Digital response of SMEs to the COVID-19 crisis

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Abstract

This paper explores the factors that are important for the digital development of SMEs in response to the COVID-19 crisis compared to large-sized enterprises. Using data from a survey in Greek firms during the pandemic, we examine the role of various factors in firms' digital development based on the Technology-Organization-Environment (TOE) framework. We find that while further investments in ICT infrastructure are important for the digital development of SMEs, the digitalization of large-sized enterprises relates to innovative activities. Also, SMEs which implement flexible human resource (HR) practices as a response to the COVID-19 crisis, and face delays in the supply of their inputs due to the COVID-19 crisis appear to have increased probability of expanding their digital activities. On the other hand, HR practices do not seem to matter while new regulations appear to discourage the digital development of large-sized enterprises during the pandemic.

Keywords: COVID-19 Crisis; SMEs; TOE Framework; Digital Development; Supply Chains; Flexible HR Practices

JEL codes: L21; M15; O33

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1. Introduction

The ongoing COVID-19 pandemic has created unique conditions for all economic actors, businesses and households, causing an exogenous shock to the global economy but almost to every regional economy and industrial activity in the world as well (Goodell, 2020; Korsgaard et al., 2020). Apart from the effect on the public health systems and the efforts that have been initiated to mitigate risks and accommodate the growing number of people that needed healthcare treatment, various economic activities were urged to halt their operations. Lockdown measures were implemented in almost all countries while firms in specific sectors such as tourism, transports, and retail were forced to postpone their activity (Greene and Rosiello, 2020; Verma and Gustafsson, 2020). Despite the gradual reopening of the developed economies, the effects on businesses and entrepreneurship caused by the pandemic seem to go beyond a temporary cyclical shock, with the risk that its structural aspect would affect the robustness and stability of the financial system and the business sector as well. Recent developments show that the waves of the pandemic could proliferate economic constrains as regional or local lockdowns are re-emerging. In any case, businesses will be required to adapt to a new modus operandi and continuous crisis management both at the organizational level, and at the strategic level will be necessary, at least in the mid-term future.

In the entrepreneurship literature, implications of external economic shocks for small and/or new ventures has been a topic broadly studied, especially with regard to the financial crisis of 2008 (Cucculelli and Peruzzi, 2020; Ogawa and Tanaka, 2013; Williams and Vorley, 2017). However, apart from financial or liquidity constraints, other causes of economic crises may relate to events such as natural disasters (i.e. earthquakes, tsunamis, hurricanes etc.) or incidents like the current pandemic with a more or less severe impact on business activity depending on the extent of the disaster. Due to its uniqueness, the current crisis has already been labelled as a black Swan event for entrepreneurship (Cowling et al., 2020; Kuckertz et

al., 2020) resulting in substantial changes in entrepreneurs' lifestyle, culture, and social interactions (Ratten, 2020) and strongly affecting the access to finance and survival of SMEs (Brown et al., 2020; Bartik et al., 2020; Donthu and Gustafsson, 2020). SMEs tend to be more vulnerable compared to their larger counterparts when major exogenous shocks jeopardize markets due to lack of resources known as liability of smallness (Eggers, 2020). In an unfolding crisis, SMEs may be reluctant to invest their limited resources into innovative projects with an uncertain outcome (Lee et al., 2015) or other activities that will increase their financial leverage (Thorgren and Williams, 2020). On the other hand, small firms may also have the ability to recognize, evaluate and exploit opportunities in times of crisis (Beliaeva et al., 2020; Davidsson and Gordon, 2016; Shepherd and Williams, 2020) and/or the flexibility to respond successfully to a crisis by using valuable information based on the close relationships between customers and managers/owners (Eggers et al., 2012).

Governments tried to tackle with the immediate problems that the crisis created mostly by adopting measures to support employment and liquidity. Such measures included reduction in specific tax rates, delays of tax or social security obligations and direct financial assistance to employees but also unemployed. In Greece, the government responded rather quickly in the pandemic and introduced such measures which are estimated at 3.6% of GDP. Additional liquidity stimulus and private sector financing measures were also introduced (IOBE, 2020). At the same time European institutions such as the European Central Bank, the European Investment Bank and the European Commission also have taken economic measures to mitigate the adverse effects on economic growth. Although the results of such fiscal policy measures on household and business demand have not yet been fully quantified, they have rather marginally managed to offset the adverse effects of the crisis. In EU countries, such interventions were financed mainly through national funding, which resulted in a negative effect on fiscal balances. Their focus is on restoring liquidity and investments, since shrinking

international trade and demand, and the subsequent restrictions on economic activity create a rather unstable environment for the banking system, especially on non-performing loans. Nevertheless, such measures affect also the incentives on the business side of the economy, with investment decisions being postponed or delayed.

But what is maybe more important is that the COVID-19 pandemic signaled a rapid process of digital expansion for the majority of the economies worldwide. In this respect, while big industries and multinational corporations have generally the resources in terms of tools, procedures, capabilities and liquidity to properly adjust to this newly transformed environment, various SMEs had to rethink and swiftly reconstruct their business plans and adjust their business functions and models. Several key adjustments including work from home, creating internet-based ventures, traveling restrictions, as well as significant drop in face-to-face transactions and relative increase in electronic ones, had to be swiftly incorporated into their daily routines and become a vital part of their business (Gonçalves and Martins, 2020; Kim and Parker, 2020). This new reality in trade, consumer and industrial markets worldwide will inevitably bring groundbreaking changes in the demand for goods and services, creating new (possibly more local) patterns which, combined with the various problems created in traditional trade, cause serious blows to global supply chains and service networks.

On the other hand, under such turbulent conditions of the COVID-19 pandemic, significant opportunities may also emerge for small businesses in developing their digitalization strategies (Scheidgen et al., 2021). Digital technologies have been long recognized as crucial for the survival and performance of firms in general and SMEs in particular, with multiple benefits in terms of organizational effectiveness, cost savings, competitive advantages and internationalization (Fauzi and Sheng, 2020; Pergelova et al., 2019). However, the COVID-19 pandemic made entrepreneurs and managers realize that engagement in digital activities is, in fact, a necessity strategic element of their daily operations

and not a luxury item, to be used occasionally. Thus, deploying and accelerating digital solutions is now widely recognized as a strategic priority intrinsically linked to the resilience and competitiveness of businesses. It is vital for SMEs to properly adjust their value chains and supply networks, utilizing new available technologies and digitally transforming their core business activities to bring significant profits in terms of productivity, flexibility, quality and service to consumer needs (Donthu and Gustafsson, 2020; Verma and Gustafsson, 2020). In order to identify and properly adjust to this new trends, enterprises are presented with the challenge to create innovative organizational and operational structures in order to devise more specialized strategies that will protect them from similar future shocks and meet the tailor-made consumer needs and new demand patterns that arise.

In this paper, we analyze to what extent SMEs respond in a different way compared to large firms with respect to their digital response to the COVID-19 pandemic. Despite the extensive research on ICT adoption, e-commerce, digital transformation and digital entrepreneurship during the recent years (Consoli, 2012; Ladeira et al., 2019; Nambisan et al., 2019; Oliveira and Martins, 2011; Paris et al., 2016; Vial, 2019), the reactions of SMEs with respect to the adoption of digital strategies in the context of a global crisis due to a pandemic have not been explored, at least in empirical terms. Based on the TOE framework this study is intended to fill this void, emphasizing on the channels through which SMEs foster their digital growth as a response to the COVID-19 crisis. We build our analysis on a survey that was conducted during the period May-July 2020 in Greece using a structured questionnaire in 238 firms from all sectors of the economy. In what follows, the next two sections present the conceptual background of our analysis based on the TOE framework and describe the data and the model specification for the empirical analysis. The presentation and discussion of results follow, whereas the last section concludes the paper and provides some policy and managerial implications.

2. Conceptual setting and hypotheses formulation

The implementation and usage of ICT is commonly grounded on various theories used to explain the adoption process of new technologies and innovation (e.g. Grandón et al., 2011; Lee and Xia, 2006). Focusing on technology adoption models, the technology, organization, and environment (TOE) model (Tornatzky et al., 1990) is considered as the most appropriate for firm-level analysis (Oliveira and Martins, 2011) which is largely consistent with other well-known theories such as the theory of diffusion on innovations (Rogers 1995). In addition, this approach is widely used for examining firms' adoption decisions and behavior related to e-commerce and e-business (Ghobakhloo et al., 2011; Kuan and Chau, 2001; Scupola, 2003; Sila, 2013; Zhu et al., 2003). The TOE framework recognizes the significance of three different elements in firms' adoption decisions, i.e. the technological context, the organizational context, and the environmental context. Following this approach, we consider a set of technology-organization- and environment-related factors as potential drivers of a firm's decision to expand e-commerce and digital marketing practices as a response to the COVID-19 crisis. We also control for firm characteristics, that is age, size and economic activity which are likely to play a relevant role in ICT adoption (Bayo-Moriones and Lera-López, 2007; Hollenstein, 2004). Figure 1 illustrates the conceptual model underlying this study based on the TOE framework.

<Insert Figure 1 about here>

More specifically, investments in ICT infrastructure and innovation activities are significant factors within the technological context of a firm that are likely to affect decisions related to firms' digitalization. A firm that systematically invests in technological infrastructure and develops technological capabilities is more likely to adopt ICT and benefit from e-commerce technologies than a company with a lower degree of technological readiness (Khoo et al., 2018; Scupola, 2003; To and Ngai, 2006; Zhu et al., 2003). Notably, it has been

recognized that ICT infrastructure is a crucial resource in crisis response (Leidner et al., 2009). Furthermore, Giunta and Trivieri (2007) suggest that R&D activities and innovative activities foster firms to absorb increased ICT endowment. Along these lines, Alshamaila et al. (2013) highlight the crucial role that accumulated experience in the usage of new technologies and innovations plays in shaping the digital behavior of SMEs. Several studies provide empirical evidence that firms' prior innovativeness and technological experience increase the probability for subsequent ICT adoption (Giunta and Trivieri, 2007; Hollenstein, 2004). Also, a firm that is innovative in technological or organizational aspects may also be more committed to the development of e-business usage (Battisti et al. 2009). The innovation profile of firms has been strongly associated to the adoption of digital technologies (Alshamaila et al., 2013; Hollenstein, 2004). Based on the above, we expect further investments in ICT infrastructure and the development of product, process or organizational innovation to advance the digital development of firms, as suggested by the following preposition.

Hypothesis 1: Further ICT investments and innovations are positively associated with the expansion of e-commerce and digital marketing practices in response to the COVID-19 crisis.

In addition, organization-related factors seem to have a significant influence on the company's decision to integrate and effectively use e-commerce practices (Dubelaar et al., 2005; Zhu et al., 2003). From an organizational perspective, managing workplace flexibility in the context of SMEs may be particularly important, especially during a recessionary climate (Whyman and Petrescu, 2015). More specifically, the implementation and use of agile human resource (HR) practices as a firm's strategic choice (Baptista et al., 2020) is considered crucial for the organizational effectiveness, performance and resilience of SMEs, helping them to recover rapidly from shocks or crises (Heilmann et al., 2020). In fact, many firms have undertaken significant organizational changes placing emphasis on new models of HR as a means to adjust to the newly altered work environment due to the COVID-19 pandemic

(Carnevale and Hatak, 2020). Such changes may include agile schemes allowing for flexible working hours, remote working, telecommuting, recruitment of highly educated employees with digital skills, etc.

Indeed, employees' human capital comprising knowledge, skills and expertise in information systems are recognized as critical factors for the integration and use of ICT and e-commerce by firms (Arvanitis and Loukis, 2009; Fabiani et al., 2005). On the other hand, the lack of qualified staff and digital skills are key obstacles to the integration and use of relevant technologies by enterprises (Cloete et al., 2002; Dubelaar et al., 2005). In general, firms that are characterized by flexible structures are more likely to proceed with organizational changes conducive to the integration of new technologies and successful modes of ICT usage (Bruque and Moyano, 2007; Jones et al., 2006). Thus, we can form the following hypothesis which indicates a positive relationship between flexible HR practices and further investments on e-commerce and digital marketing practices.

Hypothesis 2: Flexible HR practices are positively associated with the expansion of e-commerce and digital marketing practices in response to the COVID-19 crisis.

The regulative framework as well as the behavior of a firm's suppliers and customers are considered critical factors of the external environment which may influence the firm's decision with respect to the adoption and use of ICT (Gibbs and Kraemer, 2004; Zhu et al., 2006). During crisis periods, supply chains face stress which may lead to disruptions with irreversible effects on business operation. The COVID-19 crisis has, in fact, revealed the weaknesses of the global and regional value chains, resulting in spillover effects throughout the supply chains and disruptions in demand and supply (Pantano et al., 2020; Queiroz et al., 2020; Verma and Gustafsson, 2020). To cope with the short and long-term implications of the crisis, strategies based on digitalization and data sharing in value chains are considered to play a critical role (Queiroz et al., 2020; Rapaccini et al., 2020). Moreover, new business regulations (e.g.

constraints in operating times) imposed in order to face the health crisis may induce firms to greater engagement with e-commerce and digital marketing practices. Based on the above, our last hypothesis to test can be formulated as follows.

Hypothesis 3: Supply chain disruptions and new business regulations are positively associated with the expansion of e-commerce and digital marketing practices in response to the COVID-19 crisis.

3. Data and model specification

3.1 Description of the survey

The survey was designed and implemented by the Foundation for Economic and Industrial Research (FEIR/IOBE) in May-July 2020. The survey method was postal mail or e-mail while the contact person was the CEO or the General Manager of the firm. Firms from four main sectors of the economy (Manufacturing, Construction, Retail Trade, and Services) were included in the sample. It is the same sample that is used for the Business and Consumer Surveys (BCS), which are undertaken by FEIR/IOBE in the context of the relevant DG ECFIN funded project. Sampling builds on a representative sample across Greece from the four sectors of the economy. The final dataset that was used in the analysis includes 238 firms. Some of the most interesting questions of the survey are related to the qualitative and quantitative effect that the pandemic crisis and the suspension of economic activity had on the firms' operation. We also explored the firms' strategies as a reaction to the crisis, but also their qualitative assessment of the measures that were introduced by the government to mitigate the adverse effects of the pandemic. The year of establishment of each firm and additional financial and sectoral data were retrieved from the business registry of ICAP, which is the most reliable and updated business registry in Greece[1].

[1] ICAP contains business information for all S.A., Plc and Ltd firms in Greece. This database provides annual financial data derived from firms' published balance sheets and income/expenditure accounts.

3.2 Variables and model specification

In our analysis the dependent variable refers to firms' advancement of digital development in response to the COVID-19 crisis. It is a dichotomous variable, taking the value of 1 in case firms report further development of e-commerce and/or digital marketing practices, and 0 otherwise. As mentioned above, we use the TOE framework to classify our explanatory variables into three broad categories, namely, technology, organization and environment. Regarding technology, we use two variables referring to further investments in ICT infrastructure (*ICT investment*) and firms' engagement in innovation activities, i.e. the development of a product or process or organizational innovation *(innovation*) during the COVID-19 crisis. The organization-related factors refer to flexible HR practices adopted by firms during the lockdown period due to restrictions imposed by the Greek government (i.e. mid March-April 2020). These practices include personnel remote working (*remote work*), recruitment of new personnel (*personnel* recruitment) and dismissal of employees (*redundancies*). Moreover, three environmental factors are considered, i.e. new regulations (e.g. restrictions in businesses' operating hours) (*new regulations*) in force to deal with the pandemic, the delays in receiving suppliers' inputs (*suppliers*) and cancellations in customers' orders (*customers*). We also control for firm-specific characteristics related to firm size, age and sector of economic activity. More specifically, *firm size* is measured by the natural logarithm of sales in the previous year, and *firm age* is measured by the natural logarithm of the current year minus the establishment year of the firm. Finally, we include a sector dummy (*manufacturing*) indicating whether the firm operates in the manufacturing sector (taking the value of 1), considering services as the reference sector. The independent variables used in our analysis are described in detail in Table 1, where the exact survey questions used for the construction of the explanatory variables are reported. Table 2 presents frequencies for the

binary variables per size group (SMEs and large-sized firms) and sector (manufacturing and services), while Table 3 presents the correlation matrix for the independent variables[2].

From the descriptive statistics in Table 2, an initial pattern emerges. Firms from the service sectors seem to proceed to digital expansion to a greater extent than manufacturing firms, by adopting more easily remote working, further investing in ICT and innovative activities, and benefiting from implementing new regulation due to the pandemic. On the other hand, manufacturing firms face more intense problems with suppliers and seem to compensate for their hesitant digital development with recruiting additional personnel. In terms of firm size, differences between the two size groups are rather mild. Larger firms seem to adopt digital expansion strategies to a slightly higher degree than SMEs, while at the same time they report greater supply chain problems, especially due to cancellations of customers' orders.

<Insert Table 1 about here>

<Insert Table 2 about here>

<Insert Table 3 about here>

The econometric analysis is based on the estimation of a probit model of the form:

$$DigTrans_i = \beta_0 + \beta_1 Tech_i + \beta_2 Organ_i + \beta_3 Envir_i + \beta_4 Z_i + u_i \quad (1)$$

In equation (1) the dependent variable, $DigTrans_i$, stands for the decision of firm i to further proceed with digital development as a response to the COVID-19 crisis. $Tech_i$ is a vector of the technological factors considered (innovation activities and ICT investments), $Organ_i$ represents a set of organizational attributes concerning HR practices (remote work, recruitment and redundancies), $Envir_i$, is a vector that refers to the external environment of the firm (new regulations, suppliers, customers), and Z_i is a vector of the control variables (firm size, firm

[2] The correlation matrix indicates the absence of high correlations among the independent variables, which in turn ensures that the econometric estimates are not biased due to possible multicollinearity problems.

age, economic activity). Finally, u_i is the random error term and $\boldsymbol{\beta}$ denotes the vector of the coefficients to be estimated.

Since digital development is measured by a binary variable, we employ probit models to estimate the effects of the explanatory variables on a firm's probability of promoting e-commerce and digital marketing practices as a response to the COVID-19 crisis. Moreover, to explore potential differentials in the drivers of digital development in response to the COVID-19 crisis for firms of different size, we group firms of our sample into SMEs and large-sized firms based on the formal definition provided by European Commission (2003). In particular, SMEs are defined as those which employ less than 250 persons, while large firms are those with 250 or more employees.

4. Results

We estimate the probit model expressed by equation (1) for the full sample and separately for SMEs and large-sized firms, as defined above. Table 4 presents the coefficients, the robust standard errors (in parentheses) and the marginal effects of the explanatory variables on the probability of firms to advance e-commerce and digital marketing practices as a response to the pandemic crisis.

<Insert Table 4 about here>

Focusing on firms' technological aspects for the total sample, we can see that engaging in innovative activities, in terms of product/process/organizational innovation, positively affects the probability of entrepreneurial digital development at the 5% significance level. In addition, further investments in ICT infrastructure have a positive (at the 10% significance level) effect on the probability of expanding firms' digital activities during the COVID-19 crisis. The estimated average marginal effects show that engaging in innovation activities and investing further in ICT infrastructure is correlated with 8 percentage points (pp) and 6 pp increases, respectively, in the probability of reporting a digital development as a response to

the COVID-19 crisis. Thus, our results for the full sample provide support to *H1* indicating a positive association of innovations and ICT investments with the expansion of e-commerce and digital marketing practices in response to the COVID-19 crisis.

With respect to organization-related factors involving HR practices, only the personnel recruitment is found to be important (statistically significant at the 5% level) for the firms' digital development in the full sample. The coefficient magnitude obtained from the marginal effects indicates that this specific HR choice is associated with a 9 pp increase in the probability of firms' digital development. This may imply that effective and rapid digital development during the COVID-19 crisis may require specific ICT skills that can be obtained by refreshing the personnel. Thus, our results for the full sample provide limited evidence in favour of *H2* which suggests a positive relation between flexible HR practices and the expansion of e-commerce and digital marketing practices in response to the COVID-19 crisis. The same seems to hold in the case of our last hypothesis, *H3* which refers to the significance of supply chain disruptions and new business regulations for firms' digital development. In particular, out of the three environmental variables examined, only one referring to the delays in receiving suppliers' inputs is found to be positively and significantly (1% significance level) correlated with the expansion of the digital activities of the full sample firms.

More specifically, the probability of firms to engage in digital development actions is about 10 pp greater for firms that faced problems in B2B transactions as a result of the COVID-19 crisis. Hence, it seems that significant challenges in the B2B relations emerge during the pandemic with respect to inventory shortages, supply chain breakdowns, product delivery problems, etc. (Hartmann and Lussier, 2020) encouraging the digitalization of firms' business models (Ritter and Pedersen, 2020). Firms may substitute traditional marketing activities with digital marketing solutions (Cortez and Johnston, 2020) and accelerate the implementation of digitalization projects through the development of various advanced service and digital

offerings (Rapaccini et al., 2020). With respect to the control variables, firm age is also positively and strongly (1% significance level) associated with digital development. Finally, the marginal effect of the sector dummy appears to be negative, implying that the probability of adopting digital initiatives is significantly higher for the services firms compared to the manufacturing firms.

To explore whether different factors in the TOE framework matter for the digital response of SMEs to the COVID-19 crisis as compared to their larger counterparts, we discuss the empirical results for the two size groups separately. Looking, first, at the technology-related variables, investing further in ICT infrastructure appears to significantly increase the probability of digital development for SMEs, while the innovation variable appears insignificant. The opposite is true for the case of large firms where innovation capabilities appear to lead their digital development and not typical ICT infrastructure investments. Thus, our results provide partial support for *H1* for both size groups of firms. Moreover, the estimations with respect to the HR practices reveal a completely different picture concerning SMEs' response to the COVID crisis in comparison with large-sized firms: while for large firms none of the examined practices appears significant, for SMEs all HR practices appear to be related to the firms' probability of achieving digital development with the most significant effect (at the 1% level) observed in the case of remote working of personnel. With respect to employee recruitment and redundancies, the skills and expertise of personnel in new technologies may play a relevant role. In particular, seeking the engagement in digital activities may induce firms to increase the employment of high-skilled individuals and decreases the employment of low-skilled employees (Balsmeier and Woerter, 2019). Overall, SMEs that adopt flexible HR practices during the COVID crisis are more likely to broaden their digitalization under turbulent conditions. Hence, our results for SMEs corroborate *H2*, while the corresponding estimates do not validate the hypothesis in the case of large firms, indicating

that organizational changes related to HR practices are not associated with large firms' digital development during the pandemic.

Regarding the environmental context, we observe that supply chain disruptions due to delays in receiving suppliers' inputs seem to increase the probability of digital development for SMEs and large firms as well, with the marginal effect of the related variable being greater for large-sized firms than the corresponding one for SMEs. Also, the new regulations put in force by the government to face the health crisis due to the pandemic appear to have a negative marginal effect (at the 10% level) on the probability of digital development of large firms, while this variable does not have a significant effect in the case of SMEs. A possible explanation is that large firms may devote significant resources to comply with the new regulations imposed by the government to face the health crisis at the expense of promoting digital expansion strategies. Thus, our results provide only limited support for *H3*.

In addition, we observe similar effects of firm age in both size groups implying that path dependencies and knowledge accumulation favour the expansion of e-commerce and digital marketing practices in SMEs as well as large-sized firms. Finally, the marginal effect of the sector dummy appears negative and significant for SMEs indicating that SMEs in services have a higher probability to expand their digital activities compared to the SMEs in the manufacturing sector, while for large firms the sector dummy does not appear to matter.

5. Conclusions

The main objective of this paper is to analyze to what extent SMEs respond in a different way compared to large firms with respect to their digital development during the COVID-19 pandemic in Greece. Prior research on ICT adoption and digital entrepreneurship did not have the opportunity to analyze such digital reactions of SMEs in the context of a crisis with ripple effects and catastrophic impact on the business activity. By and large, the current situation represents a unique test-bed case for almost all economies (and especially for SMEs), thus

providing a volatile yet potential interesting environment. Based on the TOE framework we explore the digital strategies pursued by Greek firms as a response to the COVID-19 crisis emphasizing potential differentials in digital expansion processes adopted by SMEs in comparison with larger firms.

The results from probit estimations highlight the importance of technology-related factors for advancing firms' digital development. Particularly, it is found that being involved in innovation activities and investing in ICT infrastructure increase the likelihood of firms to grow digitally. However, our results reveal that different technological factors matter for the digital development of SMEs comparing to large firms. While investments in ICT infrastructure seem to drive the further engagement of SMEs in e-commerce and digital marketing practices during the COVID-19 period, the digitalization of large-sized firms appears to be dependent on innovation development. Furthermore, with respect to HR practices our results indicate that personnel recruitment seems to play a significant role in the greater engagement of firms in e-commerce and digital marketing. Focusing on SMEs, our findings show that applying flexible HR practices related to remote work, personnel recruitment and redundancies increases the probability of advancing digital development. On the contrary, such HR practices do not appear to be relevant for the digital responses of large firms. This may indicate that SMEs were urged to proceed to changes and adapt to the new environment to a greater extent than larger firms, since the latter had more or less an established operational pattern both in terms of collaborating with suppliers and customers that was not heavily affected, especially in manufacturing activities. Finally, among the factors of the firms' external environment, disruptions related to the supply of inputs seem to motivate firms to implement further digital actions irrespective of their size, while disruptions related to customers' cancellations remain insignificant in all estimations.

Based on the abovementioned findings, some policy implications that can be drawn relate to the need to further support SMEs under such difficult conditions. During the pandemic crisis the main funding policy tools target on urgent short-term challenges taking the form of tax deferrals, wage support, loan guarantees etc. These policy measures seem to work for the majority of company size groups and economic activities. But SMEs have to proceed with more intense digital expansion processes and probably are less able to adopt new technologies and methods. This means that they need a wider set of structural policies to support their resilience to the crisis and their swift adaptation to this new environment. They need support for finding new alternative markets, for teleworking and digitalization, for innovation and for training their workforce. Short term financial support may solve short term demand shortages but in the long run it is their faster, and more efficient digital development that will make them survive in the post-crisis business environment. On the managerial aspect, the current crisis is indeed creating unique business conditions for many firms from various sectors, some of which will not be able to survive. But on the other hand, due to the fact that consequences are not local, or regional but affect supply chains at a global level, it means that the business ecosystems will need to develop a new equilibrium. Continuous crisis management, agile strategies and operational flexibility seem to be the key for successful management both within the current crisis but also when some business normality returns.

Finally, some limitations and further research directions related to this paper are the following: First, we must highlight that this study relies on cross-sectional data and, therefore, implicitly assumes simultaneity between digital development and TOE independent variables. However, all the examined variables have been constructed based on survey questions that focus on firms' response to the pandemic crisis, providing thus unique insights for the firms' urgent reactions. Second, the survey was conducted during the period May-July 2020. Given that the pandemic seems to be a lasting crisis, repeating the survey in a broader time frame

during the pandemic would be highly valued in order to ensure the robustness of the empirical evidence provided in this study. Third, the sample used for the empirical analysis relies on SMEs and large firms, excluding micro firms. However, it would be of interest to explore the digital response of micro firms.

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Figure 1: Conceptual model based on the TOE framework for the entrepreneurial digital response to the COVID-19 crisis

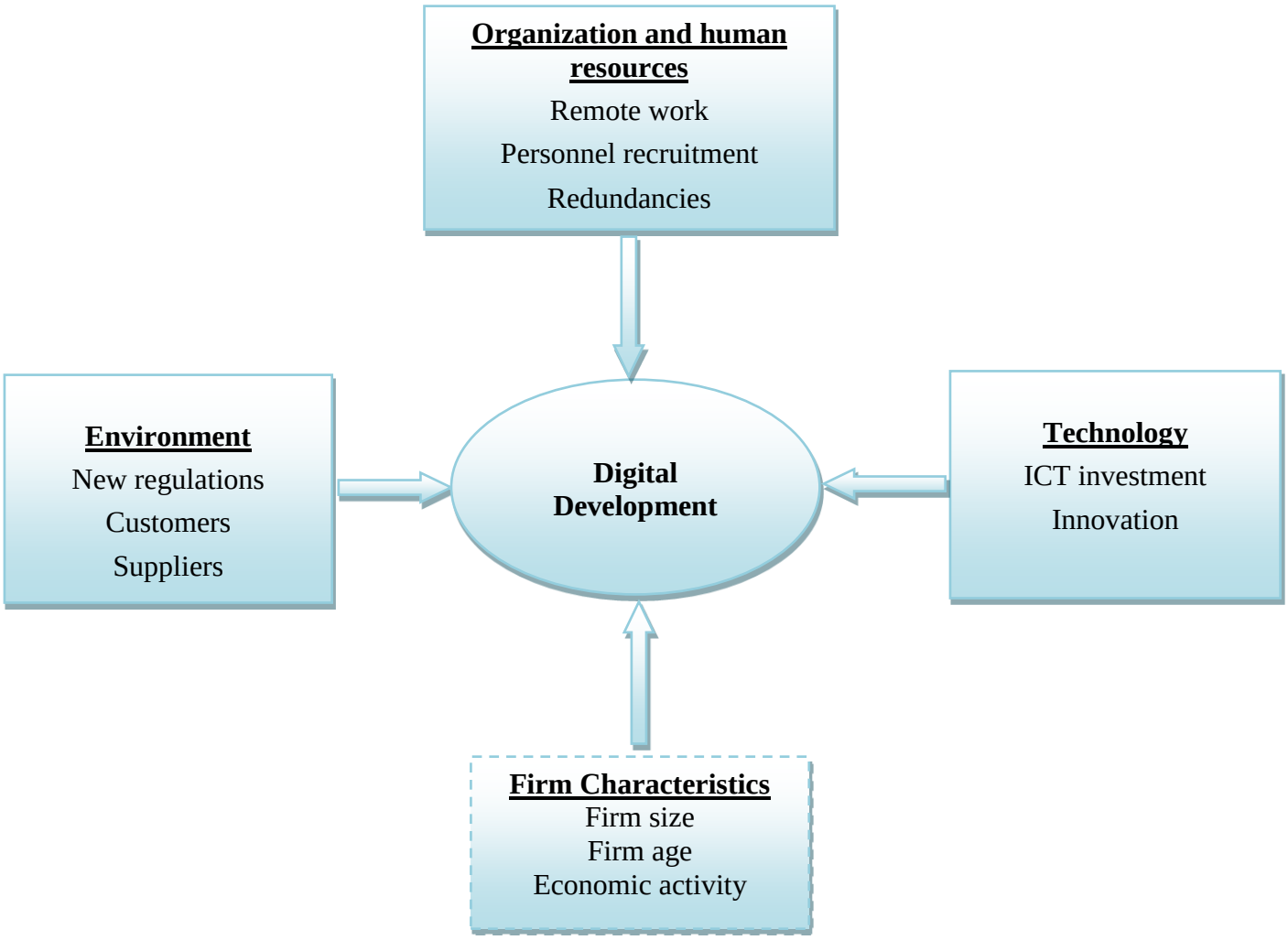

Table 1: Description of independent variables

TOE Category	Variable Name	Description
Technology	Innovation	Binary variable indicating whether the firm developed a product or process or organizational innovation during the COVID-19 crisis period.
	ICT investment	Binary variable indicating whether the firm invested in ICT infrastructure during the COVID-19 crisis period.
Organization	Remote work	Binary variable indicating whether the firm applied remote working for its employees during the COVID-19 crisis period.
	Personnel recruitment	Binary variable indicating whether the firm applied full-time remote working for its employees during the COVID-19 crisis period.
	Redundancies	Binary variable indicating whether the firm proceeded to redundancies during the COVID-19 crisis period.
Environment	New regulations	Binary variable indicating whether the firm faced new regulations affecting its business operation during the COVID-19 crisis period.
	Suppliers	Binary variable indicating whether the firm faced any problems related to delays in receiving suppliers' input during the COVID-19 crisis period.
	Customers	Binary variable indicating whether the firm faced any problems related to cancellations in customers' orders during the COVID-19 crisis period.
Control variables/Firm characteristics	Firm size	Continuous variable measured by the natural logarithm of sales in the previous year.
	Firm age	Continuous variable measured by the natural logarithm of difference between the current year and the year of firm's incorporation.
	Manufacturing	Binary variable indicating whether the firm belongs to the manufacturing sector (with reference group the services sector)

Table 2: Frequencies of binary variables

	Total sample	**SMEs**	**Large-sized firms**	**Manufacturing**	**Services**
Digital development	10.92%	8.40%	13.45%	7.09%	15.32%
New regulations	16.81%	18.49%	15.13%	11.81%	22.52%
Suppliers	25.63%	21.85%	29.41%	30.71%	19.82%
Customers	43.70%	37.82%	49.58%	46.46%	40.54%
Remote work	6.72%	7.56%	5.88%	3.15%	10.81%
Innovation	14.71%	13.45%	15.97%	10.24%	19.82%
ICT investment	10.92%	9.24%	12.61%	9.45%	12.61%
Personnel recruitment	7.98%	6.72%	9.24%	11.81%	3.60%
Redundancies	3.36%	1.68%	5.04%	3.94%	2.70%
Obs	238	119	119	127	111

Table 3: Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
New regulations (1)	1									
Suppliers (2)	0.0204	1								
Customers (3)	0.0374	0.1173	1							
Remote work (4)	-0.0325	-0.0420	0.0360	1						
Innovation (5)	0.0390	0.0089	0.0791	0.0809	1					
ICT investment (6)	0.0273	0.0195	0.0598	0.1259	0.1720	1				
Personnel recruitment (7)	0.0318	0.0796	-0.0078	-0.0802	0.0555	0.1002	1			
Redundancies (8)	0.1647	0.2130	0.1670	-0.0507	-0.0105	0.0113	0.0304	1		
Firm age (9)	-0.0859	-0.1438	-0.0370	-0.0576	-0.0512	0.0216	-0.0736	0.0006	1	
Firm size (10)	-0.1353	-0.1261	0.0026	-0.0308	0.1053	0.1705	-0.0379	-0.1796	0.3152	1

Table 4: Probit results for the probability of firms to be digitally developed as a response to the COVID-19 crisis

	Total sample		**SMEs**		**Large firms**	
	β (SE)	*marginal effects*	*β (SE)*	*marginal effects*	*β (SE)*	*marginal effects*
Technology						
Innovation	0.6626** (0.3144)	0.0885	0.8193 (0.5498)	0.0212	0.8147** (0.3982)	0.1315
ICT investment	0.4770* (0.2953)	0.0637	1.4903*** (0.5435)	0.0387	0.0252 (0.4211)	0.0040
Organization						
Remote work	0.5600 (0.4142)	0.0748	1.8715*** (0.5540)	0.0486	-0.2850 (0.7280)	-0.0460
Personnel recruitment	0.7057** (0.3705)	0.0943	1.5211* (0.8689)	0.0395	0.4924 (0.4689)	0.0795
Redundancies	0.6942 (0.5559)	0.0928	2.2025** (0.9085)	0.0572	-0.0831 (0.8130)	-0.0134
Environment						
New regulations	-0.5655 (0.3588)	-0.0755	-0.6420 (0.6442)	-0.0166	-0.8349* (0.4945)	-0.1348
Suppliers	0.7453*** (0.2431)	0.0996	1.4899*** (0.5190)	0.0387	0.8153** (0.3452)	0.1316
Customers	-0.0507 (0.2511)	-0.0067	0.0823 (0.5292)	0.0021	-0.1635 (0.3167)	-0.0264
Firm characteristics						
Firm size	-0.0027 (0.0765)	-0.0003	0.1739 (0.1820)	0.0045	-0.1160 (0.1084)	-0.0187
Firm age	0.6282*** (0.2441)	0.08397	0.7422** (0.3708)	0.0192	0.8359** (0.3948)	0.1349
Manufacturing	-0.6550** (0.2834)	-0.08755	-1.7772** (0.8427)	-0.0461	-0.4856 (0.3621)	-0.0784
Constant	-3.6198** (1.4363)		-7.8662** (3.2682)		-2.0046 (1.8052)	
Log pseudolikelihood	-66.1792		-18.8040		-38.2024	
Wald test (χ^2)	33.42***		36.27***		27.57***	
Number of obs	235		116		119	

Notes: The table reports the marginal effects of the probit regressions. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level. Robust standard errors are reported in parentheses.