital employed efficiency	CEE	CEE= Value added divided by capital employed	S&P CapitalIQ and authors' calculation	Pulic [14–16], Shahzad et al. [70], Dalwai and Salehi [73]
Firm Size	Firm Size	The natural logarithm of total assets	S&P CapitalIQ and authors' calculation	Guo and Xu [3], Cheng et al. [13], Yang and Yee [23], Zhai et al. [33], Dalwai et al. [72]
Leverage	Leverage	The ratio of total liabilities to total assets	S&P CapitalIQ and authors' calculation	Du and Jiang [4], Zeng et al. [12], Cheng et al. [13], Zhai et al. [34]
Growth	Growth	Annual change in revenue	S&P CapitalIQ and authors' calculation	Zeng et al. [12]
Capitalization	Capex	The ratio of capital expenditure to total assets	S&P CapitalIQ and authors' calculation	Bendig et al. [74]
Inflation	Inflation	Inflation rate	World Bank	Sanchez-Riofrio et al. [71], Dalwai et al. [72]

Gross domestic product	GDP	The growth in real GDP	World Bank	Sanchez-Riofrio et al. [71], Dalwai et al. [72]

4. Results and Discussion

4.1. Descriptive Analysis

Table 2 presents the descriptive statistics of the variables used in this study.

The firm financial performance is proxied by ROA and ROE for the listed healthcare sector firms of the European countries. The average ROA and ROE is −0.26 and −0.33, respectively, for the last 5 years. The firm digitalization score is denoted by Int digitech. The minimum and maximum digitalization scores are 4.14 and 13.35, respectively, suggesting that firms from different countries vary in their digital maturity. The overall intellectual capital efficiency of the firms is represented by VAIC, and its average is 1.62. The major contributor to the VAIC is structural capital efficiency (SCE). This is inconsistent with previous studies on healthcare-sector firms that reported HCE to be a higher contributor to the VAIC [50,51].

In addition to firm-level control variables, this study also includes country-level macroeconomic indicators, inflation, and GDP. The average inflation for the European countries was 1.41 with the highest being 3.09 in some. The average GDP was at 1.95 with the minimum being at −10.82 and a maximum of 13.48.

Table 2. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
ROA	965	−0.26	0.36	−1.8	0.97
ROE	965	−0.33	4.94	−67.17	72.9
Int_digitech	965	9.08	2.16	4.14	13.35
VAIC	965	1.62	9.21	−46.03	125.72
HCE	965	−0.03	3.67	−45.9	37.03
SCE	965	1.62	7.12	−10.08	87.72
CEE	965	0.03	0.38	−2.58	6.02
Firm Size (ln)	965	4.75	1.08	0	8.15
Leverage	965	2.41	1474.08	−31093.42	13170.36
Growth	965	11.58	50.15	−99.81	274.05
Inflation	965	1.41	0.71	−1.25	3.09
GDP annual growth	965	1.95	3.86	−10.82	13.48

4.2. Correlation

Table 3 presents Pearson's correlation coefficient estimation between the dependent and explanatory variables.

An insignificant correlation exists between digitalization and firm performance measures. However, intellectual capital variables are significantly and positively correlated with ROA. CEE has the highest correlation coefficient of 0.50 with ROA. This positive correlation is consistent with previous research [73,75,76].

The control variables also suggest that large-sized (FirmSize) healthcare firms with better growth opportunities have a higher ROA. The correlation coefficient analysis also supports identifying multicollinearity issues in explanatory variables. Prior studies recommend a 0.9 correlation coefficient as a maximum to signify no multicollinearity issues [77]. The VAIC and SCE variables have a correlation coefficient of 0.92; however, they are used separately in equations 2 and 3, and not in the same model. The other explanatory variables do not have a correlation coefficient of more than 0.9, thus suggesting no multicollinearity issue.

Table 3. Pairwise correlations.

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. ROA	1.00											
2. ROE	0.03	1.00										
3. Int_digitech	−0.04	0.02	1.00									
4. VAIC	0.35 ***	0.05	0.02	1.00								
5. HCE	0.31 ***	0.04	0.04	0.67 ***	1.00							
6. SCE	0.26 ***	0.04	0.00	0.92 ***	0.33 ***	1.00						
7. CEE	0.50 ***	−0.04	0.08 **	0.52 ***	0.55 ***	0.34 ***	1.00					
8. Firm Size	0.54 ***	0.00	−0.13 ***	0.30 ***	0.21 ***	0.27 ***	0.13 ***	1.00				
9. Leverage	−0.01	−0.17 ***	−0.03	−0.01	−0.01	−0.01	0.00	0.01	1.00			
10. Growth	0.07 **	0.03	0.03	0.03	0.05 *	0.01	0.07 **	−0.02	0.03	1.00		
11. Inflation	−0.13 ***	−0.02	0.17 ***	−0.06 *	0.00	−0.07 **	0.00	−0.17 ***	0.00	0.03	1.00	
12. GDPgrowth	−0.01	0.03	0.11 ***	0.04	0.06 *	0.01	0.01	0.08 **	−0.01	0.02	0.51 ***	1.00

Notes: *p*-values in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

4.3. Regression Analysis

This study applies the ordinary least squares (OLS) statistical technique for testing its hypothesis. To check the heteroskedasticity of the model, the Breusch–Pagan/CookeWeiseberg and Cameron and Trivedi's tests were applied. Some of the models suggested the variance was not homogenous thus the robust standard errors were applied in all models. The multicollinearity was tested using Pearson's correlation in Table 2 and through variance inflation factor (VIF) for all the models. None of the variables had a VIF greater than 10, confirming no multicollinearity issue. The study applied the Stata v15 sgmediation command to test the mediation effect.

Table 4 presents the results of the intellectual capital efficiency playing a mediator role in the relationship between digitalization and firm performance of healthcare-sector firms using the mediating effect test method [78].

There are three steps delineated to indicate the presence of mediation [79]. First, digitalization should be significantly linked to firm performance. Second, digitalization should have a significant impact on the mediator variable of intellectual capital efficiency. Third, a complete regression model is tested using both digitalization and intellectual capital efficiency, whereby the direct impact of digitalization on firm performance is either significant (partial mediation) or non-significant (full mediation).

The regression results of model 1, which examines the impact of digitalization (Int_digitech) on ROA, indicate a significant and positive relationship. The model has a satisfactory explanatory power (R-sq = 0.320) and was significant at 1%. This result lends support to H1 and is consistent with prior studies that have also reported a positive impact of digitalization on firm financial performance [1,12,13,23,28,32].

Panel A presents the results regarding the mediation effect of VAIC. Model 2 confirms a positive and significant relationship between digitalization and VAIC as per H2, and the result is significant at 1%. The result is consistent with the findings of Gravili et al. [47] that digital technologies enhance the intellectual capital performance of healthcare firms.

Model 3 is then estimated including both the independent and the mediating variable. Int_digitech and VAIC are both significantly positive. This signifies the relationship between digitalization and ROA is partially mediated by VAIC, which corroborates H3.

The significance of the mediation effect is measured using the Sobel test, which is the most commonly used estimate [80]. The test was introduced by Sobel [81]. It uses the standard error of a (representing the X coefficient in the X impact on the M regression model), standard error of b (representing the M coefficient in the M impact on the Y regression model). The Sobel test would generate an approximate estimate of the standard error ab (representing the indirect effect in the X impact on the Y relationship while controlling for mediator M). The Sobel test is significant at the 1% level, confirming the robustness of the mediation result. The mediating effect of intellectual capital efficiency between firm digitalization and financial performance is a novel finding and enriches the scarce empirical studies that indicate a mediating role of this variable between the firm's processes and its financial performance [70,82–84].

The relationship is simultaneously tested for all the components of IC as the mediating variable. Panel B presents the mediation effect of HCE. The results of Model 4 show that Int_digitech is significantly and positively associated with HCE at the 5% significance level. This result is consistent with the findings of Song et al. [45] and Cette et al. [46]. Model 5 confirms a positive and significant relationship between Int_digitech and ROA, with the mediating variable HCE also being significant. This suggests a partial mediation effect as both the direct and indirect impact of digitalization on financial performance is significant. The result of Sobel also confirms the mediation effect. This lends support to H4.

Panel C presents the mediation effect of CEE. Model 6 suggests digitalization is positively and significantly associated with CEE. Model 7 indicates a full mediation effect of CEE on the relationship between digitalization and ROA because Int_digitech becomes insignificant in explaining the variation of ROA and the Sobel test confirms the mediation effect. This lends support to H5.

Panel D presents the mediation effect of SCE. Model 8 reflects a positive and significant relationship between Int_digitech and SCE. This result is consistent with the argument of Chernenko et al. [40] that digital technologies lead to the creation and efficient use of new structural capital by enhancing the information processing capabilities of firms. Model 9 shows a significant direct and indirect effect of digitalization, as both Int_digitech and SCE are positive and significant to explain the variation in ROA. This suggests SCE has a partial mediation effect, corroborating H6. Previous research in healthcare settings has also reported a positive association between SCE and financial performance consistent with the finding of this study [50,54,60].

Among the control variables, firm size consistently and significantly affects firm performance in all the panel results. This suggests that large-sized healthcare firms have better financial performance, consistent with previous findings [50,51]. Leverage has no significant impact on firm performance, which is also in accordance with previous findings in healthcare settings [51,58].

Table 4. Results of the mediation effect of intellectual capital efficiency on the relationship between digitalization and firm performance (ROA).

	Panel A: Mediation Effect of VAIC			**Panel B: Mediation Effect of HCE**		**Panel C: Mediation Effect of CEE**		**Panel D: Mediation Effect of VAIC**	
	Equation (1) Model 1 ROA	**Equation (2) Model 2 VAIC**	**Equation (3) Model 3 ROA**	**Equation (2) Model 4 HCE**	**Equation (3) Model 5 ROA**	**Equation (2) Model 6 CEE**	**Equation (3) Model 7 ROA**	**Equation (2) Model 8 SCE**	**Equation (3) Model 9 ROA**
Int_digitech	0.022 ***	0.569 **	0.018 **	0.151 *	0.0194 **	0.0404 ***	0.00622	0.374 **	0.0203 ***
	(0.000)	(0.002)	(0.003)	(0.041)	(0.001)	(0.000)	(0.252)	(0.008)	(0.001)
VAIC			0.00740 *						
			(0.000)						
HCE					0.0201 ***				

					(0.000)				
CEE							0.401 ***		
							(0.000)		
SCE									0.0055 ***
									(0.000)
FirmSize	0.190 ***	2.780 ***	0.170 ***	0.813 ***	0.174 ***	0.0620 ***	0.166 ***	1.897 ***	0.180 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	−0.0005	−0.0006	−0.00001	−0.0000	−0.00000	−0.00000	−0.00000	−0.00009	−0.00000
	(0.477)	(0.546)	(0.552)	(0.798)	(0.503)	(0.826)	(0.487)	(0.531)	(0.524)
Growth	0.000 **	0.0068	0.0005 **	0.00449	0.000462 *	0.000517 *	0.000344 *	0.00181	0.00054 **
	(0.004)	(0.228)	(0.008)	(0.052)	(0.014)	(0.032)	(0.040)	(0.682)	(0.005)
Capex	0.860 **	0.292	0.858 **	−9.960 **	1.060 ***	1.760 ***	0.155	8.472	0.814 **
	(0.004)	(0.974)	(0.004)	(0.006)	(0.000)	(0.000)	(0.558)	(0.220)	(0.007)
Inflation	−0.0178	−0.811	−0.0118	0.0945	−0.0197	−0.00846	−0.0144	−0.901	−0.0128
	(0.479)	(0.271)	(0.631)	(0.753)	(0.420)	(0.787)	(0.509)	(0.118)	(0.608)
GDP	−0.00831	−0.0919	−0.00763	0.0253	−0.00882	−0.00736	−0.00536	−0.109	−0.00771
	(0.079)	(0.506)	(0.098)	(0.654)	(0.055)	(0.211)	(0.191)	(0.314)	(0.100)
Constant	−1.26 ***	−14.00 ***	−1.156 ***	−5.074 ***	−1.158 ***	−0.527 ***	−1.049 ***	−8.336 ***	−1.214 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	965	965	965	965	965	965	965	965	965
R-sq	0.320	0.104	0.352	0.065	0.359	0.072	0.489	0.086	0.331
aic	419.9	6939.3	375.4	5207.3	364.7	843.1	145.8	6462.3	406.4
p	1.92×10^{-72}	1.36×10^{-17}	2.22×10^{-81}	1.30×10^{-09}	1.23×10^{-83}	6.93×10^{-11}	7.57×10^{-130}	1.13×10^{-13}	7.12×10^{-75}
Sobel Z			0.004		0.003		0.016		0.002
Sobel Z *p*-values			0.004		0.048		0.000		0.028

Notes: *p*-values in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

4.4. Robustness Analysis

As part of the robustness check, Table 5 presents the results of the intellectual capital efficiency playing a mediator role in the relationship between digitalization and ROE as an alternative measure of performance for healthcare-sector firms. Similar to the results reported in Table 4, digitalization impacts ROE significantly and positively (Model 1). Models 2, 4, 6, and 8 indicate that intellectual capital efficiency is positively affected by digitalization. Models 3, 5, 7, and 9 indicate a significant direct and indirect effect because Int_digitech and IntellectualCapital (VAIC, HCE, CEE, and SCE) are simultaneously positive and significant to explain the variation in ROE. This effect is confirmed by the Sobel test validity as well.

Table 5. Results of the mediation effect of intellectual capital efficiency on the relationship between digitalization and firm performance (ROE).

	Panel A: Mediation Effect of VAIC			**Panel B: Mediation Effect of HCE**		**Panel C: Mediation Effect of CEE**		**Panel D: Mediation Effect of VAIC**	
	Equation (1)	**Equation (2)**	**Equation (3)**	**Equation (2)**	**Equation (3)**	**Equation (2)**	**Equation (3)**	**Equation (2)**	**Equation (3)**
	Model 1 ROE	**Model 2 VAIC**	**Model 3 ROE**	**Model 4 HCE**	**Model 5 ROE**	**Model 6 CEE**	**Model 7 ROE**	**Model 8 SCE**	**Model 9 ROE**
Int_digitech	0.061 ***	0.569 **	0.053 ***	0.151 *	0.055 ***	0.040 ***	0.0430 **	0.374 **	0.057 ***

	(0.000)	(0.002)	(0.000)	(0.041)	(0.000)	(0.000)	(0.001)	(0.008)	(0.000)
VAIC			0.014 ***						
			(0.000)						
HCE					0.038 ***				
					(0.000)				
CEE							0.450 ***		
							(0.000)		
SCE									0.012 ***
									(0.000)
FirmSize	0.240 ***	2.78 ***	0.200 ***	0.813 ***	0.208 ***	0.062 ***	0.212 ***	1.897 ***	0.217 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.0000	−0.000	0.0000	−0.0000	0.00000	−0.00000	0.00000	−0.0000	0.00000
	(0.687)	(0.546)	(0.596)	(0.798)	(0.640)	(0.826)	(0.634)	(0.531)	(0.628)
Growth	0.00073	0.0068	0.00063	0.00449	0.00055	0.00052 *	0.00049	0.00181	0.00070
	(0.081)	(0.228)	(0.124)	(0.052)	(0.174)	(0.032)	(0.220)	(0.682)	(0.088)
Capex	0.807	0.292	0.803	−9.960 **	1.190	1.760 ***	0.0148	8.472	0.707
	(0.215)	(0.974)	(0.209)	(0.006)	(0.062)	(0.000)	(0.981)	(0.220)	(0.274)
Inflation	−0.075	−0.811	−0.064	0.0945	−0.0790	−0.00846	−0.0716	−0.901	−0.0648
	(0.164)	(0.271)	(0.231)	(0.753)	(0.136)	(0.787)	(0.171)	(0.118)	(0.229)
GDP	−0.021 *	−0.092	−0.020 *	0.0253	−0.0223 *	−0.00736	−0.0180	−0.109	−0.0200 *
	(0.037)	(0.506)	(0.046)	(0.654)	(0.025)	(0.211)	(0.068)	(0.314)	(0.048)
Constant	−1.74 ***	−14 ***	−1.52 ***	−5.07 ***	−1.55 ***	−0.527 ***	−1.51 ***	−8.34 ***	−1.64 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	965	965	965	965	965	965	965	965	965
R-sq	0.142	0.104	0.174	0.065	0.181	0.072	0.200	0.086	0.155
aic	1900.4	6939.3	1864.9	5207.3	1857.3	843.1	1834.8	6462.3	1887.3
p	8.61 x 10^{-26}	1.3 x 10^{-17}	8.81 x 10^{-33}	1.30 x 10^{-09}	2.47 x 10^{-34}	6.93 x 10^{-11}	5.94 x 10^{-39}	1.13 x 10^{-13}	2.98 x 10^{-28}
Sobel Z			0.008 **		0.006 **		0.018 ***		0.004 *
			(0.005)		(0.050)		(0.000)		0.029

Notes: *p*-values in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5. Conclusions

In the context of pandemic-related challenges and improved customer services, digitalization continues to play a vital role at the country and firm levels. Previous empirical studies have explored the impact of digitalization on different organizational outcomes, but limited research has evaluated the financial impact of digitalization and the underlying mechanisms that explain this impact. Research should also consider cross-national variations in patterns of firm-level adoption of digital technologies because national variations in wealth, institutions, and culture may create a more or less supportive environment for firm digitalization [10]. In light of this, our research explored the relationship between digitalization and financial performance using a sample of healthcare firms from 12 European Union countries. The study also examined the mediating impact of intellectual capital efficiency and its sub-components in the process of digitalization affecting firm performance for the period from 2017 to 2021. The results suggested that digitalization had a positive impact on financial performance, and this was also confirmed by a robustness test. The capital employed efficiency had full mediation whereas intellectual capital efficiency, human capital efficiency, and structural capital efficiency had partial mediation in the process of digitalization influencing firm performance.

The results of this study may have diverse practical implications. For managers, the results of this study make the case for investing in digitalization as they provide evidence of significant business improvements in terms of increased intellectual capital efficiency, which may ultimately lead to improving financial outcomes. The results may also inform regulators in deciding whether to promote digitalization as a strategy from a country-level perspective. Global investors would also seek investment in countries where firms give more prominence to digitalization as it contributes to improving their financial performance.

This study also contributes to research on firm digitalization and financial performance, which thus far has barely examined the mediating mechanisms of this association. In particular, it enriches the empirical literature on healthcare, establishing the mediating role of intellectual capital efficiency on the relation between digitalization and financial performance in this highly knowledge-intensive sector.

This study suffers from certain limitations which can direct future research. First, we focused on healthcare-sector firms only. The study can be extended in the future to cover other sectors. Second, we only considered the impact of firm digitalization on financial performance. Future studies may also consider the digitalization of consumption (i.e., market digitalization) and its impact on firm performance as recent research suggests [71 Sanchez Riofrio et al. 2022]. Third, our study relies on the VAIC, which is a quantitative measure of intellectual capital efficiency and thus suffers from the inherent limitations of this method. In the future, intellectual capital efficiency can be measured through a survey instrument in order to provide a stronger measure of intellectual capital efficiency. Lastly, the firm performance measures included only accounting-based performance measures. Future studies could investigate market-based firm performance measures such as Tobin's Q or the stock growth rate.

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