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Digital readiness, Digital adoption and Digitalisation of UK SMEs Amidst the Covid-19 crisis

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Digital readiness, digital adoption and digitalisation of UK SMEs amidst the Covid-19 crisis

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ABSTRACT

Digital technologies are widespread and spreading fast. Here, based on new ERC Business Futures survey data, we examine the diffusion of digital technologies among UK SMEs in 2020, explore the factors driving digital adoption and reflect on the role that digital technologies played in helping UK SMEs to address the challenges of Covid pandemic crisis. First, we develop a measure of 'digital technology readiness' which refers to a propensity of a firm to embrace new digital technologies and capture internal and external enablers and motivators. Second, we explore the relationship between digital readiness, perceived barriers and digital adoption across ten different digital technologies. Third, we examine how digitalisation relates to business performance during the Covid crisis. Our analysis reveals that established digital technologies are well diffused among UK SMEs and that emerging digital technologies are becoming increasingly more common in 2020. This suggests a narrowing digital gap. We also find strong evidence that digital readiness is associated with the probability of digital adoption. This implies that different policy instruments and business support encouraging networking, information sharing to improve technology awareness and knowledge may result in increased digital readiness and, therefore, in increased probability of digital adoption. On the contrary, we find (surprisingly) only little evidence that barriers to digital affect the probability of technology adoption. This is not to suggest that UK SMEs do not encounter any barriers on their digital journey. Some barriers such as lack of digital skills, access to finance and broadband capacity are important impediments to digital transition. However, our analysis suggests that barriers do not prevent firms from adopting new technologies provided strong levels of digital readiness. Finally, we provide new evidence that more digitalised SMEs were better equipped to weather the storm of Covid-19 pandemic and maintain the same turnover or grow if they introduced digital technology in operations which resulted in increased innovative activity.

Keywords: digital adoption, technology readiness, SMEs.

CONTENTS

1. INTRODUCTION

Digital technologies are widespread and spreading fast (World Bank, 2016; Chakravorti et al., 2017). They change the way people live, work, think, and learn (Giudice et al., 2021), they are already shaping the workforce and the future of work and are transforming the way firms innovate (OECD, 2017; McKinsey Global institute, 2020). Even before the Covid-19 pandemic, the urge to go digital had already dominated the economy. Big data, artificial intelligence, cloud computing – these are just some of the technologies that immediately come to mind when thinking about digitalisation. They are no longer a matter solely for the future and, arguably, will continue gaining relevance in the coming years. Consequently, adapting to these realities is a matter of need rather than a matter of choice (Going digital, 2019). On a macro level, recent studies provide a mixed picture of UK progress in digitalisation in comparison to other countries: from a frontrunner (MGI's Industry Digitalisation Index, 2016; Chakravorti et al., 2017), to a performer but lagging behind EU leaders (DESI - European commission, 2020), to even a 'modest' position (EIBIS digitalisation index, 2020).

It is widely recognised that in this digitalisation process, small and medium-sized enterprises (SMEs) tend to lag behind larger firms (World Bank, 2016; OECD, 2019, 2021). The KfW report in 2018 states that: "Most SMEs are lagging behind the technological evolution. Around half of SMEs can be regarded as digital midfield" (KfW Research, 2018). The reasons for this are many: SMEs are more resource-constrained than larger businesses, they have less extensive IT equipment, lack digital skills and, oftentimes, managerial and technical capabilities. At the same time, digitalisation projects often have a minimum size for effective implementation that lead to higher fixed costs and higher burden for small enterprises. Not least, smaller businesses are more often financially constrained and have greater difficulties in obtaining external finance. Moreover, while the evidence base on large companies is rich, less is known about the digitalisation journey of SMEs, despite an increasing interest in the subject from the policy perspective (IoD, 2018; Lloyds, 2019; Going digital, 2019; BEIS, 2019; Be the Business, 2020; OECD, 2021) and the academic research perspective (Alshamaila et al., 2013; Belitski & Liversage, 2019; Bi et al, 2017; Ritz & Wolf, 2015; Garbellano & Da Veiga, 2019; Li et al., 2018; North et al, 2020; Ruivo et al., 2012; Susanty et al, 2020).

The Covid-19 pandemic generated a great number of challenges for UK SMEs. A recent insight paper published by ERC has shown that over two-fifths of SMEs have seen sales decrease in the past 12 months and just under a third have cut jobs (Hopley, 2021). However, the Covid-19 pandemic can also be seen as a kind of inevitable event that forces SMEs to leap forward in digital adoption and implementation, as not doing so might threaten their business survival. In fact, digital transformation seems to be one of the key solutions for SMEs to cope with the pandemic. As pointed out by OECD (2021), "the COVID-19 crisis has heightened the importance of SME digitalisation, and served as an accelerator. Firms have moved operations online and implemented smart working solutions to remain in business during lockdowns and overcome disruptions in supply chains, with online platforms playing an instrumental role in connecting users to new markets, suppliers or resources." In line with business surveys worldwide, the results from ERC Business Futures Survey indicate that more than 60% of SMEs intensified their use of digital technologies due to COVID-19 (ERC, 2020; OECD, 2021).

Motivated by the issues mentioned above, we seek to study the following research questions: (1) To what extent are digital technologies diffused among UK SMEs? (2) What factors lay behind digitalisation and digital adoption in SMEs? (3) Furthermore, examining business performances during the Covid pandemic, what role did digital technologies play in helping UK SMEs to weather the storm?

To address these questions, we draw on innovation diffusion literature, technology-organisation-environment framework and the concept of technology readiness. We first develop a conceptual framework and a *digital technology readiness* concept which describes a pre-disposition or propensity of SMEs to adopt digital technologies. Then, after a detailed analysis of the level of diffusion of ten different digital technologies among UK SMEs, we explore the relationship between digital readiness, perceived barriers and digital adoption. Third, we examine how digitalisation relates to business performance during the Covid crisis.

2. CONCEPTUAL BACKGROUND

2.1 Diffusion of technological innovation

The innovation diffusion-adoption research has gone a long way. As pointed out by Van Oorschot et al. (2018), it can be traced back to the beginning of the 1900s, to the work of a French sociologist Gabriel Tarde *Laws of Imitation* (Tarde, 1903). Since then, the diffusion-adoption research encompasses the advances in organisational, behavioural and innovation studies. The work of Everett Rogers gave the field a widespread recognition and stimulated extensive conceptual and empirical research across different sectors of economy and in different contexts. Today, the five editions of Everett Rogers' *Diffusion of Innovations* (DoI)[1] tie together different strands of diffusion-adoption research (Van Oorschot et al., 2018).

Rogers builds his reasoning on concepts of *uncertainty* and *information*, the former motivates individuals to seek the later, as uncertainty is an uncomfortable state. Innovation – a new idea, practice or technology – generates uncertainty as it is not initially known that innovation offers a better solution than previous practice to problem solving. The diffusion of innovation is conceptualised then as 'essentially a social process in which subjectively perceived information about new ideas is communicated from person to person'. As information about an innovation is often sought from peers, interpersonal and business networks play a crucial role in this process of information-seeking and information-processing (Rogers, 2003).

Another crucially important element in DoI framework is time. Time is involved in the '*innovation-decision process*'. During this process an individual or a firm passes through a sequence of steps or stages: from first learning of a technological innovation existence and understanding how it functions ('*knowledge*' stage), to the formation of favourable or unfavourable attitude toward the innovation ('*persuasion*'), to activities that lead to a choice to adopt or reject the innovation ('*decision*'), to the stage where the innovation is implemented and put into use ('*implementation*'), and, finally, to the evaluation of outcomes of this decision ('*confirmation*'). Other stage models, often focusing on three main stages,

[1] The original edition was published in 1962 and the latest fifth edition – in 2003.

are also widely used. To cite a few: 'initiation – adoption – routinisation' (Zhu et al., 2006); 'evaluation – adoption – routinisation' (Junior et al., 2019; Cruz-Jesus et al., 2019); 'initiation – adoption decision – implementation' (Damanpour & Schneider, 2006).

Although it is hard to say when one stage ends and another begins – in reality, they are blurred and the loops from one stage to another may also take place – the stage models of innovation-decision process are useful to better understand that adoption of a new technology starts well before the 'decision' point and does not end at this point. Businesses adopt new technology in anticipation of benefits that this technology may bring to the firm. For this to happen, however, the firm should be aware of existence of the technology, and - even more importantly - of the business need for this technological innovation (to help overcome some gaps or deficiency, to exploit new opportunities, or keep pace with competitors, etc.) (Premkumar & Roberts, 1999).

In the innovation diffusion-adoption literature, there are two main perspectives of analysis. The first - *adoption perspective* – looks at characteristics of organisations that make them receptive (or easily 'persuaded') to technological innovation and change. The second – *diffusion perspective* – focuses on how a technological innovation spreads across a group of potential adopters and within society, but also within an organisation, and what are the characteristics of innovation that lead to acceptance (Premkumar et al., 1994; Premkumar & Roberts, 1999). In other terms, one perspective is actor-centred, another – technology-centred (Nadkarni & Prügle, 2020).

Under adoption perspective, a widely used theoretical framework that has been extensively used by Information Systems (IS) scholars to explore antecedents of ICT adoption is the *Technology-Organisation-Environment* Framework (TOE) developed by DePietro et al. (1990)[2]. The TOE framework places a firm into its technological, organisational and environmental contexts when examining what influences the innovation-decision process. *Technological context* refers to both internal technologies in use within a firm and external technologies relevant to a firm available in the market, as well as technical skills available in the organisation. *Organisational context* is defined by firm's size, scope, complexity of managerial structure, business strategy, availability of resources, etc. *Environmental*

[2] Often cited as Tornatzky and Fleischer (1990), the TOE framework was developed by DiPietro, Wiarda, and Fleischer and published in chapter 7 of Tornatzky and Fleischer (1990).

context relates to the business environment in which a firm operates – its industry, competitors, customers, partners, regulations. These three groups of factors influence a firm's innovation-decision process over its different stages, from those that precede '*decision*' to those that follow it, and eventually may influence the impact of innovation on business performance (Zhu et al, 2004). To put it differently, the main idea behind the TOE framework is that both internal and external factors matter for technological adoption.

The TOE framework, as mentioned above, has been used in prior studies on the adoption of ICT and digital technologies. Scholars mainly focus on one technology, oftentimes in the context of a particular sector. Thus, for example: Zhu et al (2004) apply TOE framework to E-business adoption in financial services; Cruz-Jesus et al (2019) – to Customer Relationship Management (CRM) adoption; Alshamaila & Papagiannidis (2012) – to cloud computing; Alsheibani et al (2018) – to Artificial Intelligence adoption; Masood & Egger (2020) – to Augmented Reality (AR) adoption – to cite only a few. A small number of studies use TOE to analyse adoption of a range of ICT technologies. Thus, Premkumar & Roberts (1999) use as dependent variable adoption of ICT measured by the degree of adoption of four technologies (e-mail, online data access, internet access and electronic data interchange (EDI)).

DoI and TOE theoretical frameworks shed light on different aspects of adoption phenomena and can be used to analyse digital innovation decisions by SMEs. In this study, we integrate both the ideas of stages in innovation-decision process as well as the importance of the context for digital adoption. We do it by applying a third analytical lens – the concept of *technology readiness*. This holistic perspective allows us to explore digital adoption and digitalisation of UK SMEs across a wide range of technologies.

2.2 Digital technology readiness

Originally, '*technology readiness*' (TR) concept was developed to measure consumers' readiness to use new technologies. Parasuraman (2000) describes it as 'an overall state of mind resulting from a gestalt of mental enablers and inhibitors that collectively determine a person's predisposition to use new technologies' (Parasuraman, 2000, p.308). The original conceptualisation of TR comprised four dimensions: optimism, innovativeness, insecurity and discomfort. *Innovativeness* refers to an individual's tendency to be a technology pioneer and thought leader; *optimism* encompasses a positive view of

technology and a belief that it offers increased control, flexibility and efficiency; *discomfort* relates to perceived lack of control over technology and a feeling of being overwhelmed by it; *insecurity* refers to distrust of technology and scepticism about its ability to work properly (Parasuraman, 2000, p.311). Innovativeness and optimism act as drivers or motivators and increase TR while insecurity and discomfort act as inhibitors and decrease TR. Afterwards, the TR concept was extensively applied in marketing studies, although the conceptualisations differed: either using original four-dimensional approach, two-dimensional (motivators and inhibitors) or unidimensional (overall composite) construct (Parasuraman & Colby, 2015; Blut & Wang, 2020). The principal interest of this theoretical conceptualisation is that it provides a rich analytical framework allowing not only to capture individual's attitude towards using a specific technology[3], but also to explore consequences, i.e. usage of technology and its outcomes, and antecedents of TR such as individual characteristics. Furthermore, Blut & Wang (2020) find that motivators' dimension of TR has stronger relationship with technology usage than that of inhibitors.

Richey et al. (2007) based on Schumpeterian vision of innovation as essential in building a firm's competitive advantage and a view of a firm as a 'knowledge repository'[4], argue that technology readiness is *a form of capability* of a firm related to technology. Authors define technological readiness as 'the intangible resource capability facilitating the usefulness of the physical technology' (Richey et al., 2007, p.199).

Technology readiness, when applied to organisations instead of individuals, may be seen as a particular case of *organisational readiness to change* as used in industrial organisation and management studies. The latter refers to the state of being ready to engage in a specific activity, i.e. it is a *state* attained *prior* to commencement of a specific activity. It involves psychological, behavioural, and structural preparedness of the organisation (Helfrich et al., 2011; Lokuge et al., 2019). Weiner (2009) conceives organisational readiness in psychological rather than structural terms as a shared psychological state in which members of an organisation feel committed to implementing an organisational change and confident in their collective ability to do so (i.e. willing and able). Scholars have highlighted several factors that affect readiness for change, such as flexible organisational

[3] Or, as in this case – a set of different technologies
[4] It enables the firm to be innovative in times of need and to reinvent itself. For the discussion, see Holcombe (2013)

strategies, adequate skills and learning requirements, and a culture that favours innovation and promotes changes (Jones et al., 2005; Weeks et al., 2004; Lokuge et al., 2019).

In this study, '*digital technology readiness*' is a multi-dimensional concept that we define as *propensity of a firm to embrace and use emerging digital technologies in pursuit of strategic business goals and short term objectives*. Following previous literature (Weeks et al., 2004; Lokuge et al., 2019), we conceptualise readiness as a dynamic state, a degree of readiness in a continuum, rather than a dichotomous state of being 'ready' or 'not ready'. The proposed conceptual model of digital technology readiness is grounded in DoI, TOE and TR frameworks. Based on DoI, we argue that '*knowledge*' and '*persuasion*' stages of innovation-decision process lead to a state of more or less favourable attitude toward digital technology reflected in digital readiness. Drawing on TOE, we posit that the propensity of a firm to embrace and use digital technologies depends on two broad groups of factors: mainly internal – referring to technological and organisational contexts – on one side, and mainly external – driven principally by perceptions of environmental context – on the other side. Hence, we distinguish two principal dimensions of digital readiness: organisational and technological readiness (ODR) and environmental readiness (EDR).

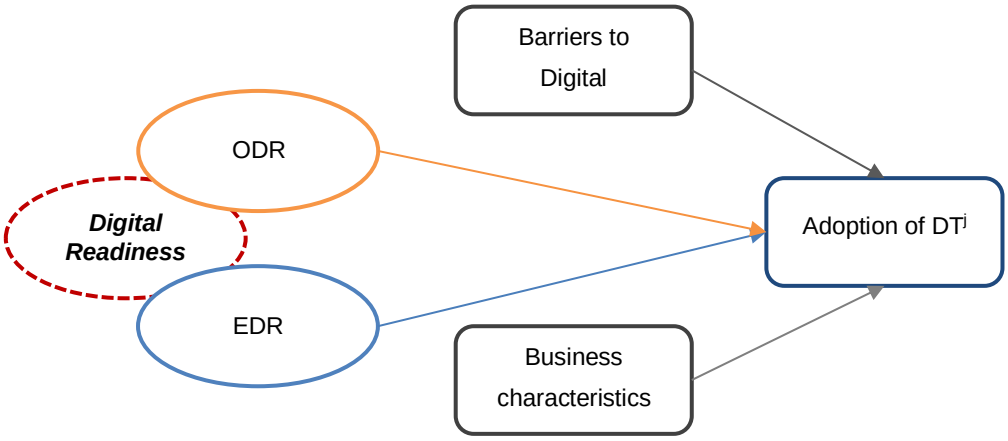
Digital technology readiness, in its ODR and EDR dimensions, is an unobservable underlying (also called latent) construct. This latent construct can be manifested (i.e. regarded as a cause of these manifestations) in different attitudes and perceptions regarding digital technologies. A brief justification for the variables selected to measure the underlying constructs is provided further in this section.

Figures 1 and 2 illustrate the research model. Figure 1 describes the impact of two dimensions of digital readiness – ODR and EDR – on the adoption of digital technologies in UK SMEs. In other words, we hypothesise that:

Hypothesis 1: Organisational/Technological digital readiness will increase the probability of digital technology adoption.

*Hypothesis 2: Environmental digital readiness will increase the probability of digital technology adopt*ion.

Figure 1. Conceptual framework 1: Digital readiness and adoption



In addition, we explore how perceived barriers to digital technologies – such as lack of skills, resistance to change of employees, financial constraints, broadband capacity etc. - influence digital adoption. We hypothesise that:

Hypothesis 3: Perceived barriers to digital will decrease the probability of digital adoption.

2.2.1 Organisational and technological digital readiness

Organisational and technological digital readiness (ODR) refers to technological and organisational capabilities, or, else, different internal resources available in the firm.

Digital technologies are becoming more and more complex, entailing a broad range of hardware and software applications. Throughout any innovation-decision process, firms require technical *skills and* flexible human resources (evolving adaptability of staff, redeployment and reskilling of employees if needed) in order to evaluate potential benefits of emerging digital technologies available on the market, to adopt and then successfully implement technologies (Cruz-Jesus et al., 2019; Lokuge et al., 2019; Zhu et al., 2006). The importance of overall awareness and *knowledge* of existing technologies is stressed in DoI theory (Rogers, 2003). Lokuge et al. (2019) consider knowledge – along with skills and adaptability – as one of the elements of 'cognitive readiness' which captures the strength of the knowledge base of a firm. The acquisition of 'knowledge' requires considerable intentional effort through technical and managerial learning. Such knowledge tends to be 'sticky' and is usually time-consuming. Consequently, 'knowledge barriers',

arising because firms – especially resource-constrained SMEs – lack time and cannot allocate enough effort to learning, hinder adoption and use of technologies (Fichman & Kemerer, 1999). Because of 'stickiness' of knowledge, we also consider *previous adoption* of digital technologies as one of the factors contributing to ODR. Previous literature attracts attention to previous adoption as one of the factors that may influence adoption decision through 'learning-by-using' effects (Roper & Bourke, 2018).

In TR literature, innovativeness is one of the dimensions of technology readiness (Parasuraman, 2000). We also posit that firms with higher levels of ODR tend to be innovative. When a firm's capacity for innovation relies on the use of digital technologies, it is more likely to maintain its knowledge base and adopt emerging technologies.

Regarding organisational context, we include *digital strategy* as one of the elements related to underlying ODR. Previous evidence suggests that strategic and organisational cultural background are important determinants of technology adoption. Thus, top management support (Premkumar & Roberts, 1999; Cruz-Jesus et al., 2019; Jeyaraj et al, 2006; Going digital, 2019), perception of strategic value (Grandon and Pearson, 2004), clarity and relevance of strategic goals (Lokuge et al, 2019), technology strategy (Bruque & Moyano, 2007) have been shown as important factors influencing technology adoption and assimilation.

2.2.1 Environmental digital readiness

Environmental digital readiness describes a firm's attitude toward digital technologies resulting from its perception of environmental context in which it operates or will operate in the foreseeable future. The adoption of new technology may be a solution to changing environmental context, its demands and constraints. The environment of a firm consists of horizontal competitors, vertical trading partners up and down value chain, customers, regulators, and overall entrepreneurial ecosystem. Environmental factors influencing adoption of technological innovations may refer to the structure of the market (competition, concentration), technological dynamism and partner readiness, regulatory environment (Damanpour & Schneider, 2002; Zhu et al., 2006b).

Competitive pressure and its intensity have long been recognised as driving forces of technology adoption and usage. Firms tend to seek competitive edge by adopting new technological innovations which may allow them find new ways to outperform their rivals,

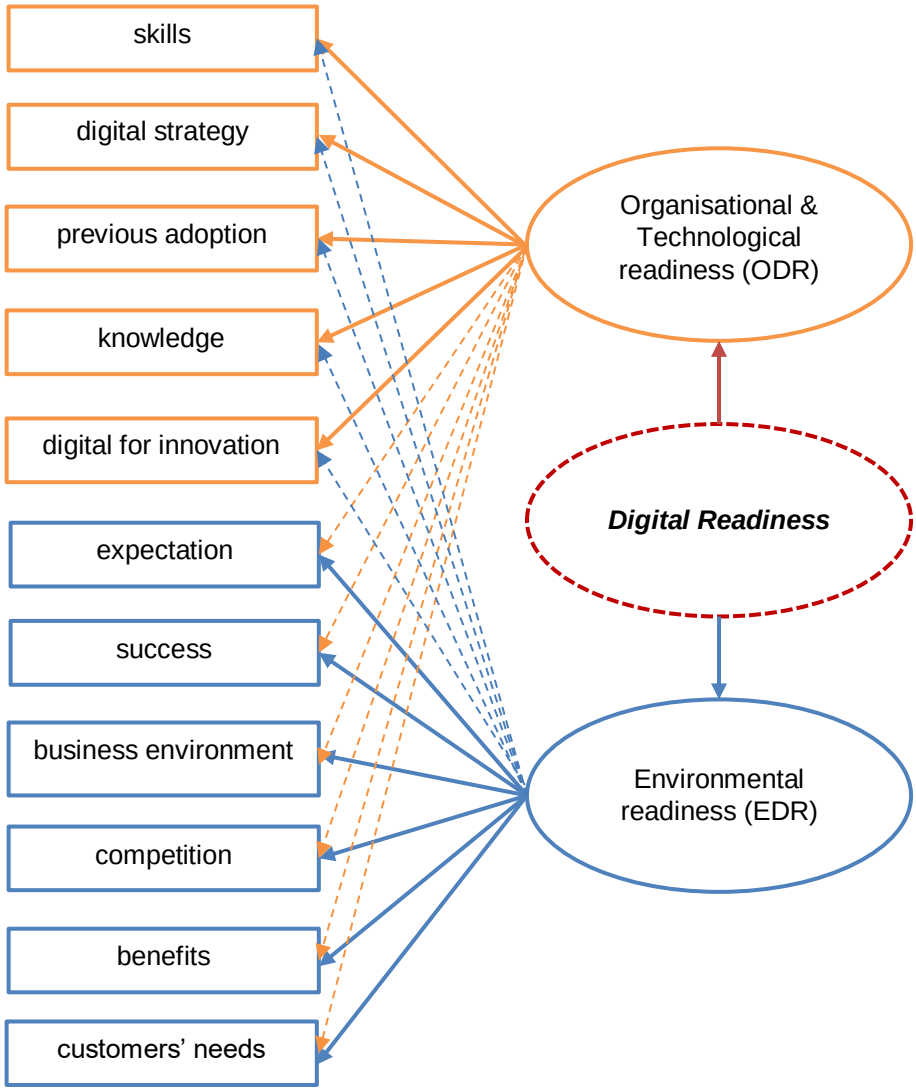
to alter competitive rules and affect industry structure (Porter & Millar, 1985; Gatignon & Robertson, 1989; Thong, 1999; Zhu et al, 2004; Zhu et al., 2006; Cruz-Jesus, 2019). *Pressure from trading partners and customers* is another important factor which may influence digital adoption. This pressure can be critical, especially for small firms, when exercised by a larger partner/customer which has a potential power of imposing new technologies through recommendations, promises or threats (Iacovu et al, 1995).

Technological dynamism of firms' *business environment* is another factor that may affect the innovation-decision process of SMEs (Damanpour & Schneider, 2002). Although, it is not a directly applied pressure as described previously, the perception of firms that digital technologies are becoming more widely used may also reflect in their propensity to embrace new technologies. This is reinforced by the fact that digital technology usage is regarded as one of the keys to business *success.* These considerations are related to the '*optimism*' (i.e. a positive view of technology) dimension in TR conceptualisation.

Two other proposed factors are also related to the optimism dimension. One is about firm's *expectations* of use of digital technologies in the future and the other is about perceived *benefits* of technology compared to efforts needed for its implementation. Perceived benefits or usefulness (also referred to as 'relative advantage' in DoI conceptualisation) has been extensively used in ICT adoption studies although criticised as a 'catch-all' variable (Premkumar, 2003; Tornatzky & Klein, 1982).

There is no clear delineation between measures we attribute to either organisational or environmental dimensions of digital readiness (Figure 2). This is the reason why opt for the flexibility of exploratory factor analysis (EFA) and construct measures of ODR and EDR based on factor loadings as it is discussed in the next section.

Figure 2. Digital readiness - measurement



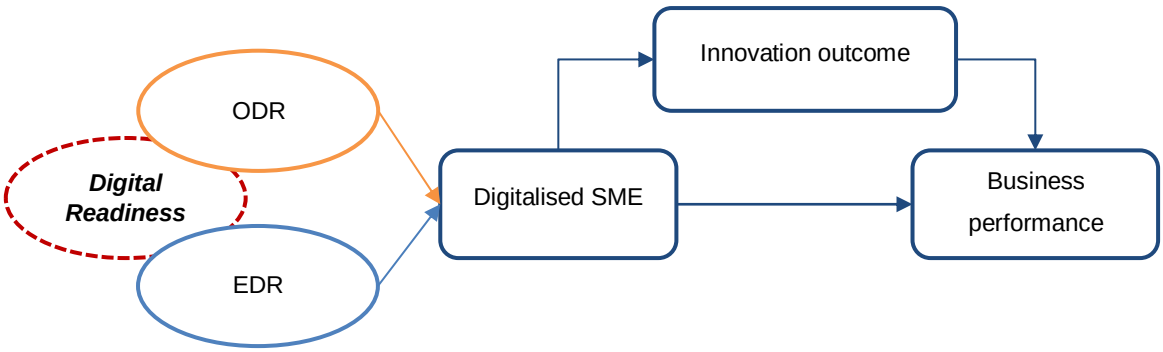
Note: the direction of the arrows signifies that the latent (unobserved) dimensions of digital readiness 'causes' the responses to the observed variables.

Thus, for example, one can argue that '*expectation'* and '*benefits'*, relate more to the organisational and technological readiness rather than to EDR. However, considering that the object of this study is not one specific technology but a wide range, we posit that both the perceived benefits of digital technologies and the expectations about the future are more driven by perceptions of environmental context of a firm rather than by organisational and technological readiness.

2.3. Digitalisation and business performances amidst the crisis

Having hypothesised the role of digital readiness on digital adoption, we now turn our attention to post-adoption stages. We investigate the relationship between digitalisation and business performances in UK SMEs in the context of Covid pandemic crisis. Figure 3 describes the research framework.

Figure 3. Conceptual framework 2: Digital readiness, Digitalisation and business Performance, direct and mediated mechanisms



The question of the contribution of technology to economic performance is subject to an important debate and controversies in the literature, well-known as the 'productivity paradox', both at macro (Aghion et al, 2017; Anzoategui et al., 2019; Brynjolffsonet al, 2017; Comin and Mistiery, 2013, 2018) and firm level (Babina et al, 2020; Brynjolffson & Hitt, 2003; DeStefano et al., 2018; Awano, 2018). Although we do not enter this debate, we however do investigate the potential relationship between digitalisation and business performance. Of note in this analysis is that we observe the already complex relationship between technology adoption and growth during very particular year of the Covid pandemic crisis.

We explore two alternative hypotheses, one describing a direct relationship between digitalisation and firm performance and another one where the relationship is mediated by innovation outcomes arising from the use of digital technologies. Indeed, suggested by the literature, it is not the adoption of digital technologies per se that affect firm performance but rather how these technologies are used inside the firm (Zhu et al, 2006). We argue that one important channel through which digital technologies may affect the performance of SMEs during the pandemic crisis, is through innovation. Indeed, the usage of digital

technologies resulting in increased innovative activity of a firm, helping it to find smart working solutions to remain in business during lockdowns, overcome disruptions in supply chains and introduce new products and services in response to changed environment, may potentially result in better business performance. Therefore, we hypothesise:

Hypothesis 4: Digitalised SMEs are more likely to have better business performance during the Covid pandemic crisis.

Hypothesis 5: Digitalised SMEs are more likely to have better business performance during the Covid pandemic crisis if digitalisation is accompanied by an increase in innovative activity.

3. DATA AND METHODS

3.1. Business Futures Survey

Our analysis is based on the Business Futures Survey, a new major survey of UK SMEs launched by the ERC in 2020. The survey aimed to understand current digital and environmental practices of UK SMEs but also to gather insights into the experiences of SMEs during the challenging times of the COVID-19 pandemic. The survey was undertaken by telephone using a CATI system between September and November 2020 and collected data from 1,019 SMEs. The sample focused on businesses employing between 7 and 250 employees and was representative of the main economic sectors. Northern Ireland SMEs were overrepresented in the sample to allow a specific analysis. In this paper, in order to provide results representative of the UK population of SMEs, observations were weighted.

Small businesses of less than 50 employees accounted for about 86 per cent of the sample. The other 14 per cent were medium-sized businesses employing between 50 and 249 employees. Well established businesses which started trading more than 10 years ago made up to 80 per cent of interviewed SMEs. Young businesses of 5 years old or less accounted for just over 5 per cent and businesses between 6 and 10 years old made up to about 15 per cent. About 74 per cent of businesses were unique site organisations while 26 per cent of businesses operated more than one site.

3.2. Digital adoption and digitalisation

The survey asked firms if they currently use any of the following ten digital technologies:

- E-commerce which involves website sales of goods and services
- Online marketing and social media
- Accounting or HR software
- Customer Relationship Management (CRM) systems
- Video conferencing tools such as 'teams' or 'zoom'
- Cloud computing solutions
- Computer Aided Design (CAD) software
- Internet of Things (IoT)
- Augmented and Virtual Reality (AR and VR)
- Artificial Intelligence (AI) and Machine Learning (ML).

This list covers both relatively well-established digital technologies, such as e-commerce, accounting and HR software, and more recent emerging digital technologies, such as AR/VR and AI.

Only 1 per cent of interviewed firms reported that they do not use any digital technologies. Among 10 digital technologies, more than 95 per cent of SMEs use at least 2 technologies. The majority of UK SMEs (50 per cent of distribution) currently use between 4 and 7 digital technologies covered by the survey with the median number of technologies being 5. We use this threshold of five digital technologies to classify a firm as '*digitalised*'. Although this classification is arbitrary and exploratory in its nature, it helps to distinguish firms which have already made substantial progress in their digital transformation from the firms which are only in the beginning of this journey[5]. In Section 4.1, we discuss in detail the extent to which digital technologies are diffused among the population of UK SMEs and how adoption rates are related to other business characteristics such as size, age and sector.

[5] Previous empirical studies used similar measures. For example, Going digital report (2019) classifies an SME as digitalised if it engaged in at least three digital activities.

3.3. Digital readiness scale

To develop the scale[6], i.e. a measure, of digital technology readiness, we followed conventional strategy in scale development (DeVellis, 2017; Wach, 2015). First, based on DoI, TOE and TR frameworks we developed a pool of items to represent motivators and inhibitors of digital adoption behaviour to include in the survey. Constrained by the overall length of the survey[7], and after consultation with experts, we reviewed the large set of items and centred our conceptual framework around the 'technology readiness' construct and its two principal dimensions as described above.

The final set of questions covering attitudes towards digital technologies in the questionnaire consisted of 12 items. These are four-point questions: from 1 'strongly disagree' to 4 'strongly agree'. One item ('our business can be successful without using the latest technologies', reversed scale) was dropped to improve the overall internal consistency reliability of the scale - Cronbach's alpha[8] - from 0.8405 to 0.8486. These final 11 items were used in an exploratory factor analysis (EFA) with orthogonal rotation. Based on eigenvalues, we retained two factors which explain 50.57% of variation in the data. In Table 1, we report the rotated factor loadings. The factor loading captures the extent to which an item is related to the identified underlying factor.

The first retained factor (Factor 1) corresponds to our *organisational/technological digital readiness* construct and is driven by five items: *skills*, *digital strategy*, *previous adoption*, *knowledge* and *digital for innovation*. 'Skills' with factor loading of 0.778 has the strongest association to the underlying latent variable (organisational/technological readiness).

[6] 'Measurement instruments that are collections of items combined into a composite score and intended to reveal levels of theoretical variables not readily observable by direct means are often referred as scales' (DeVellis, 2017, p.15)

[7] As noted above, the survey was intended to cover two major themes: net zero practices and diffusion of digital technologies in UK SMEs. The work on questionnaire design coincided with the first lockdown, therefore, inevitably the Covid-19 related questions needed to be introduced. The overall length of the questionnaire, however, could not be longer than 15 minutes to minimise possible loss of attention of the respondents.

[8] Alpha is one of the most important and most widely used indicators of a scale's quality and homogeneity of items in the scale. It is an indication of the proportion of variance in the scale scores that is attributable to the true score.

Reliability coefficient alpha for this scale is 0.7323 which is a 'respectable' acceptable level of consistency (alpha below 0.6 is unacceptable, see DeVellis, 2016, p.145).

The second retained factor (Factor 2) refers to the construct of *environmental digital readiness* and is driven by 6 items: *expectations*, *success*, *business environment*, *competition*, *perceived benefits* and *customers' needs*. Cronbach's alpha for this scale is 0.7872 which is also an acceptable level of internal consistency. We believe that considering the limited initial pool of items, the level of reliability of both digital readiness scales is quite satisfying. We also tested the scales separately on a Northern Ireland sample of 173 observations and found that the scales are stable.

Table 1. Digital technology readiness scale: factor loadings after rotation

	Factor 1	*Factor 2*
Skills	**0.778**	-0.069
Digital strategy	**0.680**	0.304
Previous adoption	**0.563**	0.165
Knowledge	**0.558**	0.351
Digital for innovation	**0.556**	0.487
Expectation	0.071	**0.724**
Success	0.209	**0.688**
Business environment	-0.112	**0.687**
Competition	0.407	**0.658**
Perceived benefits	0.315	**0.595**
Customers' needs	0.433	**0.552**
Cronbach's alpha	*0.7323*	*0.7872*

Source: calculations based on ERC Business Futures Survey

For subsequent regression analysis, we create factor scores to represent each firm's positioning on the identified two factors of digital readiness. These factor scores, *ODR* and *EDR*, are linear combinations of the corresponding observed items and are obtained by regression method. The computed factor scores are continuous variables standardised to a mean of zero and standard deviation of 1 as principal components method was applied here (DiSteffano et al., 2009).

3.4. Econometric approach

3.4.1. Digital readiness, barriers, and digital adoption

To analyse what drives the adoption of digital technologies, we estimate the following probit model for each of ten digital technologies:

$$DT_i^j = \alpha_0 + \alpha_1 ODR_i + \alpha_2 EDR_i + \alpha_3 Barriers_i + \alpha_4 Z_i + \varepsilon \qquad (1)$$

Where DT_i^j is a binary variable equal to one if a firm *i* uses digital technology *j* and zero otherwise; ODR_i and EDR_i are measures of organisational/technological and environmental digital readiness developed earlier. $Barriers_i$ is a set of binary variables that reflect barriers to digital technologies as perceived by SMEs. Finally, Z_i is a set of control variables.

The equation (1) expresses the probability of adoption of digital technology *j* dependent on digital readiness and barriers to digital technologies[9]. Among the controls, we include two binary variables taking a value of one when a firm is pursuing *product innovation objective* or *process innovation objective.* We argue here that firms pursuing product and process innovation objectives may be more prepared to adopt new digital technologies as some of these innovations may rely on digital technologies. We have also included a binary variable indicating whether or not a firm is selling outside of the UK to capture any market scale effects. In addition, we include a binary variable equal to one if a firm perceives competition as a major obstacle to the business. To capture strategic organisational capabilities, we also include a dummy equal to one if a firm has a formal written business plan.

To control for firm-specific characteristics, we introduce a categorical size variable (small or medium-sized business) and categorical variable for the age of the firm (0 to 5 years, 6 to 10 years, 11 to 20 years and more than 20 years since starting trading). We also allow for sectoral and geographical heterogeneity by including sector and nation variables.

We also run a similar model to estimate the probability of a firm to be digitalised:

[9] Barriers to digital are discussed in detail in Section 4.1.2.

$$digi_i = \alpha_0 + \alpha_1 ODR_i + \alpha_2 EDR_i + \alpha_3 Barriers_i + \alpha_4 Z_i + \varepsilon \quad (2)$$

Where $digi_i$ is a dummy variable equal to one if a firm *i* uses five or more different digital technologies.

3.4.2. Digitalisation and business performance

Our final hypothesis relates to the relationship between digitalisation and business performance amidst the pandemic crisis. To explore both direct and indirect (mediated) mechanism as schematised by Figure 3, we estimate the following trivariate simultaneous system of equations using generalised structural equation model (GSEM):

$$Digi_i = \beta_{11} ODR_i + \beta_{12} EDR_i + \gamma_{1,n} Z_i + \varepsilon_1 \quad (3.1)$$

$$InnovOutcome_i = \beta_{21} Digi_i + \beta_{22} ODR_i + \beta_{23} EDR_i + \gamma_{2,n} Z_i + \varepsilon_2 \quad (3.2)$$

$$Perform_i = \beta_{31} InnovOutcome_i + \beta_{32} Digi_i + \gamma_{3,n} Z_i + \varepsilon_3 \quad (3.3)$$

Equation (3.1) expresses the probability of a firm to be digitalised depending on its digital organisational and environmental readiness. Equation (3.2) reflects the probability of a firm to have experienced an increase in innovative activity depending on whether it is digitalised or not. We also include here measures of digital readiness, ODR and EDR, to control for potential direct effect of digital readiness on innovative outcome. Finally, equation (3.3) is our business performance equation that refers to the probability of a firm to experience turnover stability or growth depending on innovation outcome and digitalisation.

In the survey, firms were asked if their turnover increased, decreased or stayed the same over the previous 12 months. Considering the circumstances of 2020, even maintaining the turnover as stable during this period was challenging. Hence, we use a binary variable equal to one if a firm experienced either increase or stability in turnover and zero otherwise.

To explore the mediated relationship between digitalisation and business performance amidst the crisis, we use an 'innovation outcome' variable that takes a value of one if innovation activity of a firm increased as a result of introduction of digital technologies and zero otherwise.

Among controls we include a dummy indicating whether a firm is selling outside of the UK to account for the link between exporting and innovative activity as established by previous literature (Love and Roper, 2015). Competition is another factor that might strongly influence firm innovation and performance. Here, we control for it by adding another dummy variable that reflects whether a firm agrees that competition is one of the major obstacles to their success. We also include a dummy equal to one if a firm has a formal written business plan as an indicator of the firm's strategic organisational capabilities. We also control for other firm-specific characteristics: size, age, sector and geography by including dummies.

4. EMPIRICAL RESULTS

4.1. Preliminary analysis

4.1.1. Digitalisation and digital adoption

Preliminary analysis of the digital adoption levels of UK SMEs provides interesting lessons. *First*, *although larger firms are more likely to be digitalised than smaller firms, the digital gap tends to decrease for established digital technologies.* Thus, looking at the adoption rates of individual digital technologies, such as e-commerce, online marketing and social media, accounting or HR software, we observe that small firms have even higher adoption rates than medium-sized firms[10]. It is also the case for Internet of Things (IoT) technologies (Figure 4). For the Customer Relationship Management systems (CRM), the gap is only of 5 percentage points: adoption rate for small firms is 46 per cent and 51 per cent for medium-sized firms. From a theoretical point of view, it makes sense as technology diffusion goes from larger to smaller businesses. With time, the cost of implementation of established technologies decreases making these more affordable and easier to implement for smaller firms. Low-cost "ready to use" solutions (as opposed to more complex bespoke digital systems requiring substantial organisational change, relevant skills, and some fine-tuning to the needs of a particular business) become available.

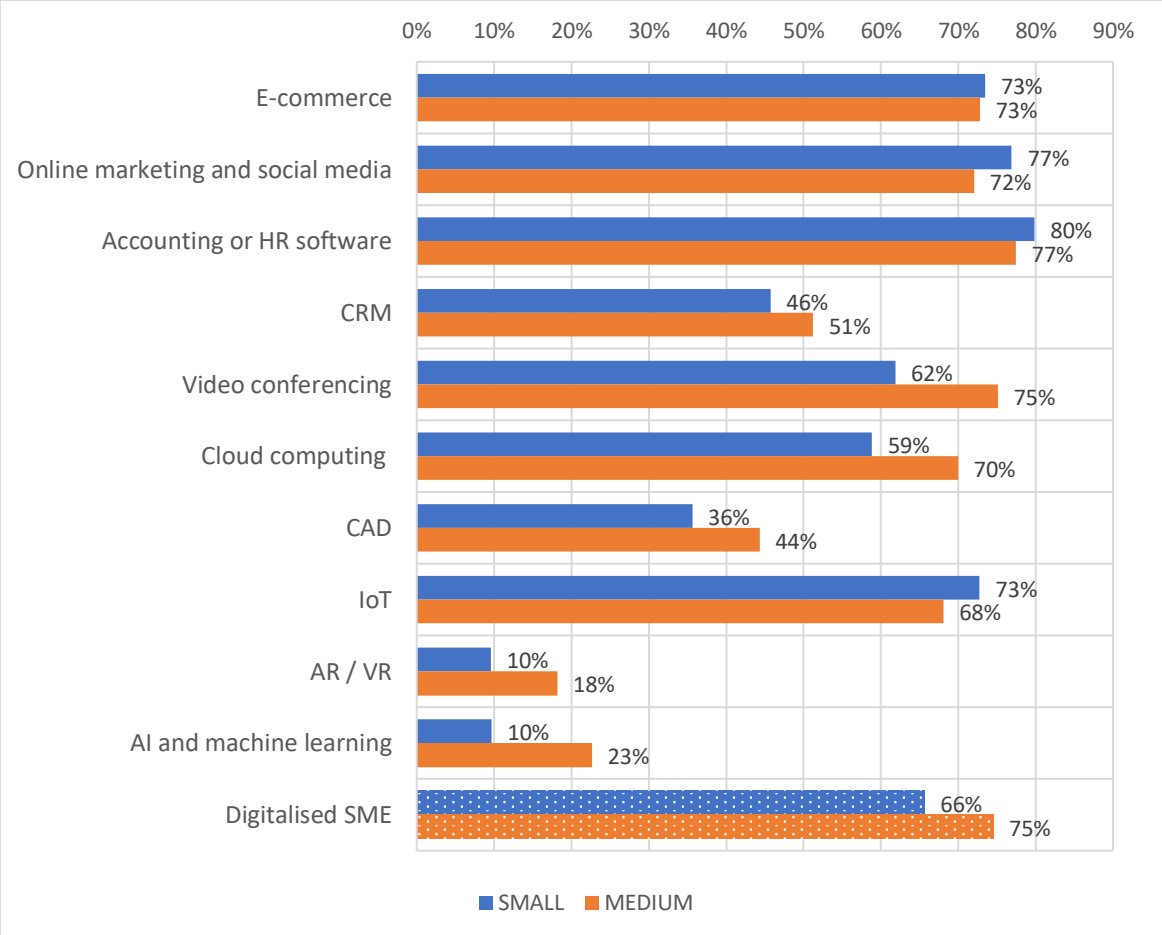
For more recently emerged technologies, such as cloud-based computing, Augmented (AR) and Virtual Reality (VR), Artificial intelligence (AI) and machine learning, size still matters:

[10] Although these differences are not statistically significant

there are substantial statistically significant differences in digital uptake between small and medium-sized businesses. Overall, in line with previous literature medium-sized businesses are more likely to be digitalised than small businesses: in our sample, 75 per cent of businesses employing more than 49 employees are using at least five different digital technologies compared to 66 per cent of small businesses.

Second, *the observed rates of digital adoption of UK SMEs in 2020 appear to be higher when compared with previous years*. The comparison with data from different sources should be done with all possible caution because of existing differences in definitions used, types of technologies covered, sampling and other methodological differences. However, using previous evidence may provide useful reference points.

Figure 4. Adoption of different digital technologies by firm size (%)



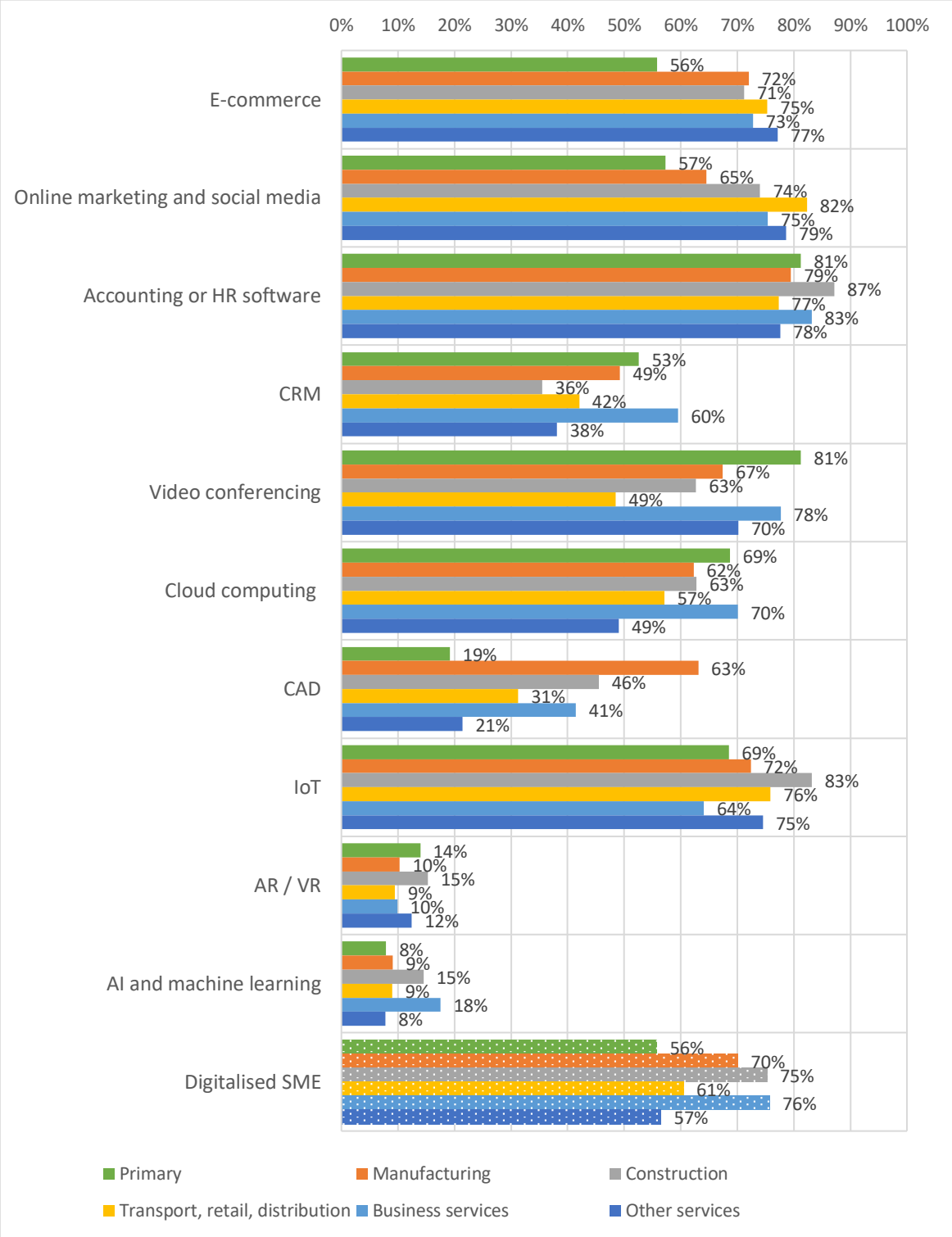
Note: digitalised SMEs are defined as those firms who currently use five or more different digital technologies.
Source: ERC Business Futures Survey

According to the E-commerce Survey, in 2019, 81 per cent of small and 92 per cent of medium-sized businesses had a website, but only 25 and 26 per cent respectively were making website sales (ONS, 2021). However, given the difference in definitions, we cannot directly compare these numbers with what we observe from the Business Futures 2020 data[11]. The Going digital report (2019) found that 53 per cent of UK SMEs undertook e-commerce activity in 2019 and that other 17 per cent were planning to introduce it. This indicates a significant uplift of e-commerce activity of UK SMEs in 2020 (73 per cent in BF survey, see Figure 2) as compared to 2019. The same can be said about the use of cloud computing (59 for small and 70 per cent for medium in 2020) if we compare with the following reference points: (1) 58 per cent of SMEs in 2019 (Going digital, 2019); (2) 50 per cent of small and 65 per cent of medium-sized firms in 2019 (ONS, 2021). There is also a first indication of an increased use of CRM systems in 2020 (46 and 51 per cent in BF survey), especially by small businesses: only 26 per cent of small businesses and 49 per cent of medium-sized businesses were using CRM software in 2019 (OECD, 2021). Recent data from Longitudinal Small Business Survey also provides useful reference points for emerging advanced digital technologies. Thus, in 2019 only about 1 per cent of small and 2 per cent of medium-sized businesses said that they were using VR / AR technologies and 3 per cent of small and 8 per cent of medium – AI, Robotics and Automation.

Third, sector matters for digital uptake, with some technologies being more sector specific (Figure 5). For example, Computer Aided Design (CAD) software is more largely adopted in manufacturing (63 per cent of manufacturing firms) than in other sectors. Businesses in primary sector are less likely to adopt e-commerce and online marketing but have relatively high rates of adoption of CRM, video-conferencing, cloud-computing, IoT and AR/VR. AI and machine learning technologies have highest rates of adoption among professional and business services firms (this category includes ICT - 18 per cent of businesses) but also interestingly in construction and civil engineering (15 per cent). Interestingly, the diffusion of AR/VR and AI technologies across sectors is relatively even, confirming their general-purpose nature.

[11] In Business Futures questionnaire the exact wording for e-commerce technology was 'website to sell goods and services' and it would fit somewhere in between the two indicators from E-commerce survey.

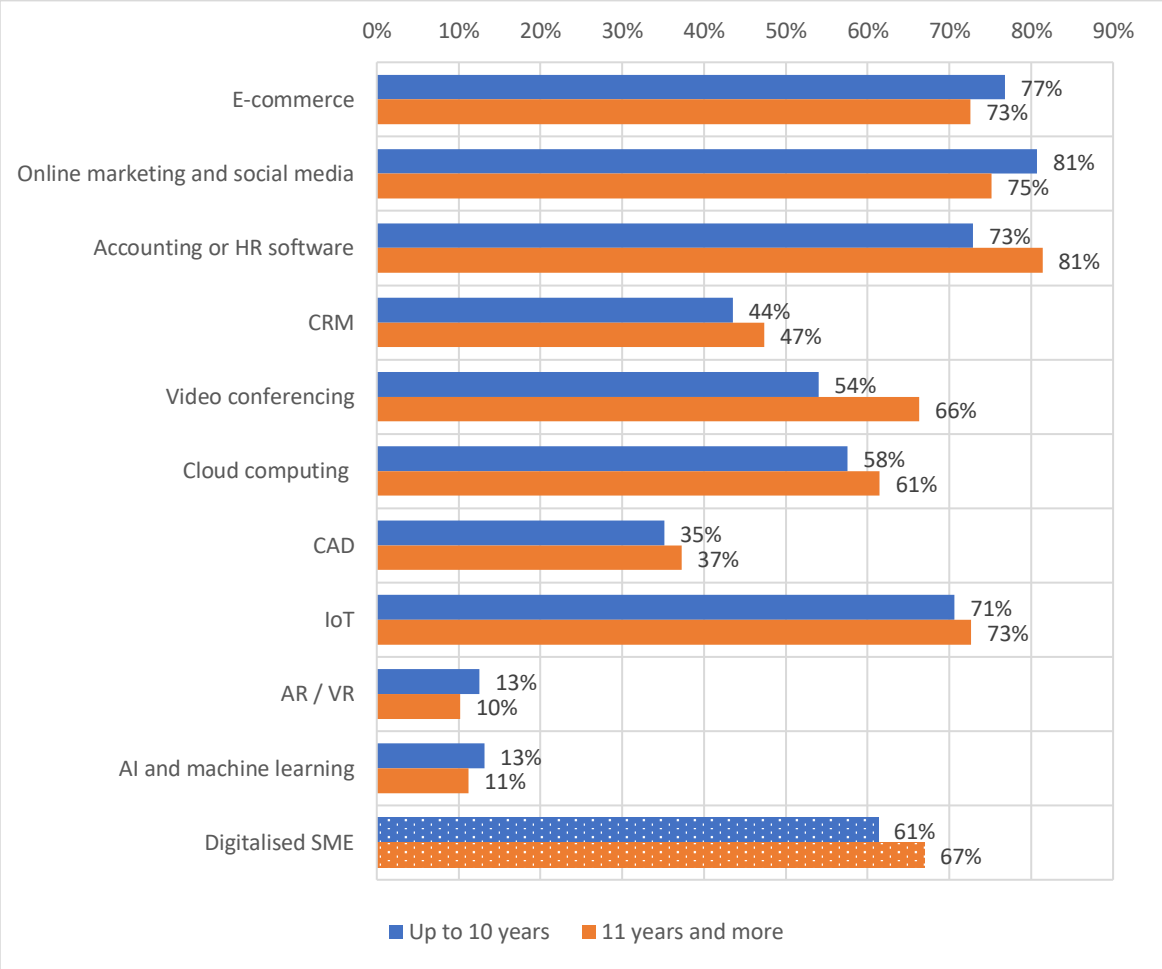
Figure 5. Adoption of different digital technologies by sector (%)



Note: digitalised SMEs are defined as those firms who currently use five or more different digital technologies.
Source: ERC Business Futures Survey

Overall, the highest proportion of digitalised SMEs is observed in business and professional services (76 per cent of businesses use five or more digital technologies), closely followed by construction (75 per cent) and manufacturing (70 per cent). However, in other sectors more than half of businesses can be also qualified as 'digitalised' – 61 per cent of SMEs in transport, retail and distribution, 57 per cent in other services and 56 per cent in primary sector.

Figure 6. Adoption of different digital technologies by firm age (%)



Note: digitalised SMEs are defined as those firms who currently use five or more different digital technologies.
Source: ERC Business Futures Survey

Finally, we find only little evidence of the influence of business age on digital adoption (Figure 6). The percentage of businesses using accounting and HR software is higher for older businesses (of more than 10 years since starting trading – 81 per cent) than for younger ones (up to 10 years – 73 per cent). It also counts for video-conferencing tools,

although part of this difference may be related to the size of the business rather than age. On the contrary, younger businesses are more likely to use online marketing and social media, especially those who started trading in the last 5 years. There are no statistically significant differences in digital adoption by age group for other digital technologies. Younger and older businesses are almost equally likely to be digitalised (61 and 67 per cent).

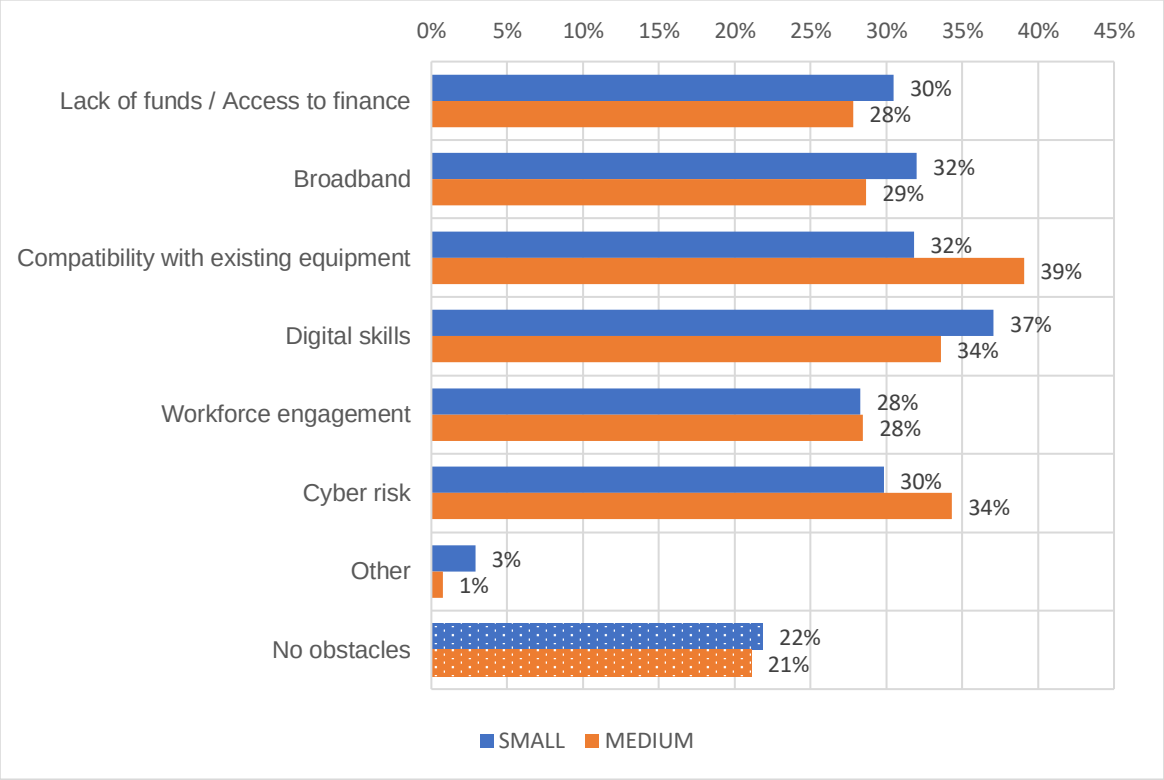
4.1.2 Barriers to digital

To better understand what factors may hinder digitalisation of UK SMEs, we conducted a preliminary analysis of perceived barriers to digital. The following insights resulted from this analysis.

First, lack of digital skills is the most frequently cited barrier to the adoption of digital technologies in the UK. This result is in line with previous evidence (EIBIS, 2019; Going digital, 2019). Lack of access to finance, broadband capacity, compatibility with existing equipment and cyber risk are also cited by more than one third of UK SMEs.

Second, these barriers concern both small and medium-sized firms. Figure 7 shows that there are only small differences between small and medium-sized firms in their perception of barriers to digital. Compatibility with existing equipment, workforce engagement and cyber risk are more frequently reported by medium-sized firms than by smaller firms (but only the first difference is statistically significant).

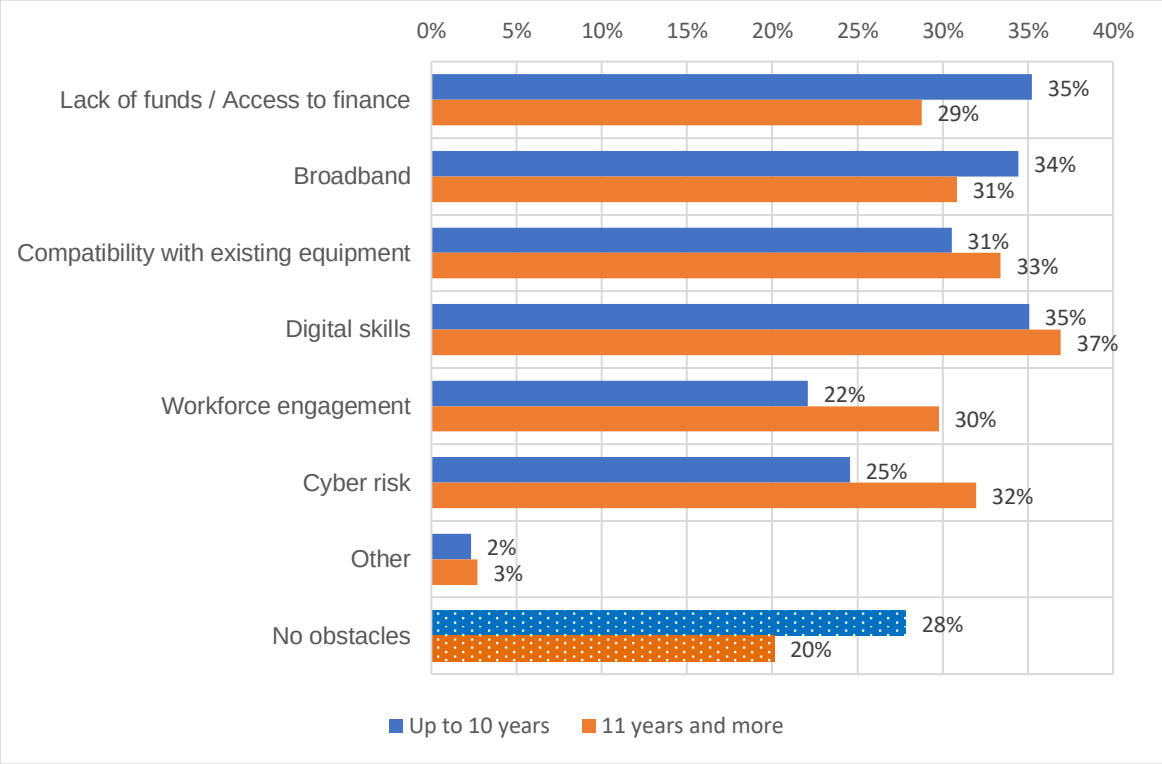
Figure 7. Barriers to digital adoption by firm size (%)



Source: ERC Business Futures Survey

Third, the perception of barriers to digital is different depending on a firm's age. Younger firms are more likely to report lack of internal funds and lack of access to finance as a barrier than older firms (Figure 8: 35 per cent and 29 per cent of businesses respectively). On the contrary, older firms are more likely to encounter workforce resistance to change (30 per cent versus 22 per cent of young firms) and be concerned about the cyber risk (32 and 25 per cent respectively). Interestingly, younger firms are more likely to report no obstacles to digital adoption than older firms.

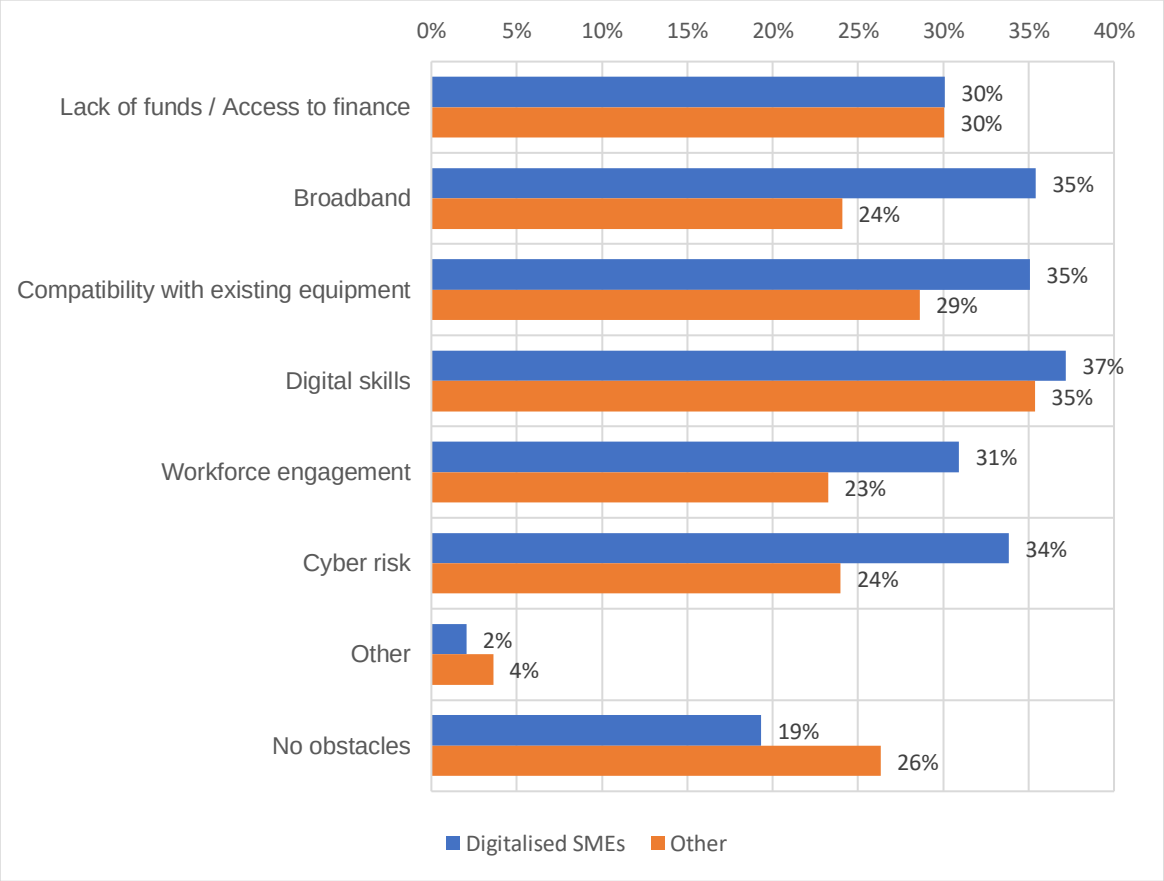
Figure 8. Barriers to digital adoption by firm size (%)



Source: ERC Business Futures Survey

Finally, digitalised SMEs and other businesses have different perception of barriers to digital. While digital skills and lack of access to finance are equally important for both groups of UK SMEs, broadband capacity, compatibility with existing equipment, workforce engagement and cyber risk are more frequently cited by digital firms than by their counterparts (Figure 9). On the contrary, less digitalised firms are more likely to see no obstacles to their digital transformation. This indicates that SMEs lagging in their digital journey may be not sufficiently aware or underestimate the obstacles to implementation of new digital technologies.

Figure 9. Barriers to digital adoption (%), digitalised vs other



Note: digitalised SMEs are defined as those firms who currently use five or more different digital technologies
Source: ERC Business Futures Survey

4.1.3. Characteristics of digitalised SMEs

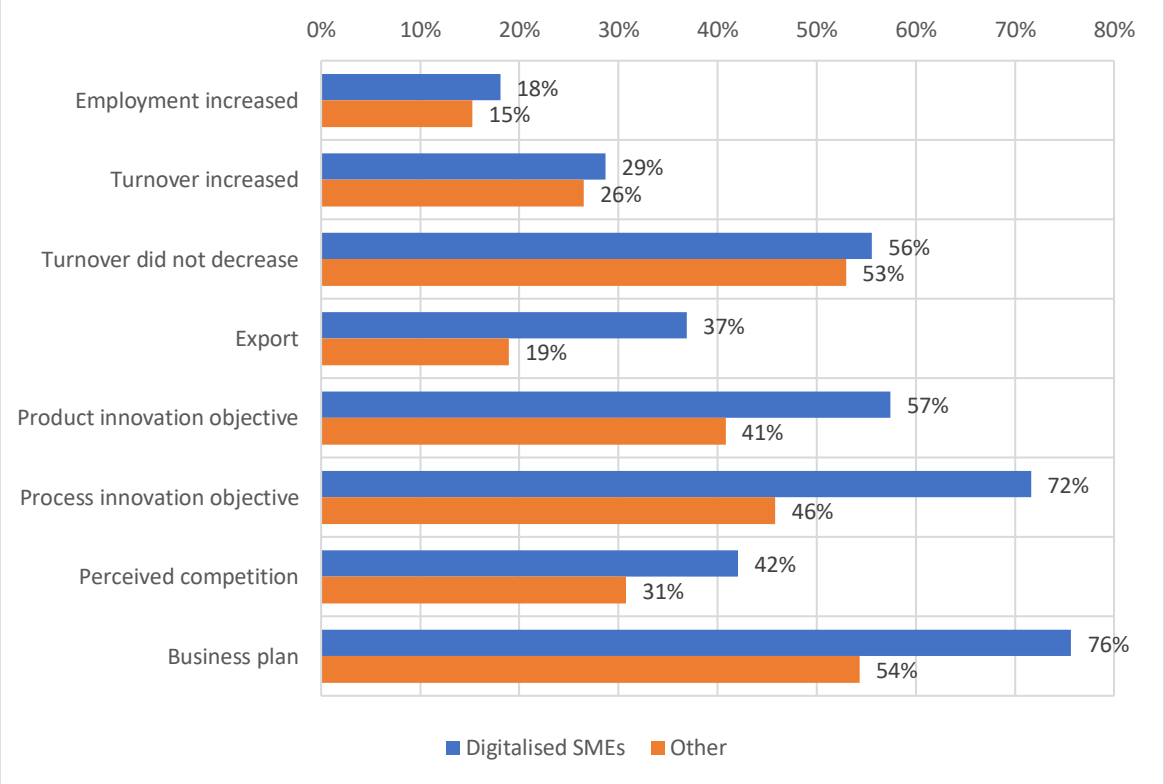
In 2020, digitalised SMEs performed about as well as other firms in terms of turnover and employment growth [12] (Figure 10): 18 per cent of digital firms reported increased employment and 29 per cent increased turnover. Considering the challenges that 2020 put in the way of UK SMEs, maintaining the turnover without any loss was already a notable performance (56 per cent of digitalised businesses).

When looking at other characteristics, however, clear differences appear. Digitalised SMEs tend to report exporting more often than other firms (37 and 19 per cent respectively), to

[12] Although, digitalised SMEs were slightly more likely to report growth than other firms, these differences are not statistically significant.

have product and process innovation as one of the business priorities (57 and 72 per cent to compare with 41 and 46 per cent for other firms) and to have a formal business plan (76 versus 54 per cent for other firms). Digitalised SMEs are also more likely to operate in a highly competitive environment: 42 per cent perceive competition in the market as a major barrier.

Figure 10. Characteristics (%), 'digitalised' vs 'non-digitalised'



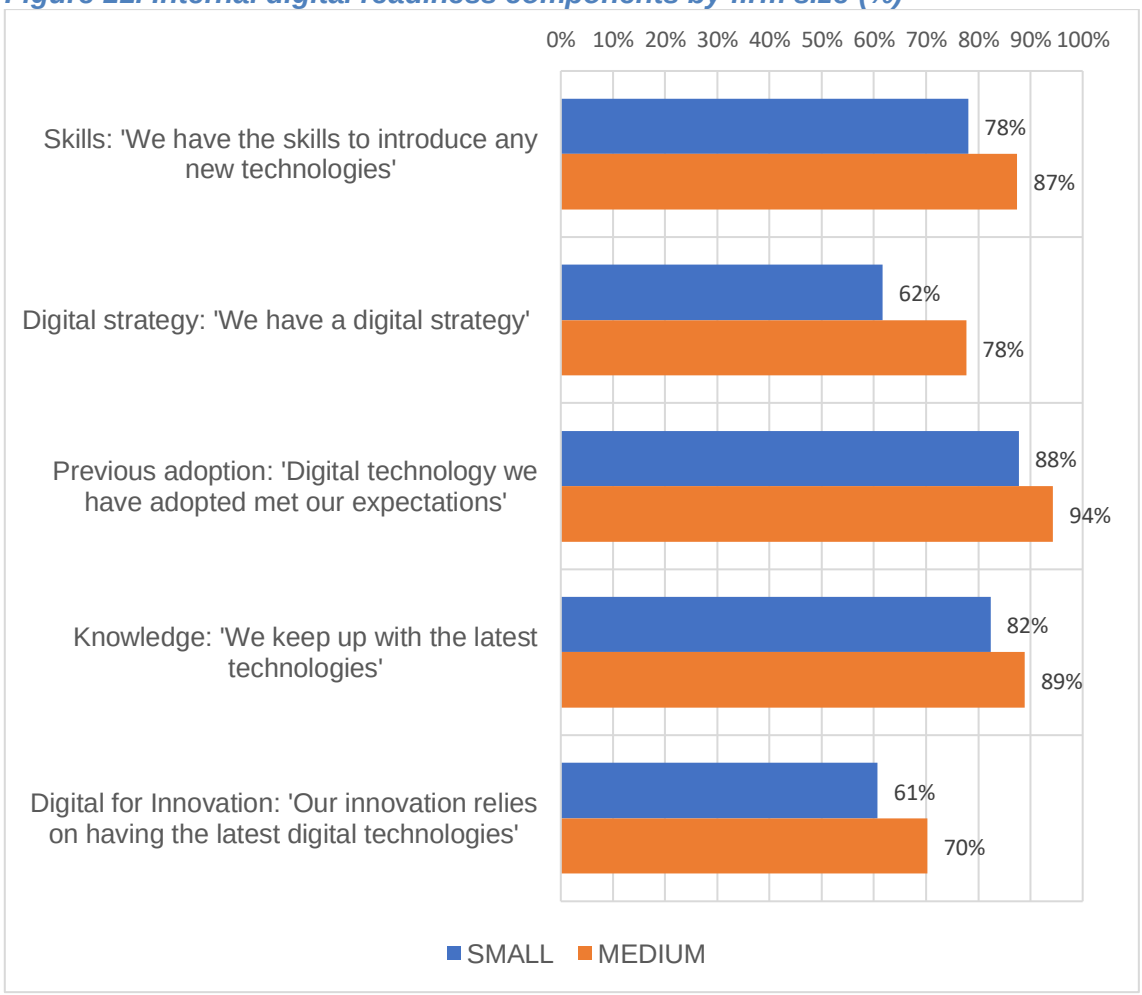
Note: digitalised SMEs are defined as those firms who currently use five or more different digital technologies
Source: ERC Business Futures Survey

4.1.4. Digital readiness of UK SMEs

Previous evidence shows that adoption of digital technologies is very much driven by size and sector. But what can be said about digital readiness? Preliminary analysis of components of digital readiness construct by size and sector reveals some interesting patterns.

For items composing *internal (technological and organisational) digital readiness*, there are considerable, statistically significant differences, between small and medium-sized firms (Figure 11). Thus, 87 per cent of medium firms perceive having relevant skills for introducing new technologies. This is almost 10 per cent higher than for smaller firms. Medium-sized firms are also more likely to have a digital strategy (78 per cent) than small firms (62 per cent). Previous experience of technology adoption, an important factor in decision to adopt new technologies, was reported to meet the expectations by 94 per cent of medium firms and by 88 per cent of small firms. The 'knowledge' component was also higher among medium firms (89 per cent) than among small firms (82 per cent). Finally, while just above 60 per cent of small firms perceive that their innovation relies on having the latest digital technologies, around 70 per cent of medium-sized firms agree with this statement.

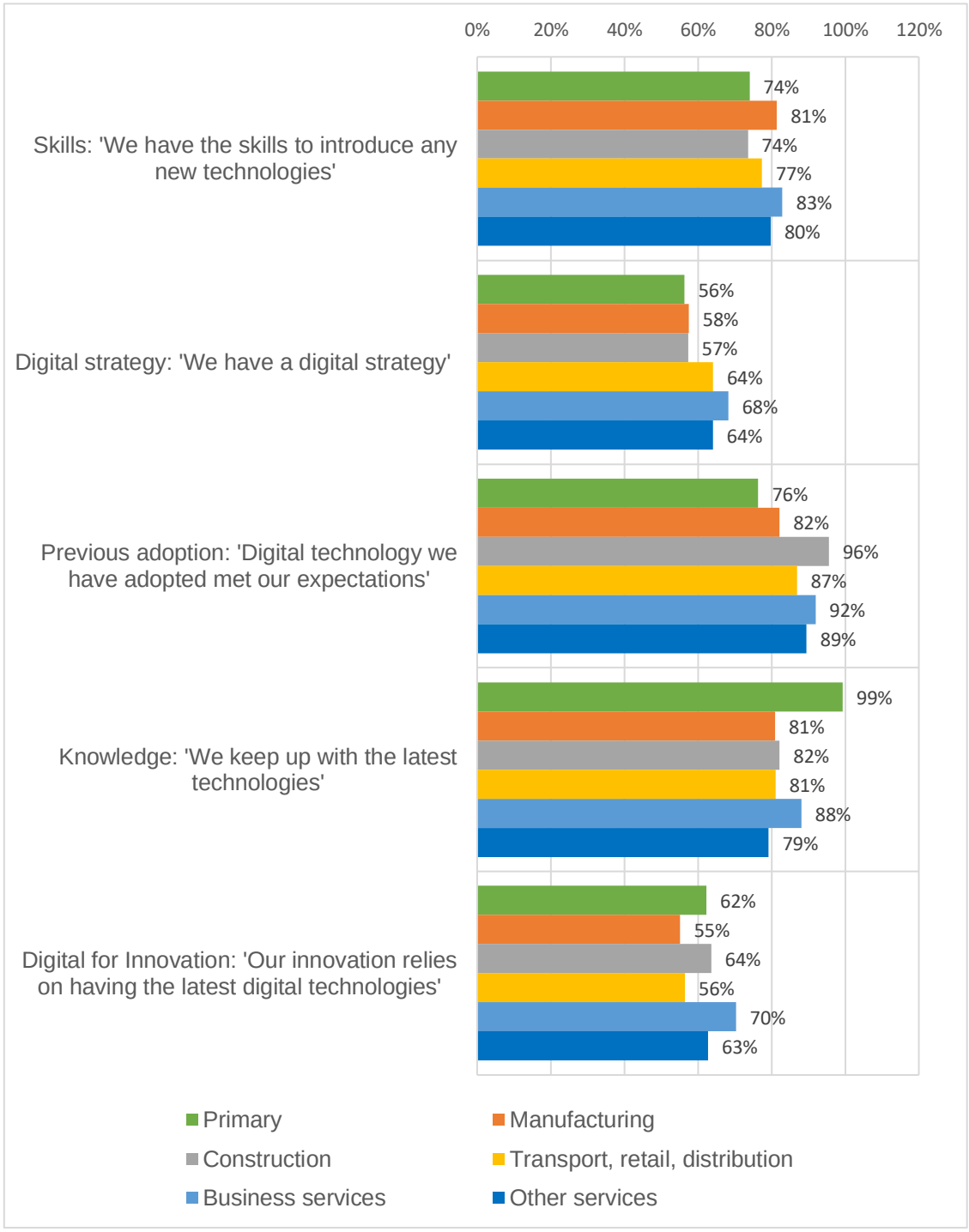
Figure 11. Internal digital readiness components by firm size (%)



Note: percentage of firms who either strongly agree or somewhat agree with the statement ('don't know' and 'refused' excluded).
Source: ERC Business Futures Survey

Figure 12 also demonstrates some differences in technological and organisation readiness by sector. Firms in manufacturing, business, professional and other sectors are more likely to report better readiness in terms of skills than firms in primary sector, construction and transport, retail and distribution. The business and professional services sector has the largest proportion of firms with digital strategy (68 per cent), this is significantly higher than in primary sector (56 per cent), manufacturing (58 per cent) and construction (57 per cent). Interestingly, there is some variation in terms of success of previous adoption of technology with the highest proportion of satisfied firms in construction (96 per cent) and business services (92 per cent) and the lowest in primary sector (76 per cent). New technologies awareness and knowledge appears to be important to SMEs across all sectors with the highest proportion of firms reporting that they keep up with the latest technologies occurring in primary sector (99 per cent of surveyed firms) and in businesses services (88 per cent).

Figure 12. Internal digital readiness components by sector (%)



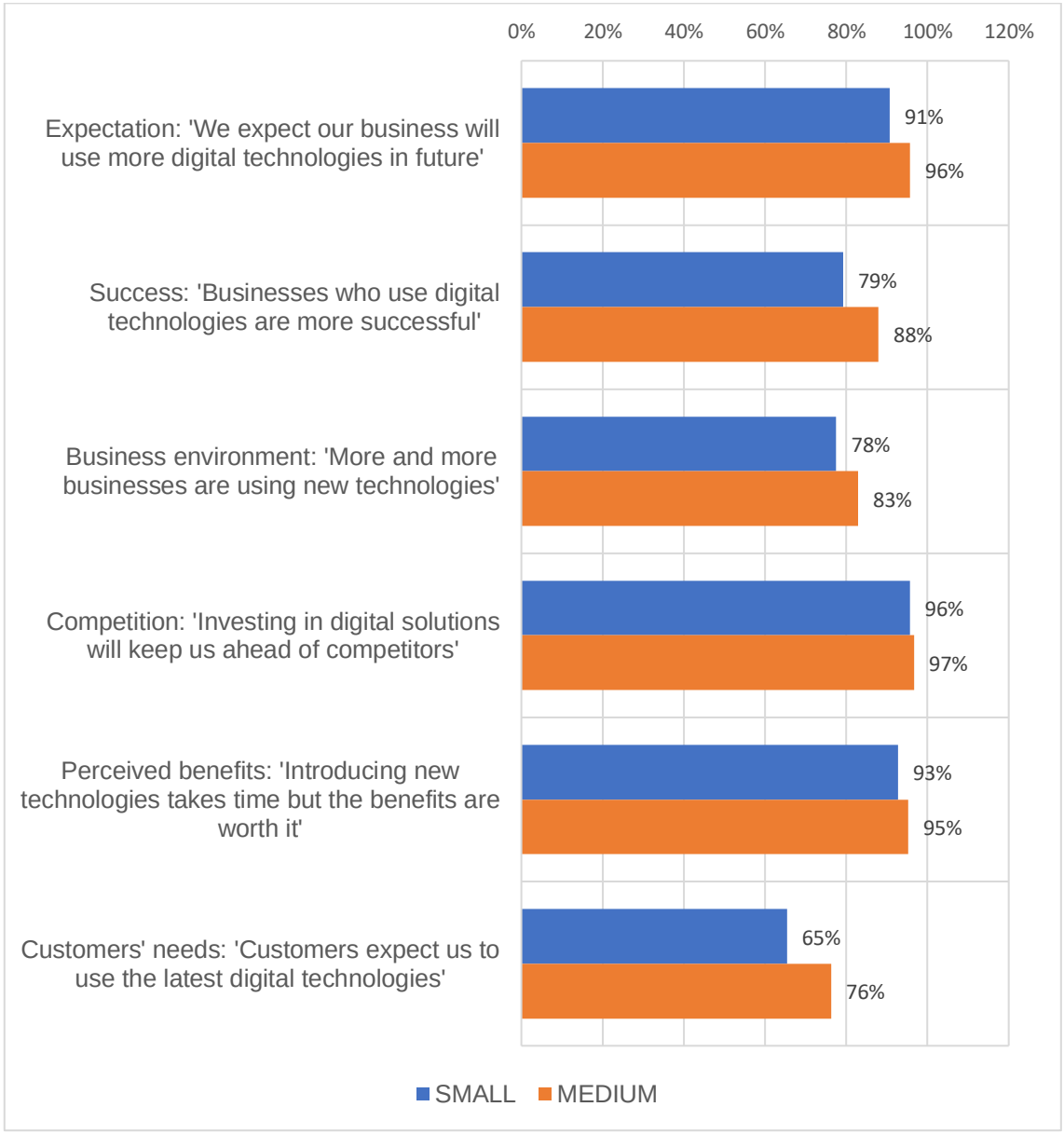
Note: percentage of firms who either strongly agree or somewhat agree with the statement ('don't know' and 'refused' excluded).
Primary sector corresponds to sections A, B, D and E of sic 2007 classification; Manufacturing – section C; Construction – section F; Transport, retail, and distribution – Sections G, H and I; Business services – J, K, L, M and N; other services – P, Q, R and S.
Source: ERC Business Futures Survey

As for relevance of digital technologies for innovation, it is the highest among business and professional services (this category includes information and communication and financial sector) with 70 per cent of firms agreeing that their innovation relies on having the latest digital technologies.

When looking at perceptions of firms' competitive environment and the benefits resulting from the use of digital technologies, which may drive the decision to adopt digital technologies, there is only a small (not statically significant) difference between small and medium firms. The majority of SMEs, more than 90 per cent, see investment in digital technologies as a solution to stay ahead of competitors and see benefits of this investment despite being a significant investment of time and effort (Figure 13). Medium-sized businesses are slightly more likely than small firms to expect an increase in the future use of digital technologies (96 and 91 per cent respectively) and to associate business success with digital technologies use (88 and 79 per cent). Medium-sized businesses are also more likely to feel pressure from customers to implement the latest digital technologies (76 per cent to compare with 65 per cent among small firms).

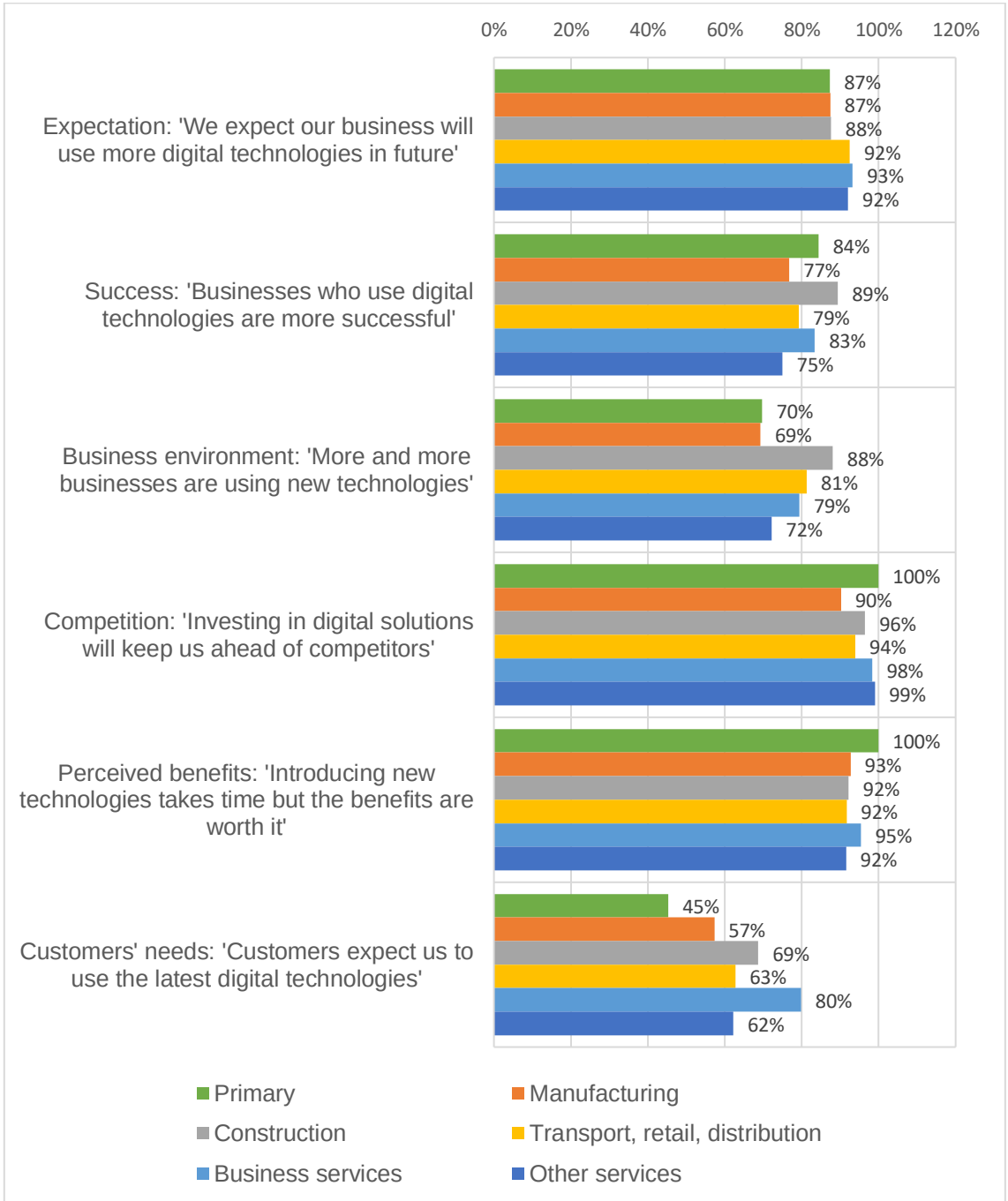
When analysing sectoral variation of external components of digital readiness, it comes out that there is only little difference for 'competition', 'benefits' and 'expectation' elements (Figure 14). Interestingly, a higher percentage of SMEs in the construction sector perceive an increased digitalisation of their overall business environment (88 per cent) and associate business success with digital technologies use (89 per cent) than in other sectors. Customers' needs are an important driver of digital practices especially among firms of business, financial, ICT and other professional services (80 per cent) while it is less important in the primary sector (45 per cent of firms).

Figure 13. External digital readiness components by firm size



Note: percentage of firms who either strongly agree or somewhat agree with the statement ('don't know' and 'refused' excluded).
Source: ERC Business Futures Survey

Figure 14. External digital readiness components by sector



Note: percentage of firms who either strongly agree or somewhat agree with the statement ('don't know' and 'refused' excluded).
Source: ERC Business Futures Survey

4.2. Estimation results

4.2.1. Digitalisation and Digital Readiness – what relationship?

Marginal effects of *digital readiness* and *barriers to digital* on the *probability of digital adoption* resulting from the estimation of probit models (eq. 1 and 2) are reported in Tables A3 and A4 in annex. Table 2 hereafter summarises principal results.

Table 2. Probability of digital adoption: summary

	E-comm	E-market	Acc / HR	CRM	'Zoom'	Cloud	CAD	IoT	AR / VR	AI	Digital SME
ODR	+**			+***	+***	+***	+***		+***	+***	+***
EDR	+*	+**		+***	+***	+***			+**	+*	+***
Finance		+*									
Broadband	+*							+***	-***	-***	
Compatibility											
Skills											
Workforce engagement							+**				
Cyber risk		-**					-*				
No barriers			-**						-**	-**	
Business plan				+***	+*					+*	+*
Exporting					+**				+*	+**	+***
Prod innov obj		+**	-*	+*			+**			+**	
Process innov obj	+***	+**	+***	+**	+***	+**		+***			+***

Note: only statistically significant results reported: '+' stands for a positive relationship, '-' for negative relationship; significance level: *** p<0.01, ** p<0.05, * p<0.1.
Source: ERC Business Futures Survey

First, the results suggest strong support for the importance of organisational and technological readiness for digital adoption and *Hypothesis 1*. We find that higher ODR is associated with a higher probability of adoption of seven out of ten digital technologies. Although the relationship is positive, it is not significant for online marketing and social media, accountancy and HR software, and (surprisingly) IoT. One explanation of this exception is that as these technologies are already well diffused among SMEs and relatively easy to implement, they do not require high level of internal capabilities reflected in ODR. When comparing magnitude of effect of ODR across our set of digital technologies, we observe that the organisational/technological dimension of digital readiness is particularly powerful in predicting the probability of adoption of CAD, CRM, cloud and AI: a one point increase in ODR is associated with 12 percentage points increase of the

probability of adoption of CAD, 9 percentage point increase of the probability of CRM adoption and 7 percentage points – of cloud and AI (Tables A3 and A4).

Second, we also find strong support for *Hypothesis 2*: external motivators captured by environmental dimension of digital readiness (EDR) are positive and significant for the probability of adoption of 7 out of 10 technologies (the relationship for Accountancy and HR software, CAD and IoT is not statistically significant). Thus, for example, firms are more likely to engage in online marketing and social media by 3.3 percentage points with the increase by one point in their level of EDR.

When we look simultaneously at marginal effects of ODR and EDR on the probability of adoption of each technology, some interesting patters emerge. For some technologies both dimensions are almost equally important, for example for E-commerce, CRM, video-conferencing tools or cloud. For others, on the contrary, one or other dimension of digital readiness is dominating. Thus, for CAD, AR/VR and AI, an increase in internal readiness (ODR) is associated with higher increase in probability of adoption compared to environmental readiness (EDR). The results of estimation of equation (2) suggest that both dimensions of digital readiness are important predictors of the probability of a firm to be digitalised with ODR being more potent than EDR.

Third, interestingly, we find only little support for the negative effect of barriers to digital on probability of adoption envisaged in *Hypothesis 3*. As expected, firms experiencing issues with broadband capacity are 7 percentage points less likely to adopt AR/VR and 6 percentage points less likely to adopt AI/ML. However, these concerns do not prevent firms adopting E-commerce and IoT (positive and significant relationship). In addition, results indicate a positive relationship between lack of funds / access to finance and probability of adoption of online marketing and social media The unexpected sign of the relationship may indicate that financially constrained firms seek to develop relatively low-cost solutions to promote their products/services by using digital marketing and social media instead of more costly traditional options. We do not find any significant relationship between lack of finance and the probability of adoption of other technologies. Despite the fact that lack of digital skills is the most frequently cited barrier to digital adoption, our analysis does not find any statistically significant relationship between this barrier and the probability of technology adoption. Moreover, as discussed earlier, firms that do not see any obstacles preventing them introducing digital technologies, are not more likely to adopt them. On the contrary,

we find that these firms are less likely to adopt advanced digital technologies, such as AR/VR and AI, but also accountancy and HR software. These results indicate that firms may be lagging behind their counterparts in digitalisation process not so much because of barriers they encounter but more so because of intrinsic factors. On the contrary, when starting to invest in digital, firms are likely to face different obstacles, although these do not necessarily prevent them from implementing technologies if the firm has strong motivators to adoption (captured by digital readiness) and the ultimate benefits of digital adoption are worth it. One implication from these findings, is that it is important to showcase both benefits and possible obstacles to digital adoption when providing business support to SMEs. Also, our results indicate that infrastructure investments (e.g. increasing broadband capacity) may also be beneficial to support adoption of advanced digital technologies.

Finally, concerning strategic behaviour and capabilities, we find some evidence of positive association with the technology adoption behaviour. However, it differs for each type of technology. Thus, the probability of adoption of AI and ML is associated with having a formal business plan, with exporting and with business objective to introduce new products / services. The latter is also associated with higher probability of adoption of CAD, CRM and online marketing. Process innovation as business objective is associated with a higher probability of adoption of established digital technologies helping to increase the efficiency of busines operations.

Regarding other control variables, the results suggest a ‘size matters’ effect only for AI/ML technologies, confirming our intuition that the digital gap between small and medium enterprises narrows down for the established digital technologies. We do not find any consistent age affect across digital technologies, most coefficients being not significant. Results also confirm sector-specificity of some of the technologies: for example, CAD is 32 and 16 percentage points more likely to be adopted in manufacturing and construction than in transport, retail and distribution. On the contrary, other technologies such as AI are general purpose technologies with no statistically significant sectoral effect identified. Overall, digitalised SMEs are more likely to operate in manufacturing, construction, business, professional and other services rather than in transport, retail and distribution.

4.2.2. Digitalisation and business performance amidst Covid-19 crisis

In Table 3 we report the marginal values derived from simultaneous estimation of probit models (Eqs. 3.1 – 3.3) which refer to the joint probability of business performance (stable

or increased turnover growth), positive innovation outcome (increased innovative activity) and digitalisation.

Table 3. Joint probability of business performance, increased innovative activity and digitalisation (average marginal effects)

VARIABLES	(1) Eq. (3.1) *Digi*	(2) Eq. (3.2) *InnovOutcome*	(3) Eq. (3.3) *Perform*
Innovation outcome (0/1)			0.073*
			(0.040)
Digitalised SME (0/1)		0.112**	0.013
		(0.051)	(0.043)
ODR	0.094***	0.060***	
	(0.015)	(0.020)	
EDR	0.073***	0.121***	
	(0.016)	(0.021)	
Business plan (0/1)	0.087**	0.035	0.022
	(0.039)	(0.046)	(0.042)
Competition (0/1)	0.051	0.047	-0.142***
	(0.033)	(0.040)	(0.038)
Exporting (0/1)	0.110***	0.059	0.051
	(0.037)	(0.044)	(0.042)
Size (*baseline: small*)			
Medium (>49 employees)	0.036	-0.036	-0.001
	(0.041)	(0.042)	(0.042)
Age (*baseline: 0 to 10 years*)			
> 10 years	-0.039	-0.019	0.003
	(0.042)	(0.051)	(0.047)
Industry dummies	yes	yes	yes
Geography dummies	yes	yes	yes
Observations	725	725	725

Note: standard errors in parenthesis *** p<0.01, ** p<0.05, * p<0.1. Observations are weighted to give representative results.
Source: ERC Business Futures Survey

Our *Hypothesis 4* relates to potential direct effects of digitalisation on business performance measured by turnover during the Covid-19 pandemic crisis. The estimation results do not support this hypothesis: the relationship between digitalisation and business performance, although positive, is not significant.

However, the results suggest an indirect effect of digitalisation on business performance via increased innovative activity. Digitalised SMEs were 11 percentage points more likely to report an increase in innovative activity than other UK SMEs. At the same time, positive innovation outcome was associated with a higher (by 7 percentage point) probability of having stable or increased turnover. Therefore, we find support for *Hypothesis 5*. The

cross-section character of the data does not allow us to judge about the causality of the relationship. However, these first results may point out on benefits of digitally enabled innovation. We argue that digitalised SMEs were better equipped to weather the storm of the Covid-19 pandemic if digital technology they introduced in operations allowed them to increase innovation and thus be better prepared to react to the uncertainty which dramatically increased during 2020. The results of estimation of equation (3.3) also indicate that firms operating in highly competitive environments were less likely to maintain and grow turnover in 2020: high competition was associated with lower probability of business performance by 14 percentage points.

The results also confirm previous findings on the importance of digital readiness, both organisational and environmental, for the probability of digitalisation.

5. DISCUSSION AND CONCLUSIONS

Diffusion of digital technologies accelerated over recent years and sped up even more in 2020, a year marked by the challenges of Covid-19 pandemic. Our analysis, covering a wide range of established and emerging digital technologies, sheds some light on the degree of diffusion of digital technologies among the understudied population of firms – SMEs – which were pointed out by previous studies as lagging behind larger firms in digital transformation. The results suggest that, in 2020, the adoption rates are higher when compared to evidence from previous years indicating narrowing digital gap. Moreover, there is no difference in rates of adoption of established digital technologies between small and medium-sized businesses. Emerging technologies such as cloud, AI/ML and AR/VR are becoming more common, although the differences in adoption rates between small and medium-sized firms persist for these technologies.

Our analysis examines factors lying behind digital adoption by developing a scale of *digital readiness* that refers to both internal and external motivators regarding digital technologies behaviour. It also provides first insights into the role played by digital technologies in helping UK SMEs to maintain sales during unprecedented pandemic crisis times. The following key findings emerge.

First, we find strong evidence that digital readiness is associated with the probability of digital adoption through both internal (organisational and technological) and external (environmental) dimensions. Depending on type of technology, these dimensions are more

or less important in predicting the probability of adoption. For instance, organisational and technological readiness proves to be more important for emerging technologies such as AI/ML and AR/VR.

Second, we find (surprisingly) only little evidence that *barriers to digital* affect the probability of technology adoption. Firms experiencing issues with broadband capacity are found to be less likely to adopt emerging digital technologies. The implication is that infrastructure investments increasing broadband capacity may be beneficial to support the adoption of advanced digital technologies. Interestingly, we also find some unexpected results: for instance, positive association between lack of access to finance and digital marketing/ social media. This may reflect the search of low-cost digital solutions as an alternative to traditional marketing campaigns by financially constrained firms. Also, firms reporting 'no obstacles' are not more likely to adopt technologies, quite the contrary: these firms are found to be less likely to adopt emerging digital technologies. This indicates that firms may be lagging behind their counterparts in digitalisation process not so much because of barriers they encounter but more so because of intrinsic factors. This reinforces the importance of *digital readiness* concept in explaining adoption behaviour. One implication from these findings, is that it is important to showcase both benefits and possible obstacles to digital adoption when providing business support to SMEs.

Finally, we find indications that more digitalised SMEs were better equipped to weather the storm of Covid-19 pandemic and maintain the same turnover or grow if the digital technology they introduced in operations resulted in increased innovative activity.

More generally our results highlight the complexity of digital adoption behaviour which relies both on intrinsic factors and perceptions of external environment by owners-mangers. In policy terms, it suggests the importance to reach out for 'not digitally ready' firms, i.e. those firms that do not see the benefits of digital transformation for their business and do not feel the pressure from their immediate business environment. In this sense, networking, information sharing mechanisms and business support may alter the perception of the environment and better showcase the benefits of adoption, as well as provide instruments to facilitate increased knowledge of emerging technologies and better understanding of barriers to implementation. Digital readiness as well as digitalisation are not a static 'state' but rather dynamic and evolutive process that may pay off in increased flexibility, innovativeness, competitiveness, and preparedness to address uncertainty and adversity.

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ANNEX

Table A1. Correlation Matrix 1: technologies, digital readiness, and business objectives

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Digitalised	1																	
2	E-comm	0.28*	1																
3	E-marketing	0.29*	0.17*	1															
4	Acc/HR	0.32*	0.06	0.06	1														
5	CRM	0.40*	0.12*	0.04	0.09*	1													
6	'Zoom'	0.47*	-0.05	0.09*	0.16*	0.23*	1												
7	Cloud	0.43*	0.03	0.02	0.08*	0.21*	0.28*	1											
8	CAD	0.25*	0.09*	0.02	-0.01	0.11*	0.09*	0.04	1										
9	IoT	0.23*	0.05	0.03	0.09*	0.04	-0.03	-0.02	0.04	1									
10	AR/VR	0.15*	0.03	0.04	0.01	0.10*	0.11*	0.08*	0.21*	0.07	1								
11	AI	0.16*	0.02	0.03	-0.01	0.18*	0.08*	0.14*	0.14*	0.02	0.23*	1							
12	OR	0.20*	0.07	0.02	0.00	0.22*	0.14*	0.16*	0.22*	0.02	0.20*	0.25*	1						
13	ER	0.21*	0.08*	0.09*	0.02	0.19*	0.15*	0.19*	0.00	-0.01	0.10*	0.14*	0.05	1					
14	BPlan	0.14*	0.02	0.08*	-0.02	0.18*	0.15*	0.09*	0.07	0.03	0.12*	0.13*	0.17*	0.11*	1				
15	Competition	0.12*	-0.01	0.05	0.05	0.06	0.04	-0.01	0.09*	0.07	0.05	0.04	-0.03	0.01	0.03	1			
16	Exporter	0.15*	0.01	-0.04	0.00	0.05	0.12*	0.10*	0.14*	-0.04	0.08*	0.11*	0.07	0.05	0.06	0.03	1		
17	Obj1	0.12*	0.08*	0.09*	-0.04	0.12*	0.07	0.12*	0.11*	0.01	0.02	0.11*	0.10*	0.08*	0.04	0.09*	0.13*	1	
18	Obj2	0.18*	0.12*	0.13*	0.12*	0.16*	0.12*	0.12*	0.01	0.12*	0.03	0.00	0.02	0.08*	0.06	0.04	-0.03	0.27*	1

Note: Spearman correlation, * correlation coefficients are significant at the 5% level or lower;

Obj1 refer to product innovation objective (introducing new products or services) and Obj2 – to process innovation objective (introducing new processes).

Table A2. Correlation matrix 2: technologies and barriers to digital

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Digitalised	1																		
2	E-comm	0.37*	1																	
3	E-marketing	0.41*	0.27*	1																
4	Acc/HR	0.43*	0.17*	0.18*	1															
5	CRM	0.46*	0.18*	0.14*	0.18*	1														
6	'Zoom'	0.51*	0.08*	0.18*	0.25*	0.26*	1													
7	Cloud	0.51*	0.13*	0.14*	0.21*	0.25*	0.34*	1												
8	CAD	0.34*	0.12*	0.09*	0.11*	0.14*	0.17*	0.12*	1											
9	IoT	0.32*	0.18*	0.14*	0.20*	0.10*	0.07*	0.10*	0.11*	1										
10	AR/VR	0.18*	0.04	0.07*	0.02	0.13*	0.15*	0.12*	0.20*	0.08*	1									
11	AI	0.21*	0.05	0.06*	0.04	0.20*	0.13*	0.18*	0.16*	0.05	0.26*	1								
12	DTB1	0.01	0.09*	0.10*	0.02	0.01	0.04	-0.01	-0.03	0.07*	0.06	-0.05	1							
13	DTB2	0.10*	0.07*	0.05	0.05	0.03	0.08*	0.01	-0.01	0.13*	0.01	-0.01	0.16*	1						
14	DTB3	0.09*	0.05	0.09*	0.08*	0.05	0.10*	0.05	0.00	0.07*	0.06	0.04	0.29*	0.25*	1					
15	DTB4	0.02	0.05	0.06	0.04	-0.05	0.06	0.00	-0.02	0.02	-0.01	-0.05	0.26*	0.19*	0.24*	1				
16	DTB5	0.09*	0.08*	0.07*	0.10*	0.00	0.06	0.06	0.04	0.07*	0.04	0.01	0.12*	0.13*	0.23*	0.36*	1			
17	DTB6	0.09*	0.05	0.02	0.06	0.08*	0.08*	0.07*	0.07*	0.06	0.07*	0.10*	0.18*	0.21*	0.20*	0.23*	0.18*	1		
18	DTB7	-0.03	-0.04	-0.05	0.03	0.01	-0.03	-0.03	0.01	-0.01	-0.06	-0.04	-0.10*	-0.10*	-0.11*	-0.12*	-0.10*	-0.10*	1	
19	DTB	0.12*	0.11*	0.11*	0.11*	0.03	0.12*	0.06*	0.01	0.10*	0.06	0.01	0.53*	0.45*	0.64*	0.73*	0.57*	0.50*	-0.20*	1

Note: Spearman correlation, * correlation coefficients are significant at the 5% level or lower;

DTB1 to DTB7 refer to different barriers to implementation of digital technologies: DTB1 – access to finance; DTB2 – broadband; DTB3 – compatibility with equipment; DTB4 –digital skills; DTB5 – workforce engagement; DTB6 – cyber risk; DTB7 – other barriers; DTB is a composite factor obtained by a linear combination of DTB1 to DTB7.

Table A3. Probability of digital adoption (average marginal effects)

Variables	(1) E-commerce	(2) E-marketing	(3) Accounting / HR	(4) CRM	(5) Video conferencing
Digital Readiness					
Organisational &	0.037**	0.022	0.017	0.089***	0.054***
Technological (ODR, cont)	(0.017)	(0.015)	(0.015)	(0.019)	(0.018)
Environmental (EDR, cont)	0.033*	0.033**	0.002	0.078***	0.050***
	(0.018)	(0.015)	(0.014)	(0.021)	(0.018)
Barriers to Digital					
Lack of funds/Access to finance	0.056	0.063*	-0.040	-0.033	0.002
(0/1)	(0.040)	(0.034)	(0.033)	(0.045)	(0.042)
Broadband (0/1)	0.068*	-0.004	0.001	0.007	-0.007
	(0.038)	(0.033)	(0.033)	(0.045)	(0.041)
Compatibility with existing	-0.019	0.013	0.015	-0.005	0.049
equipment (0/1)	(0.038)	(0.032)	(0.033)	(0.045)	(0.042)
Digital skills (0/1)	0.033	0.013	0.005	-0.037	-0.042
	(0.040)	(0.035)	(0.035)	(0.045)	(0.042)
Workforce engagement (0/1)	0.006	0.013	0.007	-0.015	-0.021
	(0.039)	(0.035)	(0.036)	(0.045)	(0.044)
Cyber risk (0/1)	-0.022	-0.066**	-0.004	-0.020	0.012
	(0.038)	(0.033)	(0.033)	(0.046)	(0.041)
No barriers (0/1)	0.088	0.001	-0.104**	-0.041	-0.035
	(0.056)	(0.045)	(0.042)	(0.062)	(0.056)
Business plan (0/1)	0.016	0.060*	-0.040	0.141***	0.071*
	(0.039)	(0.036)	(0.029)	(0.046)	(0.041)
Exporting (0/1)	0.037	-0.018	-0.001	0.006	0.079**
	(0.037)	(0.033)	(0.032)	(0.044)	(0.039)
Product/service innovation	0.050	0.065**	-0.055*	0.078*	0.025
objective (0/1)	(0.036)	(0.030)	(0.030)	(0.042)	(0.038)
Process innovation objective	0.108***	0.063*	0.120***	0.099**	0.113***
(0/1)	(0.040)	(0.033)	(0.033)	(0.044)	(0.042)
Size (*baseline: small*)					
Medium (>49 employees)	0.021	-0.059	-0.009	-0.006	0.067
	(0.039)	(0.037)	(0.033)	(0.043)	(0.042)
Age (*baseline: 0 to 10 years*)					
> 10 years	0.020	0.024	-0.032	-0.051	-0.118**
	(0.043)	(0.036)	(0.038)	(0.049)	(0.047)
Broad sector (*baseline: Transport, Retail and Distribution GHI*)					
Primary ABDE	0.001	-0.134	0.076	0.361***	0.239*
	(0.112)	(0.091)	(0.116)	(0.126)	(0.143)
Manufacturing C	-0.003	-0.141***	0.066	0.091	0.151***
	(0.052)	(0.042)	(0.045)	(0.059)	(0.052)
Construction F	-0.031	-0.058	0.137*	-0.088	0.136*
	(0.069)	(0.064)	(0.080)	(0.089)	(0.078)
Business services JKLMN	-0.051	-0.108***	0.019	0.169***	0.222***
	(0.044)	(0.038)	(0.035)	(0.049)	(0.044)
Other services PQRS	0.036	-0.065	0.057	0.046	0.228***
	(0.055)	(0.047)	(0.044)	(0.057)	(0.052)
Geography dummies	yes	yes	yes	yes	yes
Observations	725	725	725	725	725
LR chi2 (23)	37.47	78.43	41.93	99.95	82.64
Pseudo R-squared	0.06	0.10	0.08	0.13	0.15

Note: standard errors in parenthesis *** p<0.01, ** p<0.05, * p<0.1. Observations are weighted to give representative results. Here, number of observations for computing marginal effects

Table A4. Probability of digital adoption (average marginal effects), suite

Variables	(6) Cloud	(7) CAD	(8) IoT	(9) AR / VR	(10) AI	(11) Digitalised SME
Digital Readiness						
Organisational	0.069***	0.121***	0.011	0.049***	0.067***	0.091***
&Technological (ODR, cont)	(0.018)	(0.019)	(0.016)	(0.015)	(0.014)	(0.016)
Environmental (EDR, cont)	0.077***	-0.001	-0.007	0.033**	0.028*	0.060***
	(0.019)	(0.020)	(0.017)	(0.014)	(0.016)	(0.017)
Barriers to Digital						
Lack of funds/Access to	0.005	-0.002	0.022	0.004	-0.028	-0.019
finance (0/1)	(0.043)	(0.045)	(0.039)	(0.030)	(0.030)	(0.037)
Broadband (0/1)	-0.030	-0.008	0.135***	-0.074***	-0.059**	0.048
	(0.043)	(0.042)	(0.037)	(0.028)	(0.029)	(0.039)
Compatibility with existing	0.019	-0.045	0.017	0.008	0.000	0.008
equipment (0/1)	(0.043)	(0.043)	(0.037)	(0.027)	(0.028)	(0.037)
Digital skills (0/1)	-0.010	-0.037	-0.061	-0.008	-0.033	-0.006
	(0.044)	(0.044)	(0.037)	(0.027)	(0.029)	(0.039)
Workforce engagement (0/1)	0.014	0.104**	0.009	0.015	0.003	0.023
	(0.044)	(0.044)	(0.037)	(0.029)	(0.029)	(0.042)
Cyber risk (0/1)	0.024	-0.073*	-0.019	0.010	0.018	-0.030
	(0.043)	(0.043)	(0.036)	(0.029)	(0.028)	(0.038)
No barriers (0/1)	0.043	-0.018	0.015	-0.079**	-0.099**	-0.018
	(0.058)	(0.063)	(0.052)	(0.040)	(0.044)	(0.052)
Business plan (0/1)	0.065	0.071	0.017	0.037	0.053*	0.073*
	(0.044)	(0.043)	(0.038)	(0.029)	(0.029)	(0.039)
Exporting (0/1)	0.042	-0.001	-0.024	0.056*	0.056*	0.106***
	(0.041)	(0.042)	(0.038)	(0.030)	(0.029)	(0.035)
Product/service innovation	0.064	0.087**	-0.040	0.016	0.063**	0.054
objective (0/1)	(0.039)	(0.041)	(0.035)	(0.026)	(0.028)	(0.035)
Process innovation objective	0.103**	-0.047	0.116***	0.004	-0.019	0.138***
(0/1)	(0.043)	(0.042)	(0.038)	(0.026)	(0.029)	(0.038)
Size (*baseline: small*)						
Medium (>49 employees)	0.059	0.037	0.002	0.051	0.109***	0.057
	(0.041)	(0.045)	(0.037)	(0.032)	(0.035)	(0.039)
Age (*baseline: 0 to 10 years*)						
> 10 years	-0.008	-0.011	-0.017	0.066*	0.055	-0.039
	(0.047)	(0.048)	(0.044)	(0.037)	(0.037)	(0.042)
Broad sector (*baseline: Transport, Retail and Distribution GHI*)						
Primary ABDE	0.103	-0.102	0.058	0.067	-0.014	0.123
	(0.132)	(0.167)	(0.149)	(0.083)	(0.106)	(0.128)
Manufacturing C	0.067	0.322***	-0.008	-0.008	-0.024	0.093*
	(0.057)	(0.056)	(0.051)	(0.041)	(0.041)	(0.049)
Construction F	0.076	0.165**	0.126	0.061	0.024	0.164*
	(0.083)	(0.083)	(0.084)	(0.052)	(0.054)	(0.084)
Business services JKLMN	0.099**	0.044	-0.156***	-0.067**	0.034	0.089**
	(0.047)	(0.048)	(0.040)	(0.032)	(0.032)	(0.042)
Other services PQRS	-0.000	-0.065	-0.030	0.036	0.028	0.084*
	(0.055)	(0.060)	(0.053)	(0.038)	(0.044)	(0.048)
Geography dummies	yes	yes	yes	yes	yes	yes
Observations	725	725	725	725	725	725
LR chi2 (23)	78.24	111.5	59.15	71.64	98.42	87.88
Pseudo R-squared	0.11	0.13	0.09	0.13	0.18	0.18

Note: standard errors in parenthesis *** p<0.01, ** p<0.05, * p<0.1. Observations are weighted to give representative results. Here, number of observations for computing marginal effects

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