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The role of digital technologies in firms' performance: A panel data study on family firms and SMEs

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Abstract

In the current big data era, digital technologies play a vital role for firms to improve their business and economic growth. Considering the firm type and the firm size, this study explores how digital technologies impact their performance in the financial and employment perspectives. The performance variables are presented at the capital, profit, debt-paying, and development levels from Total Economy Database TM and the Amadeus database for European companies from 2008 and 2019, in a panel data analysis. In this study, the sample only consists of good companies that generate profit. The results demonstrate that digital technologies positively affect shareholders' funds to a greater degree for non-family firms and non-SMEs. They make a positively larger impact on the return on capital employed by non-family and non-SMEs. Digital technologies would increase the solvency ratio for firms, except for SMEs. Finally, they make a positively larger impact on the operating revenue for firms that are non-family and non-SMEs, while the opposite is true for family firms and SMEs. Scientific research on digital technologies has significant managerial importance and competitiveness connecting family firms and SMEs. The research makes contributions for the relevant literature on digital technologies and offers four perspectives affecting performances. The findings benefit scholars, managers, and policymakers of family firms and SMEs.

Keywords: *Digital technologies, financial performance, employment, family firms, SMEs.*

JEL Classification: O12, M13, M21

1 INTRODUCTION

Firms are increasingly adopting emerging technologies to drive a process of improvement to digital operations (Kessler et al., 2022). Digital technologies (DTs) have played essential roles in firms due to their advantages and features (De et al., 2020; Gupta et al., 2020). In this regard, scholars and entrepreneurs have examined the influence of digital technologies on companies' performances (Yan et al., 2021). However, few studies focus on how digital technologies comprehensively impact financial performances in terms of family firms and small and medium enterprises (SMEs). Often, scholars study the effect of digital technologies on a kind of firm type or size, which is reductionist (Dutta et al., 2021; Han & Trimi, 2022).

There are different impact degrees or types for family firms or SMEs from the financial and employment perspectives, though previous studies suggested that digital technologies have been relevant in promoting firms' success factors. For example, SMEs have fewer assets, a lower capital reserve, and lower levels of productivity than larger firms, and thus, they are more vulnerable due to economic turbulences, such as financial crises (Qin et al., 2021;Wang et al., 2021). Recent studies have suggested that appropriate adoption of digital technologies could enhance performance, productivity, and competitiveness, since they crosslink the value creation process (Xu et al., 2021). Neumeyer et al. (2021) determined that innovation adoption is a critical factor of long-term competitive advantage in firms. Despite limited resources, SMEs appear to be unaffected by the waning inclination to use digital technologies and are more likely

to strengthen their digital exports (Elia et al., 2021). The existing literature notes that some entrepreneurs have succeeded in financing their firms due to the advent of digital technologies, which shows the importance of digitization in improving efficiency and productivity in SMEs (Stankovska et al., 2016).

As for family firms, researchers have investigated the effects of DTs on performance, and they have presented two views. One believes that compared with non-family enterprises, DTs have a more significant impact on family enterprises, because there is a positive correlation between digital business innovation and family enterprises (Soluk et al., 2021). On the other hand, researchers think that family business managers do not prefer the risks associated with exploratory technologies, and the benefits brought by diversification are lower than the cost of giving up family-centered goals, and the participation of family managers restricts the development of exploratory DTs innovation to a certain extent (Ceipek et al., 2021). Due to the economic features of family enterprises, there are substantial but ambiguous effects when adopting DTs(Qin et al., 2021). There is limited evidence on how DTs comprehensively impact performances of family firms or SMEs, and exploring these effects is exciting from multiple perspectives. Clearly, there is a strong need for a systematic understanding of the performance of firms driven by digital technologies.

However, little literature has explained the effect of DTs on different types and sizes of firms. Firms' performances could be divided into four dimensions: capital ability, profitability, debt-paying ability, and development ability (Joura et al., 2021). A multidimensional level helps understand different influences of DTs on performance. Our work aims to fill this research gap according to panel data analysis, and we explore the effect of DTs on the separate performances at four levels for different kinds of firm types and firm sizes.

This study documents the current changes in family firms or SMEs and the impacts of DTs on their performances. In this process, we mainly study four kinds of performance: capital capacity, profitability, debt-paying ability and development ability, and four different types of enterprises: family firms, non-family firms, SMEs and non-SMEs. There is a lack of empirical research on the relationship between DTs and these performances across different business types and sizes, respectively.

The contributions of this study mainly concern the effects of DTs on four kinds of performances by four kinds of firms. First, the capital ability of the firm is the actual performance, and we investigate how DTs influence this performance, which encourages the boards to take into account capital orientation, such as shareholders' funds, to contribute to the firm's strategies for practical allocating resources with the effect of DTs in terms of family firms or SMEs. Second, the relationship between the level of profitability of the firm and DTs is explored for family firms or SMEs, which contributes to the firm's operation through its links to the operating model and the external environment. Third, we confirm the influence of DTs on the role of the debt-paying ability of the firm. The findings are different in terms of firm type and size, which contribute to enhancing risk capacity and improving firm risk management, especially for entrepreneurs and shareholders for family firms or SMEs. Fourth, we discuss the effect of DTs on the development ability of the firm from the financial and employment perspectives, which contributes to improving the firm's development management. Boards of directors could make rational decision-making depending on the findings.

The rest of this paper is constructed as follows: Section 2 reviews literature on digital technologies for firms. Section 3 presents the data and the model. The results and discussions comein Section 4. Section 5 concludes the work.

2 THEORETICAL BACKGROUND

DTs, such as big data, artificial intelligence, the Internet of things, Industry 4.0, cloud computing, and block-chain technology, use digital coding to express, transmit and process information through a computer, communication satellite and other equipment, and have been becoming valuable sources of competitiveness for contemporary firms (Ancillai et al., 2023). The literature explores the impact of DTs from several perspectives, however, researchers agree that DT has improved companies' ability to cope with challenges in the rapid development era. For example, DTs at the director's level make it possible to achieve close engagement, and promote the management by better communication processes. On the other hand, directors who are ill-equipped or digitally illiterate may misunderstand and ignore external changes caused by competition (Oliveira et al., 2022). At the social value level, firms would be faster and more frequent in their communications with customers, suppliers, strategic partners, and investors (Bergh et al., 2019). At the economic value level, DTs enhance operational efficiencies and improve firm competitiveness to provide timely information related to markets and products. An excellent understanding of DTs could promote the managers' sustainable competitive advantage (Cambrea, 2021).

The existing literature shows that DTs improve the efficiency for firms in the short term, but it also has a serious negative impact on learning ability, emotions, and consume the ability of relationship capital and human capital. (Usai et al., 2021). Some researchers have recognised that DTs have a role to play in achieving competitive advantage in business performance (Shih & Tsai, 2016). For example, DTs incorporate a standardized knowledge that has forced companies to do intelligent work and distance learning during the COVID-19 era, relying entirely on having unique resources that competitors cannot easily copy (Baia et al., 2020). Table 1 lists studies about the relationships of DTs and firms.

Tab. 1 – Recent studies about DTs and firms. Source: own research

Reference	Sample	Country	Feature of firms	Aspect
Oliveira et al. (2022)	26	UK	Medium-sized	Board director capabilities
Troise et al. (2022)	28	European firms	SMEs	Innovation capability
Baia et al. (2020)	107	Portuguese	Knowledge-intensive business service firms	Value, rareness, competitive Advantage, and performance
Ceipek et al. (2021)	204	US	Fortune 500 manufacturing firms	Prior economic performance
Ricci et al. (2021)	174	Italy	SMEs	Knowledge search paths
Elia et al. (2021)	102	Italy	Small, medium, and large firms	Digital export drivers
Soluk & Kammerlander (2021)	15	Germany, Austria, and Switzerland	Family-owned Mittelstand firms	Managerial aspects

By and large, DTs have a positive impact on firms in the short run, especially in an uncertain and complex environment. Although researchers have found a positive correlation between DTs and a firm's performance, recent studies revealed that the impact of DTs on different levels of firm performance is ambiguous. Therefore, this work aims to improve understanding of the impact of DTs on four types of businesses: family, non-family, SMEs and non-SMEs. In addition, we study four different capabilities of firms' performance, and explore the impact of DTs on the four results for the four kinds of firms.

In this paper, we measure the effect of DTs on performance in terms of firm type and firm size, respectively. The four specific parts, within the domain of the financial view of the firm, that are examined in our research model are (1) capital ability; (2) profitability; (3) debt-paying ability; and (4) development ability. To be specific, total assets, cash flow, and shareholders' funds reflects capital ability; Profit or loss before taxes, net income, return on equity, and return on capital employed are regarded as profit performance; Current ratio and solvency ratio based on asset are considered as debt paying performance; Operating revenue, profit margin, and the number of employees represent development performance.

3 RESEARCH OBJECTIVE, METHODOLOGY AND DATA

The research objective is to explore the effect of DTs on the separate performances at four levels for different kinds of firm types and sizes. According to the systematic literature reviews, adopting DTs could result in an increased need for investments from stakeholders, and the following hypothesis is proposed:

H1. DTs have a positive effect on shareholders' funds performance for firms.

In DTs, the number of employees will be controlled, and they face a role transition from operators to problem solvers. This provides the necessary flexibility for employees to function responsively and increases the return on capital employed. Thus, we formulate the following hypothesis:

H2. DTs have a positive effect on the return on capital employed performance for firms.

Considering that DTs may increase the financial leverage, thereby increasing the risk, the following hypothesis is proposed:

H3. DTs harm solvency ratio performance for firms.

DTs and the intelligent environment allow firms to sustain the consumer demands and rapidly changing environment, increase the operating revenues, and promote the development of the firm. Therefore, our last hypothesis is as follows:

H4. DTs have a positive effect on operating revenue performance for firms.

To explore the effect of DTs on firms' performance at type and size levels, we used the Total Economy Database TM and the Amadeus database to collect relevant data from 2008 and 2019.

For the firm-type data, we consider family and non-family. According to the Global Family Business Index methodology 2019, a family firm is supposed to meet at least three conditions (Skare & Porada-Rochon, 2021): (1) The enterprise is controlled by the second generation or above; (2) One or more is a member of the board of directors or a member of the management team and participates in the operation and management; (3) The family holds a considerable share of the company. Specifically, this applies to public companies with more than 50 percent of private voting rights and shares in the company, and families with at least 32 percent of voting rights and shares in the company. As a result, 62 family businesses are included in the 2019 Global Family Business Index. In terms of non-family businesses, the 2019 Fortune Global 500 list offers the largest non-family businesses and includes corresponding business metrics from the Amadeus database. Therefore, we found 98 non-family companies from the 2019 Fortune Global 500 list and listed them in the Amadeus database.

For the firm-size data, we considered SMEs and non-SMEs. There are different definitions of SMEs based on the number of employees and revenues in different countries (Child et al., 2022). To ensure the validity, we collected firms with the more significant turnover or employment in the databases. Under such a circumstance, we judged a selected firm, whether a SME or not, by comparing the number of employees. In this study, the threshold of employees is set as 2,000, which is the world's leading indicator (Zahoor et al., 2020).

Tab. 2 – Description of variables. Source: own research

Variables	Descriptions	Remark
TURNOVER	Operating revenue	Logarithm
P/L	Profit or loss before taxes	Logarithm
P/L_1	Net income	Logarithm
CF	Cash flow	Logarithm
TA	Total assets	Logarithm
SF	Shareholders' funds	Logarithm
CR	Current ratio	
PM	Profit margin	Percentage
ROE	Return on equity using profit or loss	Percentage
ROCE	Return on capital employed using profit or loss	Percentage
SOL	Solvency ratio	Percentage
EMP	The number of staff	
FAMILY	Family firms or non-family firms	Family firms denoted as 1, non-family firms denoted as 0
SME	SMEs or non-SMEs	SMEs denoted as 1, non-SMEs denoted as 0
ICT	Information and communication technologies	Percentage

The key financial and employment indicators are used with different metrics to ensure the results' robustness (Williams et al., 2020; Yun et al., 2021). To be specific, we pre-process six indicators, which are the operating revenue, profit or loss before tax, net income, cash flow, total assets, and shareholders' funds, using a natural logarithm function to better interpret and analyze, improving the accuracy and reliability of the modeling. Note that missing values or negative numbers in the sample are removed as invalid information, because the domain of the variable should be greater than 0. Moreover, invalid information occupies a small proportion in the panel data, so it will not have a differential impact on the results. Another four indicators, profit margin, return on equity, return on capital employed, and the solvency ratio, are presented as percentages. Two other indicators, i.e., current ratio and the number of employees, are used directly without pre-processing. To measure the effect of DTs on firms at type and size level, respectively, we use the variable of information and communication technologies, changing the percentage for a country where firms are registered, from the Conference Board Total Economy Database (Conference Board, 2021). Nominal data on the ICT investment, including hardware, communication equipment, and software, are deflated using harmonized deflators, based on alternative deflators developed by Byrne and Corrado (2017), updated and revised in August 2021. Table 2 reports the description and metrics of variables.

Furthermore, this study defines two dummy variables to distinguish family firms and SMEs. One is denoted as FAMILY, which defines family firms as 1, while non-family are 0. The other is denoted as SME, which defines SMEs as 1, and non-SMEs as 0. Table 1 lists all variables in this study and their descriptions in detail. This study compiles a data panel covering 62 family firms, and 98 non-family firms between 2008 and 2019. Table 3 reports descriptive statistics for the entire sample data.

Tab. 3 – Descriptive statistics of variables. Source: own research

Variables	Obs.	Mean	Std. Dev.	Min	Max
Id	1.600	80.50	46.20	1	160
Year	1.600	2.014	2.873	2.009	2.018
TURNOVER	1.408	33.348	43.880	0	372.513
P_L	1.387	2.644	4.484	-8.824	42.796
P_L1	1.395	1.924	3.782	-9.378	71.724
CF	1.329	3.900	6.098	-4.796	88.816

TA	1.433	47.824	63.560	0.140	458.156
SF	1.433	17.153	27.274	-2.952	245.092
CR	1.405	2.057	5.992	0.0500	94.44
PM	1.312	8.773	11.22	-31.19	100
ROE	1.365	19.21	24.98	-97.53	368.7
ROE1	1.250	12.36	9.949	-23.52	80.10
SOL	1.437	39.23	19.29	-29.28	100
EMP	1.342	99.445	106.490	1	655.722
FAMILY	1.600	0.388	0.487	0	1
ICT	1.600	10.74	2.814	0.0875	29.99

To measure the impact of digital technologies (ICT as the proxy) on firms' performance, we examine the impact using the ICT indicator on other variables representing different performances between the selected variable in the firm and the year, applying a benchmark regression model (Loterman et al., 2012) in the following form:

$$Y_{it} = \alpha_0 + \alpha ICT_{it} + \beta X_{it} + u_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where $Y_{it} = [Y_{1it}, Y_{2it}, \cdots, Y_{kit}]^T$ is a vector of dependent variables; ICT_{it} is an explanatory variable and is the corresponding estimation parameter.

We establish two group regression models in reduced forms:

$$Y_{it} = \delta_0 + \delta_1 ICT_{it} + \beta X_{it} + u_i + \lambda_t + \varepsilon_{it} \quad if \quad FAMILY = 1 \quad (2)$$

$$Y_{it} = \gamma_0 + \gamma_1 ICT_{it} + \beta X_{it} + u_i + \lambda_t + \varepsilon_{it} \quad if \quad FAMILY = 0 \quad (3)$$

$$H0: \delta_1 = \gamma_1, H1: \delta_1 \neq \gamma_1 \quad (4)$$

Similarly, we establish two group models to indicate the effect of ICT on firms' performance in terms of SMEs and non-SMEs as follows:

$$Y_{it} = \bar{\delta}_0 + \bar{\delta}_1 ICT_{it} + \beta X_{it} + u_i + \lambda_t + \varepsilon_{it} \quad if \quad SME = 1 \quad (5)$$

$$Y_{it} = \bar{\gamma}_0 + \bar{\gamma}_1 ICT_{it} + \beta X_{it} + u_i + \lambda_t + \varepsilon_{it} \quad if \quad SME = 0 \quad (6)$$

$$H0: \bar{\delta}_1 = \bar{\gamma}_1, H1: \bar{\delta}_1 \neq \bar{\gamma}_1 \quad (7)$$

The model is a one-class variable approach in spatial panel data that varies over individuals but not over time, and it is used to explore the relationship between multiple predictors and the target variable and contains one or more fixed effects, which means that the impact of all the predictors is fixed regardless of the number of observations.

4 RESULTS AND DISCUSSION

4.1 The impact of ICT on firms' performance in terms of firm type

Table 4 reports the estimated results about the effect of DTs on the capital ability of firms with different levels of significance.

Tab. 4 – The impact of ICT on capital ability. Source: own research.

Variable	TA			CF			SF		
	All	Family	Non-family	All	Family	Non-family	All	Family	Non-family
ICT	-563.6*** (-4.68)	-9.195 (-0.10)	-601.8*** (-3.70)	60.34* (2.31)	-11.79 (-0.59)	90.68* (2.45)	243.3*** (5.05)	10.76 (0.32)	301.2*** (4.63)
Adj R^2	0.8312	0.9022	0.8345	0.7438	0.5808	0.7525	0.7837	0.9007	0.7921
Samples	1158	379	779	1123	374	749	1158	379	779
Test	9.47 (0.0021***)			4.01 (0.0451**)			8.88 (0.0029***)		

Notes: (1) Figures in the ICT and group-difference test parentheses indicate t-values and p-values, respectively. (2) *, ** and *** represent the 10%, 5% and 1% significance levels, respectively.

In terms of all sample data, when ICT increases by 1%, TA goes down by 563.6%, while CF and SF increase by 60.34% and 243.3%, respectively. The evidence indicates that digital technologies harm TA but positively impact CF and SF. Further considering the firm type, a 1% increase in ICT leads to a decrease (9.195%) in TA, a decrease (11.79%) in CF, and an increase (10.76%) in SF of family firms. At the same time, it results in a decrease (601.8%) in TA, an increase (90.68%) in CF. An increase (301.2%) in SF of non-family firms shows that DTs have a more significant negative effect on TA, and significantly positively impact SF for non-family firms. The difference is that DTs show a negative effect on CF for family firms but have a positive effect on CF for non-family firms. In general, DTs have a positive effect on shareholders' funds performance for firms.

Table 5 lists the estimated results about the impact of DTs on firms' profitability with different levels of significance. Considering P/L and P/L1, there is a consistent and negative impact of ICT for firms, and the impacts are more extensive for non-family firms. Considering ROE and ROCE, the results are different for various firm types. For example, when ICT increases by 1%, ROE increases by 0.0781% for all samples and increases by 0.269% for family firms, but decreases by 0.288% for non-family. On the contrary, a 1% increase in ICT generates a 0.111% increase for all samples and a 0.152% decrease for family firms, but a 0.211% increase for non-family. The results show that ICT has the same impact on P/L and P/L1, but has the inverse impact on ROE and ROCE.

Tab. 5 – The impact of ICT on profitability. Source: own research.

Variable	P/L			P/L_1			ROE			ROCE		
	All	Family	Non-family	All	Family	Non-family	All	Family	Non-family	All	Family	Non-family
ICT	-61.07* (-2.16)	-0.880 (-0.08)	-97.07* (-2.48)	-44.76 (-1.88)	-6.717 (-0.69)	-70.49* (-2.09)	0.0781 (0.40)	0.269* (2.18)	-0.288 (-0.99)	0.111 (1.79)	-0.152 (-1.70)	0.211** (2.92)
Adj R^2	0.5769	0.8117	0.6082	0.7442	0.7924	0.7559	0.4843	0.8028	0.4736	0.6203	0.7795	0.6452
Samples	1123	374	749	1123	374	749	1203	423	780	1123	374	749
Test	7.39 (0.0066***)			4.17 (0.0411**)			2.92 (0.0875*)			5.98 (0.0144**)		

Notes: (1) Figures in the ICT and group-difference test parentheses indicate t-values and p-values, respectively. (2) *, ** and *** represent the 10%, 5% and 1% significance levels, respectively.

Tab. 6 – The impact of ICT on the debt-paying ability. Source: own research.

Variable	CR			SOL		
	All	Family	Non-family	All	Family	Non-family
ICT	-0.00728 (-0.44)	-0.0391 (-0.73)	0.00772 (1.59)	0.140 (1.56)	0.546** (3.14)	0.0479 (0.51)
Adj R^2	0.0980	0.1854	0.0965	0.2619	0.2834	0.3855
Samples	1158	379	779	1203	423	780
Test	0.50 (0.4781)			3.95 (0.0470**)		

Notes: (1) Figures in the ICT and group-difference test parentheses indicate t-values and p-values, respectively. (2) *, ** and *** represent the 10%, 5% and 1% significance levels, respectively.

At the debt-paying ability level, Table 6 reports the estimated results concerning the impact of ICT on CR and SOL. The model concerning ICT and CR test does not meet the lowest significance level. Therefore, we focus on the results from the model of ICT and SOL that has the 0.05 significance level. When ICT increases by 1%, SOL increases by 0.140% for all samples and by 0.546% for family companies and 0.0479% for non-family companies, respectively. The evidence shows that DTs positively impact SOL and have a more significant effect on family firms, which confirms the hypothesis. The phenomenon is related to the leverage of firms. Because family endowment is higher, family firms in active management increase leverage more significantly than non-family firms (Gottardo & Moisello, 2014).

Tab. 7 – The impact of ICT on development ability. Source: own research.

Variable	TURNOVER			PM			EMP		
	All	Family	Non-family	All	Family	Non-family	All	Family	Non-family
ICT	351.7** (3.19)	-2.168 (-0.04)	449.8** (2.85)	-0.0124 (-0.21)	-0.176* (-1.97)	0.0649 (0.87)	-1104.7*** (-3.32)	493.0 (1.19)	-1759.7*** (-4.02)
Adj R^2	0.6172	0.8369	0.6192	0.4127	0.5014	0.4323	0.2619	0.2834	0.3855
Samples	1123	374	749	1237	412	825	1123	374	749
Test	6.78 (0.0092***)			3.77 (0.0522*)			10.53 (0.0012***)		

Notes: (1) Figures in the ICT and group-difference test parentheses indicate t-values and p-values, respectively. (2) *, ** and *** represent the 10%, 5% and 1% significance levels, respectively.

At the development ability level, Table 7 lists the estimated results considering the impact of ICT on turnover, PM, and EMP. In terms of all samples, when ICT increases by 1%, turnover increases by 351.7%, but PM decreases by 0.0124%, and EMP decreases by 1104.7. The impacts of ICT on development ability are different concerning these three indicators. Specifically, turnover decreases by 2.168% for family firms but increases by 449.8% for non-family firms when ICT increases by 1%. A 1% increase in ICT results in a 0.176% decrease in PM for family firms but a 0.0649% increase for non-family firms. EMP increases by 493 for family firms but decreases by 1759.7 for non-family firms when ICT increases by 1%. Interestingly, an increase in DTs will reduce the number of employed workers, especially in non-family firms. The reason may be that new technologies will make some jobs redundant. Non-family businesses mainly rely on market rules to obtain the maximum income, while non-family enterprises depend more on the emotional and trust relationships between members. As a result, the results indicate that DTs have a different impact on family firms. In general, there are positive impacts of ICT on turnover and PM that are in line with the hypothesis, but there is a negative impact of ICT on EMP for non-family firms.

4.2 The impact of ICT on firms' performance in terms of firm size

Similarly, Table 8 reports the estimated results about the effect of DTs on the capital ability of SMEs and non-SMEs. As a result, the model concerning the ICT and CF test does not meet the lowest significance level. Therefore, we focus on the results from the model of ICT and TA with the 0.01 significance level and the model of ICT and SF with the 0.05 significance level. When ICT increases by 1%, TA goes down by 204.6% for all samples and decreases by 225.5%

for non-SMEs but increases by 38.38% for SMEs. On the other hand, when ICT increases by 1%, SF increases by 222.8%, 17.96%, and 230.7% for all samples, SMEs, and non-SMEs, respectively. The evidence indicates that DTs positively impact ICT on TA for SMEs but have a negative impact on non-SMEs. Moreover, there are all positive impacts of ICT on SF for firms and a more significant impact for non-SMEs than SMEs.

Tab. 8 – The impact of ICT on the capital ability of SMEs. Source: own research.

Variable	TA			CF			SF		
	All	SMEs	Non-SMEs	All	SMEs	Non-SMEs	All	SMEs	Non-SMEs
ICT	-204.6 (-1.93)	38.48 (1.85)	-225.5 (-1.93)	26.94 (1.20)	86.50** (3.11)	29.42 (1.18)	222.8*** (4.86)	17.96 (0.16)	230.7*** (4.76)
Adj R^2	0.8248	0.9966	0.8288	0.7438	0.5808	0.7525	0.7828	0.5545	0.8022
Samples	1163	44	1079	1166	44	1082	1199	48	1110
Test	8.35 (0.0039***)			1.61 (0.2048)			6.00 (0.0143**)		

Notes: (1) Figures in the ICT and group-difference test parentheses indicate t-values and p-values, respectively. (2) *, ** and *** represent the 10%, 5% and 1% significance levels, respectively.

Tab. 9 – The impact of ICT on profit ability of SMEs. Source: own research.

Variable	P/L			P/L_1			ROE			ROCE		
	All	SMEs	Non-SMEs	All	SMEs	Non-SMEs	All	SMEs	Non-SMEs	All	SMEs	Non-SMEs
ICT	-38.91 (-1.66)	-3.592 (-1.06)	-53.53* (-1.97)	-31.23 (-1.67)	2.430 (0.53)	-35.58 (-1.62)	0.123 (0.67)	-0.364 (-1.32)	0.0693 (0.36)	0.172* (2.39)	-0.295 (-0.56)	0.126 (1.85)
Adj R^2	0.6614	0.9480	0.6726	0.7442	0.7924	0.7559	0.5267	0.9645	0.5380	0.4235	0.7340	0.5043
Samples	1205	73	1083	1204	71	1083	1163	44	1079	1166	44	1082
Test	2.80 (0.0945*)			3.33 (0.0679*)			2.28 (0.1312)			2.82 (0.0931*)		

Notes: (1) Figures in the ICT and group-difference test parentheses indicate t-values and p-values, respectively. (2) *, ** and *** represent the 10%, 5% and 1% significance levels, respectively.

At the profitability level, Table 9 lists the estimated results about the effect of DTs on the profitability of SMEs and non-SMEs. In this part, we pay more attention to P/L, P/L1, and ROCE due to the significance levels. When ICT increases by 1%, P/L decreases by 38.91%, 3.592%, and 53.53% for all samples, SMEs, and non-SMEs, respectively, which has a consistent and negative impact. In terms of P/L1 and ROCE, the results are different from various firm sizes. P/L1 decreases by 31.23% and 35.58% for all firms and non-SMEs, respectively, but increases by 2.430% for SMEs when ICT increases by 1%. ROCE increases by 0.172% for all samples and increases by 0.126% for non-SMEs, but decreases by 0.295% for SMEs. The findings show that ICT has the same impact on P/L but has the inverse impact on P/L1 and ROCE, for SMEs and non-SMEs. Moreover, ICT has a more significant and negative impact on P/L for non-SMEs than SMEs.

Tab. 10 – The impact of ICT on the debt-paying ability of SMEs. Source: own research.

Variable	CR			SOL		
	All	SMEs	Non-SMEs	All	SMEs	Non-SMEs
ICT	0.0397 (0.87)	0.201 (0.50)	-0.0124 (-1.04)	0.140 (1.56)	-0.706* (-2.06)	0.162* (2.30)
Adj R^2	0.0117	0.0135	0.1684	0.2619	0.7174	0.4616
Samples	1248	75	1117	1203	71	1083
Test	0.22 (0.6388)			4.68 (0.0305**)		

Notes: (1) Figures in the ICT and group-difference test parentheses indicate t-values and p-values, respectively. (2) *, ** and *** represent the 10%, 5% and 1% significance levels, respectively.

At the debt-paying ability level, Table 10 reports the estimated results considering the impact of ICT on CR and SOL of SMEs and non-SMEs. Similarly, we focus on the results of ICT and SOL because it has the 0.05 significance level. When ICT increases by 1%, SOL increases by

0.140% for all samples and 0.162% for non-SMEs but decreases by 0.706% for SMEs, respectively. The evidence indicates that DTs have a negative effect on SOL for SMEs but have a positive effect on SOL for non-SMEs.

Tab. 11 – The impact of ICT on the development ability of SMEs. Source: own research.

Variable	TURNOVER			PM		
	All	SMEs	Non-SMEs	All	SMEs	Non-SMEs
ICT	296.0** (2.72)	-116.5 (-1.16)	309.8** (2.61)	-0.0984 (-1.45)	-0.236 (-0.44)	-0.0889 (-1.39)
Adj R^2	0.5928	0.4761	0.6003	0.3422	0.0054	0.4427
Samples	1163	44	1079	1203	48	1113
Test	6.82 (0.0090***)			0.20 (0.6576)		

Notes: (1) Figures in the ICT and group-difference test parentheses indicate t-values and p-values, respectively. (2) *, ** and *** represent the 10%, 5% and 1% significance levels, respectively.

Table 11 lists the estimated results in terms of the impact of ICT on turnover and PM at the development ability. The model concerning ICT and PM does not meet the lowest significance level. We pay attention to the results of the model considering ICT and turnover. When ICT increases by 1%, turnover increases by 296% for all samples and 309.8% for non-SMEs but decreases by 116.5% for SMEs. The results indicate that DTs harm turnover for SMEs but positively impact turnover for non-SMEs.

4.3 Discussions

This study is attempting to understand the outcomes of the effect of DTs on firms' performance. Although an increasing interest in DTs for firms, recent studies focused on one kind of enterprise, while family firms, non-family firms, SMEs, and non-SMEs have been less studied systemically. This paper measures the effect of DTs on firms' performance at both firm-type and firm-size levels. It provides novel insights on the effect of ICT on performance-related indicators from the perspectives of capital ability, profit ability, debt-paying ability, and development ability. The research demonstrates that DTs have a noticeable effect on a firm's performance and reveals the effects on family, non-family, SMEs, and non-SMEs.

Recent studies related to DT literature have proliferated since scholars have focused on the effect of advanced information technologies on firms' performance. For example, Manita et al. (2020) provided the impact of digitalization on the audit business and revealed the role of audit as a governance mechanism. From a theoretical perspective, this study improves understanding regarding the role of DTs in the big data era, revealing the relationships and impact on performance in detail. The work contributes to the literature investigating the impacts of DTs on financial indicators in different firms. Moreover, the results of this study suggest that DTs have a significant role in firms, and it is necessary to consider advanced technologies to improve the firm performance, and it has different effects for whether it is a family firm or a SME. These results highlight applying DTs in in terms of managers committing further financial resources. Therefore, we encourage managers to assess DTs according to the firm type and size.

From a practical perspective, the work provides valuable guidance to managers and entrepreneurs in applying DTs. The research reveals the relationships of DTs with a set of financial and employment indicators that represent the performance of firms. At the same time, entrepreneurs may pay attention to whether applying DTs could increase success or revenues with different firm sizes. Therefore, we discuss the implications of the impact of DTs on performance in terms of the firm type and the firm size at four levels.

(1) At the capital ability level, the findings suggest that although applying DTs harms total assets, it has a positive effect on shareholder's funds for family firms and non-family firms, and

the impacts are more extensive. The study indicates that even if DTs cost a certain amount of assets, they would increase shareholders' returns so that shareholders may support applying these advanced tools, especially for non-family firms. Moreover, the evidence shows that using DTs has a negative impact on cash flow for the family firm, but a positive impact for non-family firms. This phenomenon highlights that family firms may lose cash flow to use advanced technologies, while non-family firms may take other measures to attract funds for this purpose. On the other hand, the similar result of the impact on shareholder's funds for SMEs and non-SMEs has a more considerable impact for non-SMEs than SMEs. However, there is a positive effect on total assets for SMEs while a negative effect on non-SMEs. These results are essential for managers to control the firm size and guide them in determining the firm type when DTs are used.

(2) At the profitability level, entrepreneurs could apply DTs to have more robust earnings and better manage risk. Furthermore, it is also a big way for SMEs to increase profit and increase financial risk. Besides, using DTs contributes to improving the return on capital employed for non-family firms and non-SMEs while negatively impacting family firms and SMEs. From another perspective, it has emerged that DTs would increase return on equity for family firms but would decrease it for the other. These results are relevant for stakeholders such as policymakers who could encourage managers to support (or not) DTs and improve the firm's development.

(3) At the debt-paying ability level, managers could be aware that DTs increase the solvency ratio for firms, thereby increasing the risk to the firms, especially for family firms. As for SMEs and non-SMEs from this perspective, using DTs decreases the solvency ratio for SMEs but increases the indicator for non-SMEs. This is a valuable attempt to be part of participants in DTs for SMEs and risk reduction. However, DTs may create more practical activities and earn an enhanced reputation from another perspective, although using high-tech tools may increase the solvency ratio for some firms.

(4) At the development ability level, the results emphasize the importance of DTs in influencing the operating revenue and profit margin for non-family firms and non-SMEs, while the opposite is true for family firms and SMEs. The study suggests that entrepreneurs in non-family firms and non-SMEs could enhance their efforts in supporting DTs for the future development strategy, to build stronger relationships with high-tech actors. Due to the application of DTs requiring specialist employees, there is a positive impact for family firms to recruit staff, while it suggests cutting staff for non-family. In this regard, limitations to the influence of DTs would lead to board decisions in terms of firms' development capability, with potentially irreversible financial implications for companies.

This study suggests that entrepreneurs support DTs to an appropriate degree as part of their future development strategy, to build stronger relationships with high-tech actors, according to the impact on four levels of performance and their firm type and firm size.

5 CONCLUSION

The motivation for this work was to measure the effect of DTs on performance for family firms and SMEs. While some studies have identified the importance of DTs for SMEs, only a few researchers have investigated the effects of DTs on the performance of multiple aspects, oth family type and the family firm. For DTs, we envisaged an impact on performance for family firms and SMEs in four aspects: capital ability, profitability, debt-paying ability, and development ability. How this change plays out remains dependent on the firm-type and firm-size. In this study, we have outlined what we see as some impacts of DTs that need to be examined. These findings demonstrate that DTs could also be considered a double-edged sword

with substantial consequences. This study could help managers or entrepreneurs make scientific and rational decisions to achieve superior performance.

In the emerging information and technologies era, firms need to decide whether to apply DTs or not, to leverage social activities efficiently. Based on the evidence, managers could encourage the use of DTs to stakeholders to increase the profit and reduce the risk, especially for non-family firms and non-SMEs. Moreover, using DTs would increase firm visibility and efficiency, and it would also support online and offline business activities to promote the firm. In summary, this study calls the attention of entrepreneurs and policy managers to the need for DTs to improve performance at four related levels, to get valuable advantages considering the firm type and size.

This study had several limitations. First, since missing values or negative numbers in the sample are removed as invalid information, the sample only consists of good companies that generate profit. Another limitation of this study is that we define a firm, whether an SME or not, mainly considering the number of employees without other factors, such as operating revenue and total assets, to minimize the number of firms due to missing data. The third limitation lies in selecting the used indicators to represent firms' performance in terms of different dimensions. Studies on firms' performance have developed several indicators for each level that will be possible to consider in future research. For example, receivables turnover, inventory turnover ratio, and total assets turnover could help measure firms' operation capability. This study offers a helpful research perspective for understanding the effect of DTs on the multidimensional performance of firms.

A future direction is to focus on the specific tools of DTs, such as block-chain, big data, and artificial intelligence, and their impact on firms at different dimensions. Furthermore, another intriguing research direction would be to construct a cross-cultural model to study the effect of DTs on different firms worldwide.

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