KU LEUVEN

FACULTEIT ECONOMIE EN BEDRIJFSWETENSCHAPPEN

Management, Strategy and Innovation (MSI)

The growing digital divide in Europe and the United States

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MSI_2007

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Abstract: Using a new survey on digitalisation activities of firms in the EU and the US, we identify digitalisation profiles based on the current use of digital technologies and future investment plans in digitalisation. Our analysis confirms the trend toward digital polarisation and a growing digital divide in the corporate landscape with, on one side, many firms that are not digitally active, and on the other side, a substantial number of digitally active firms forging ahead. Old small firms, with less than 50 employees and more than 10 years old, are significantly more likely to be persistently digitally non-active. We show that these persistently non-digital firms are less likely to be innovative, increase employment or command higher mark-ups. These trends are likely to exacerbate the digital divide across firms in the EU and the US.

JEL classification: D22, E22, L25
Keywords: digital technology, investment, firm performance

[1] We thank Federica Ambrosio, Stephen Gardner, Julien Ravet, Debora Revoltella, Patricia Wruuck and participants at a seminar at Bruegel (Brussels) and the 7th European conference on corporate R&D and innovation (Sevilla) for helpful comments. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the European Investment Bank.

1. Introduction

The adoption of digital technologies in the business sector is spreading rapidly, from the provision of digital products and services online to robotised production processes, the internet of things (IoT), big data and artificial intelligence (AI), and applications, including the use of digital systems to manage back office tasks. Because of its transformative impact on the economy and the labour market, from both a creative and a destructive angle, digitalisation is being vigorously discussed by economists and policy makers. Numerous optimistic statements have been made that it will boost growth and productivity and trigger a fourth industrial revolution. However, there has been so far little hard evidence of a significant productivity boost. More than 30 years after Robert Solow's (1987) statement "you can see the computer age everywhere but in productivity statistics", productivity growth in advanced economies remains subdued. At the same time, many people fear that digitalisation can be a source of disruption, leading to a more polarised economic structure, with the benefits concentrated in a few "superstar" firms, while many firms and workers will be on the losing side.

Several recent studies provide evidence of this polarisation and "winner-takes-all" markets linked to the use of digital technologies. Andrews, Criscuolo and Gal (2016) show an increasing productivity gap between firms at the global frontier and laggard firms.[2] The superstar firms at the global frontier are typically larger, more innovative and have higher rates of digital technology adoption. There is also evidence of rising market concentration (Autor et al., 2017; Philippon, 2019) and increasing firm mark-ups (De Loecker and Eeckhoudt, 2017). In particular, mark-ups are rising among firms in the highest decile of distribution of mark-ups within their industry, consistent with winner-takes-all patterns (Diez et al., 2018). These trends tend to be more pronounced in the sectors in which digital technologies, especially digital services, are developed or widely adopted (Calligaris, Criscuolo and Marcolin, 2018). Digital technologies often come with features such as scale and synergies, which give an advantage to large firms and foster market concentration (Haskel and Westlake, 2017).

The discussion on winner-take-all markets and rising mark-ups by firms that already have the highest mark-ups is perhaps most associated with "Big Tech" firms, such as Alibaba, Alphabet, Apple, Amazon, Facebook, Huawei and Microsoft. All these companies are from the US or China. European firms are not present among the Big Tech giants or the leading digital R&D investors that push the frontier of digital technology (Veugelers, 2018; EIB, 2018).

The EU has fallen behind in the digital technologies and services race but might be able to take up leading positions in new industrial races. This will depend on the integration of digital technologies, including IoT and AI, into manufacturing and services (Bughin et al, 2019). For

[2] Andrews, Criscuolo and Gal (2016) define global frontier firms as the top 5% of firms in terms of labour productivity levels, within each two-digit sector and in each year, across all countries since the early 2000s. All other firms are defined as laggards.

example, car manufacturing, a pivotal sector for the EU economy, is now done in the context of a whole series of digital services (smart electricity grids, personalised entertainment systems, smart mobility), which are all part of a network centred on the physical platform represented by the car and based on IoT and AI.

Growing digital polarisation in the global corporate landscape between the technology haves and have-nots also has implications for the rising polarisation of productivity. If European firms are unable to integrate new digital technologies into their business models, they will lose out, even in those sectors where they are currently still leading, such as the automotive sector. There is growing concern that EU firms in non-digital sectors lag behind in the adoption of digital technologies, especially in the services sector (EIB, 2018). This correlates with subdued EU productivity growth.

Even though these are first-order concerns, there is little large-scale firm-level evidence about digital technology adoption across EU countries and the US. Using a unique recent survey on the digitalisation activities of EU and US firms in the manufacturing and services sectors, we present new evidence for a growing digital technology divide. Our main contributions are as follows. First, we identify digitalisation profiles based on the current use of digital technologies and future investment plans in digitalisation. We document that these profiles can be used to show a growing digital polarisation. Second, we discuss the relationship between digital profiles and various measures of firm performance – including employment growth, innovation activities and mark-ups. Our analysis of digital profiles also provides evidence that firms along the digital divide grid face different obstacles to investment. The findings suggest that addressing barriers to skills should be a priority for policymakers in order to support firms to digitalise further. Similarly, addressing the regulatory burden and the uncertainties regulation can create should also be high on the digital policy agenda.

2. Data

In 2018, the EIB Digital and Skills Survey interviewed 1,700 companies in the EU and the US about their digital investment activities. To categorise companies according to their stage of digitalisation and identify digitalisation profiles, we use information from the survey on two dimensions:

(i) the current adoption of the most prominent state-of-the-art digital technologies,
(ii) future investment plans in digital technologies.

The data cover firms with at least five employees in the manufacturing and services sector. As shown in Table 1, the sample is stratified by industry group (manufacturing and services sector), size class and region. To make the sample representative of the economy, the EIB Digital and Skills survey computes weights based on firm size. More specifically, the weights compare the number of employees of the firms included in the survey with data on employment from

structural business statistics in specific cells – where the cells are defined by region, sector and firm size class.[3]

Table 1. Survey sampling in the EIB Digital and Skills Survey

	Manufacturing	Services
Region		
EU	456	432
West and North Europe	198	198
South Europe	122	89
Central and East Europe	146	145
US	411	389
Northeast	93	83
Midwest	126	136
South	106	82
West	86	88
Size		
Micro (5-9)	143	172
Small (10-49)	291	333
Medium (50-249)	287	223
Large (250+)	146	93

Note: West and North Europe: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, the Netherlands, Sweden, and the United Kingdom. South Europe: Cyprus, Greece, Italy, Portugal, and Spain. Central and East Europe: Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia. US regions according to US Census Bureau geography divisions.

2.1 Adoption of digital technologies

To assess the degree of digitalisation of companies in the EU and the US, we use information on the adoption of digital technologies (listed in Table 2) based on the following survey question:

- "Can you tell me for each of the following technologies if (i) not heard about them, (ii) have heard about them but not implemented, (iii) implemented them in parts of your business, or (iv) whether your entire business is organised around them?".

We classify as "fully digital" companies that report their entire business is organised around at least one of the four technologies. If at least one of the technologies is implemented in parts of the business, we classify the companies as "partially digital" instead. We classify as "non-

[3] The sample size in the EIB Digital and Skills Survey is relatively small. The survey is representative at the level of three aggregate groups of countries in the EU (and four regions in the US) but not at individual EU country level. Similarly, it is representative for the manufacturing and services sectors (i.e. representative for two sectors separately in each aggregate group of EU countries or US region) but it does not provide more detailed information on industry classification (e.g. NACE or ISIC classification at two digits that would classify the firms across different sub-industries within the manufacturing sector).

digital" all companies that have not heard about digital technologies or only heard about them but not implemented them.

Table 2. State-of-the-Art Digital technologies in the EIB Digital and Skills Survey

Manufacturing a) 3-D printing – also known as additive manufacturing b) Automation via advanced robotics – a second generation of robots, which are more autonomous, flexible and often more easily programmable c) Internet of Things – electronic devices that communicate with each other without human assistance d) Big data and analytics
Services a) Digitalisation and automation of internal routines, including back-office, purchasing and logistics management – for example, software that automates routine tasks such as billing, accounting, etc. b) Web-based applications for marketing and sales – for example, using a specific app through which customers can order goods or services from your company c) Provision of digital products and services over the internet – for example offering of automated market intelligence or digital content streaming d) Big data and analytics

The state-of-the-art digital technologies considered are different for manufacturing and services. Big data and analytics is the only digital technology that is asked to both manufacturing and service sector firms. Firms in the services sector tend to be more digitally active and are more likely to be 'fully digital', which could be related to the different set of state-of-the-art digital technologies used in the survey to characterise the level of digitalisation.[4]

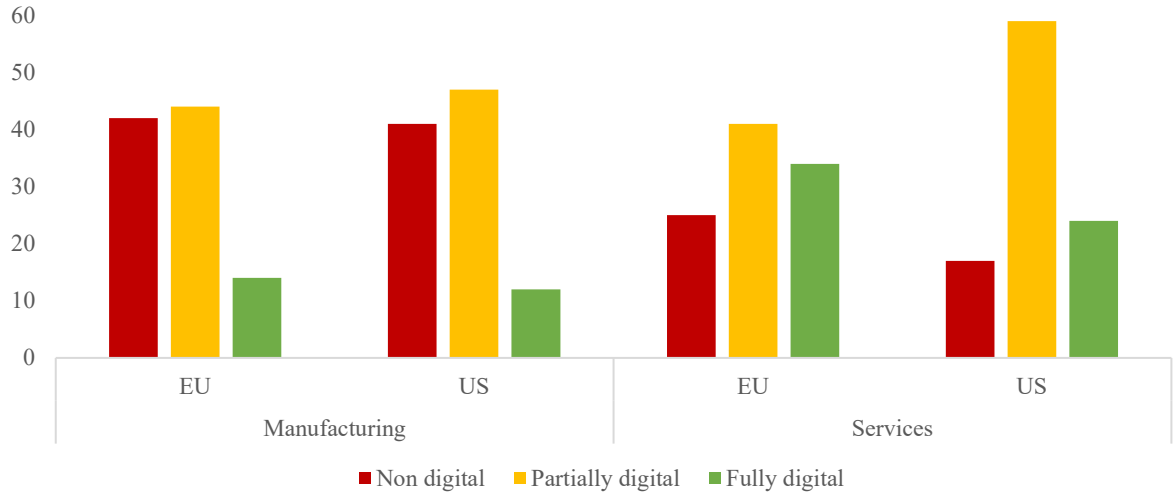
The EIB Digital and Skills Survey provides unique information compared to other databases with evidence on the adoption of digital technologies in the EU and the US. Eurostat data used

[4] Focusing on firms that have never heard about the digital technologies, 22 firms in manufacturing and 19 firms in services have not heard about any of the four technologies. More specifically, few companies in manufacturing have not heard about 3-D printing (6% in both the EU and the US) and advanced robotics (5% in the EU and 7% in the US), while a larger share of companies has not heard about IoT (18% in the EU and 22% in the US) and Big Data (21% in the EU and 18% in the US). In the services sector, the share of companies that have not heard about a technology is highest for Big Data (24% in the EU and 15% in the US), and lower for digitalisation and automation of internal routines (7% in the EU and 9% in the US), web-based applications for marketing and sales (7% in the EU and 4% in the US) and provision of digital products and services online (11% in the EU and 8% in the US). There is no large difference between the US and the EU, except for the share of firms that have not heard about Big Data, which is somewhat higher in the EU than the US, especially in the services sector.

in the Digital Economy and Society Index (DESI) do not include US firms, which is paramount information for the analysis of the digital divide discussed in this paper.[5] Similarly, OECD statistics on ICT access and usage by businesses provide data on two indicators for the US but only in 2007 and 2012.[6]

A first finding is that EU firms do not appear to be lagging behind their US counterparts. Figure 1 shows no evidence for EU manufacturing firms to be less digitally active compared to the US. For services sectors, the share of EU firms that are non-digital is larger than in the US. However, at the same time, the share of EU firms that have organised their entire business around digital technologies is larger compared than in the US.

Figure 1. Share of firms (in %) that are digitally active, by sector and country



Note: All firms are weighted using employment weights to make them representative of the business population.

The results of regression analysis indicate that firm size matters for digital technology adoption: smaller firms (with less than 50 employees) are less likely to be digitally active.[7] At the same

[5] Eurostat provides data on the share of enterprises (with more than 10 employees) using industrial robots (16% of the enterprises in manufacturing) in the EU in 2018, which is about half the share reported by EU manufacturing firms that have implemented automation via advanced robotics according to the EIB Digital and Skills survey (29%). Similarly, the shares of enterprises (with more than 10 employees) using 3-D printing or analysing big data are about half the share reported in the EIB Digital and Skills survey. The differences between Eurostat data and the EIB Digital and Skills survey may be driven by the relatively small sample of the survey as well as differences in the questions that were asked to the firms (e.g. whether the use of digital technologies is general or very specific to the daily operations of the business or whether it is regular or irregular).

[6] For the US, the ICT Access and Usage by Businesses database provides data on (i) the share of business with a website or home page (in 2007 and 2012) and (ii) the share of business placing orders (i.e. making purchases) over computer networks (in 2007).

[7] The regression analysis considers the likelihood to be digitally active (i.e. either partially or fully digital) after controlling for the effects of country (US, EU), sector (manufacturing, services), firm size (micro, small, medium, large) and firm age (young, old). An alternative specification combines the information on firm age and size to create four categories: young small, old small, young large and old large. The findings are qualitatively similar using the alternative specification.

time, firm age seems to matter less for digitalisation; young firms (less than 10 years old) are not more likely to be digitally active than older firms.

2.2 Digital investment plans

The second dimension of the digital divide profiles, namely the digital investment outlook, is based on the following two survey questions:

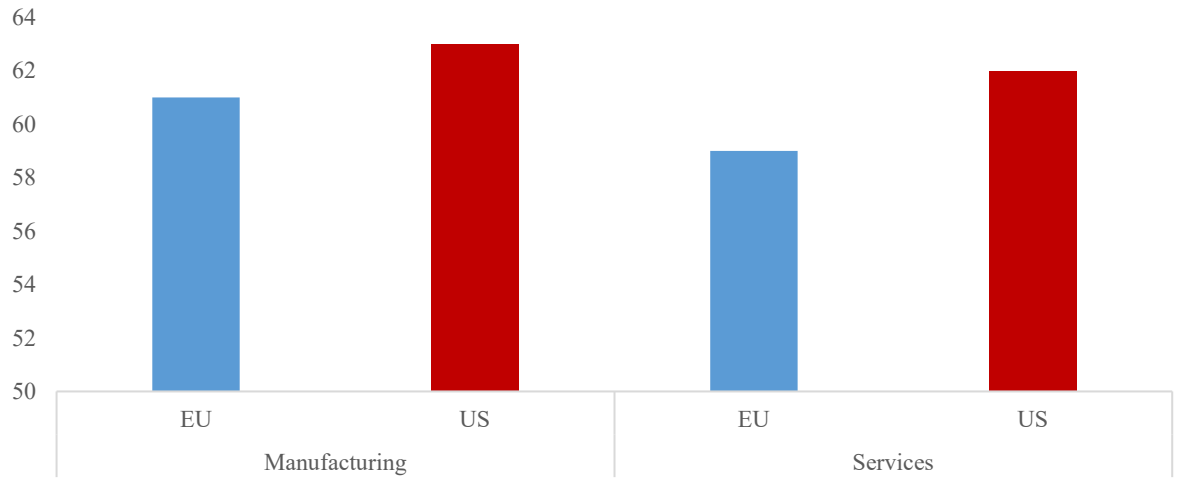
- For firms that have already implemented one of the digital technologies:
  - "Over the next three years, do you expect your investment spend in digital technologies to (i) increase, (ii) stay around the same, (iii) decrease, (iv) no investment planned in digital technologies?"
- For firms that are non-digital:
  - "Looking ahead to the next three years, do you plan to invest in digital technologies?"

We classify companies as "increasing" if they plan to increase their investment or, if they have not yet made digital investments but plan to start doing so. We label all other firms as "stable/inactive/reduced".

Figure 2 shows that around 60% of the firms have plans to step up investment in digital technologies in the coming three years. Although EU firms score slightly lower than their US counterparts, both in manufacturing and services, the differences between the EU and US when it comes to future investments in digital technologies tend to be small.

The results of regression analysis confirm that there is no significant differences between the EU and the US or between manufacturing and services sectors. However, it shows a firm size effect for digital investment plans: larger firms are not only more likely to be currently digitally active, they are also more likely to expand their digital investments in the future.

Figure 2. Share of firms (in %) that plan to increase investment in digital technologies in the next 3 years

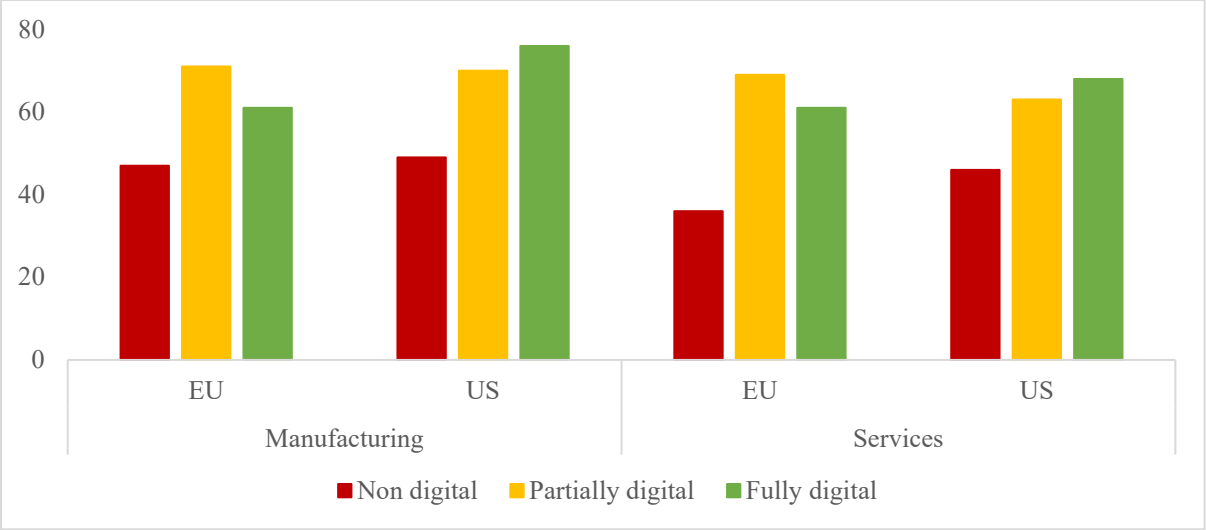


Note: All firms are weighted using employment weights to make them representative of the business population.

3. Is there a corporate digital divide? Which firms are falling behind and which firms are forging ahead?

Combining firms' current state of digital investments with their plans for digital investments allows us to characterise firms according to their positions on the digital divide. Figure 3 shows how digitally active firms are significantly more likely to have plans to expand their digital investments further. On the other side, firms that are currently not using state-of-the-art digital technologies are less likely to have future digital investment plans. This holds both in the EU and the US, in the manufacturing and services sectors.

Figure 3. Share of firms (in %) that plan to increase investment in digital technologies in the next 3 years, by digital intensity



Note: All firms are weighted using employment weights to make them representative of the business population.

The results of regression analysis indicate that firms that are already digitally active have a significantly higher probability (21% higher on average) to have digital investment expansion plans, everything else equal.[8] This provides evidence of a corporate digital divide: firms that are not (yet) digitally active are significantly less likely to have digital investment expansion plans compared to those that are already digitally active. This trend is likely to exacerbate the digital divide across firms, both in the EU and the US. This digital polarisation is a general phenomenon: the digital divide is not significantly larger in the EU than in the US or in the services sector compared to manufacturing.

[8] The regression analysis considers the likelihood to have digital investment expansion plans depending on whether the firm is currently digitally active (yes or no), and controlling for the effects of country (US, EU), sector (manufacturing, services), firm size (micro, small, medium, large) and firm age (young, old). The OLS estimated coefficient for digitally active is 0.207 (with standard error 0.040).

A next step is to identify and characterise the firms on each side of the divide. Which companies are falling behind, which firms are forging ahead? To address this question, Figure 4 positions firms on the digital divide grid, based on the combination of their current level of digitalisation and their digital investment outlook.

Firms that have not implemented any digital technology and do not plan to invest in digital technologies in the next three years are falling behind on the digital divide grid. We categorise them as "persistently non-digital". Companies that are currently non-digital but have plans to invest in digitalisation are categorised as "beginners".

Within the group of firms that have implemented digital technologies, there are firms that are already digital but do not intend to increase investment in digital technologies in the coming three years: we categorise them as "stable digital". Digital firms that are planning to further invest in digitalisation are categorised "forgers ahead". "Forgers ahead" can be further divided depending on whether they have implemented a digital technology in parts of their business or whether their entire business is organised around digital technologies. "Catching-up" firms are partially digital and plan to increase further their digital investments, while "frontrunners" are already fully digital and continue to increase their investment spend on digital technologies.

Figure 4. The corporate digital divide categories

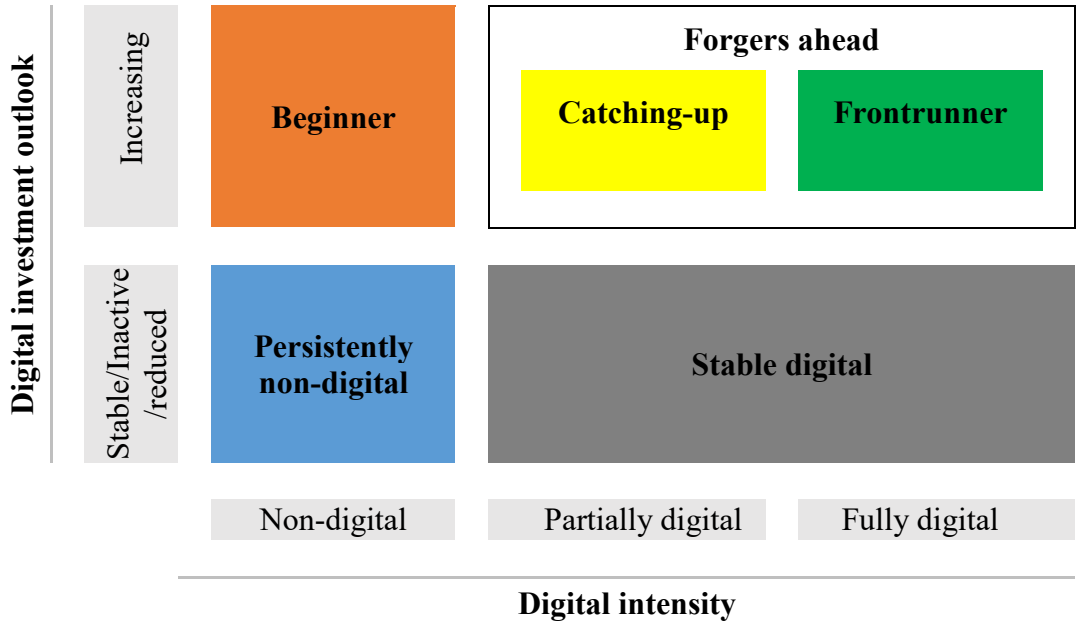
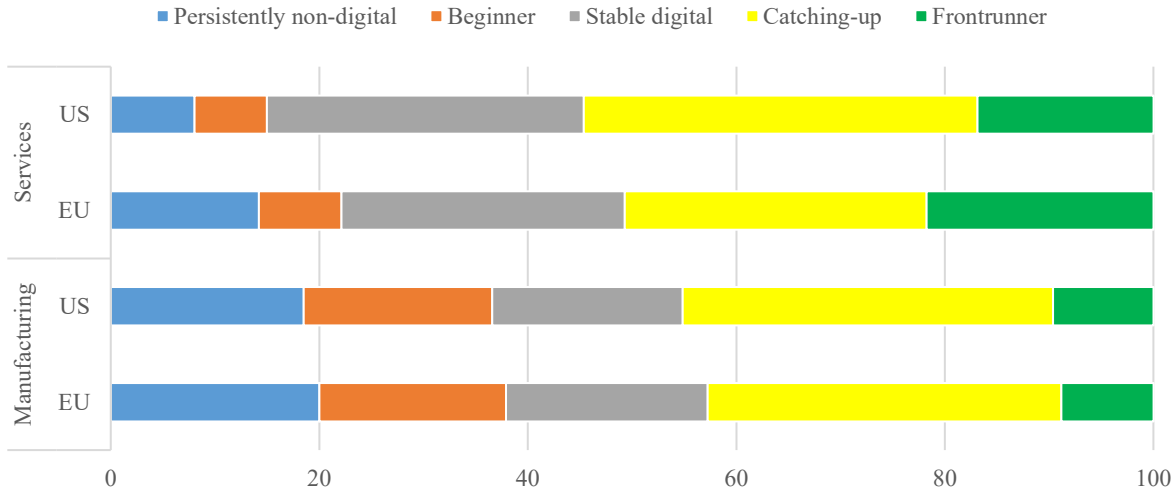


Figure 5 shows the share of companies in the EU and the US, separately for manufacturing and services, in each of the digital divide profiles, depending on their position on the grid.[9] For manufacturing firms, there are no major differences in terms of digitalisation divide profiles

[9] Table A.1 in the Appendix reports the number of observations.

between the EU and the US. In the services sector, however, the EU seems to have more firms lagging on digitalisation. At the same time, the EU has somewhat more 'frontrunners' in services compared to the US. There is thus some evidence of a deeper and more polarised digitalisation divide among services companies in the EU than the US.

Figure 5. Digital divide, share of firms (in %), by sector and country



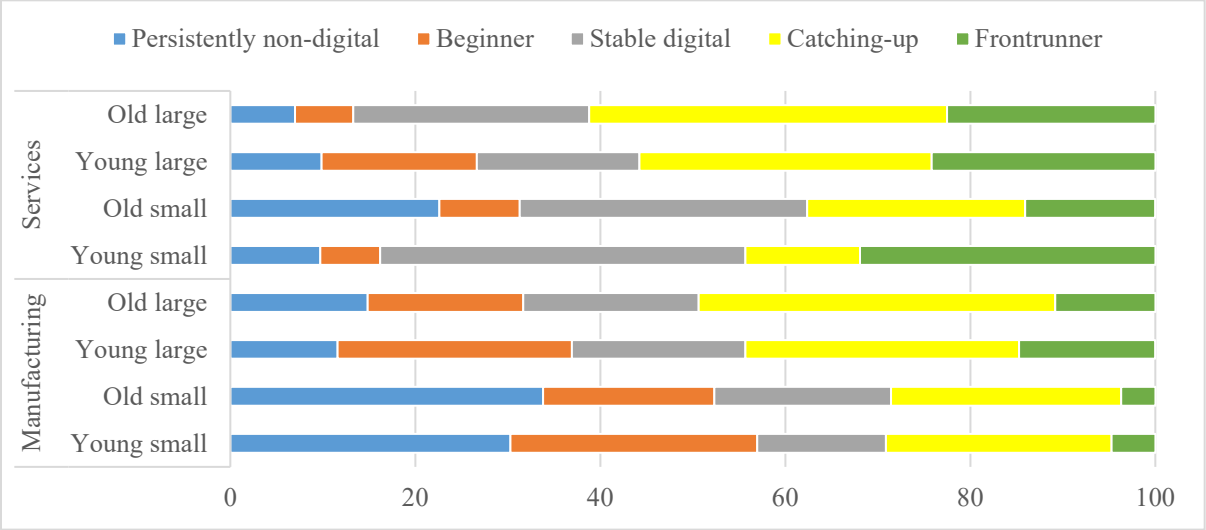
Note: Digital profiles defined as in Figure 3. All firms are weighted using employment weights to make them representative of the business population.

In Figure 6, we show that old small firms, i.e. firms with less than 50 employees and older than 10 years, are significantly more likely to be on the wrong side of the digital divide. [10] Old small firms, which represent a significant share of the corporate landscape in the EU, are more likely to be "persistently non-digital" and less likely to be "forging ahead" ("catching-up" and "frontrunner"), both in services and manufacturing.

Table 3 confirms the importance of firm size for the position on the digital divide grid. We find that small manufacturing firms (with less than 50 employees) are more likely to be "persistently non-digital". This holds both for small young and especially old small firms: they have, respectively, a 15% and 19% higher probability of being non-digital compared to large firms.[11] In services, only old small firms are significantly more likely to be "persistently non-digital": they have a 15% higher probability compared to large firms. Nevertheless, young small services firms are not significantly more likely to be digitally left behind.

[10] Because of the relatively small sample sizes, the figure includes both EU and US firms. The results are qualitatively similar when disaggregating the sample also by country, in addition to sector and age-size categories.
[11] The estimates reported in this paper are based on OLS regressions and are virtually identical when using probit regressions.

Figure 6. Digital divide, share of firms (in %), by sector and age-size categories



Note: Young: less than 10 years old. Small: less than 50 employees. Digital profiles defined as in Figure 3. All firms are weighted using employment weights to make them representative of the business population.

Similarly, on the other side of the divide, small firms are significantly less likely to be "forging ahead". In the manufacturing sector, both young and old small firms are significantly less likely to be "forging ahead" (a 20% lower probability compared to large firms and a 7% lower probability to be "frontrunner). In services, young small, and especially old small, firms are significantly less likely to be "forging ahead" (respectively 17% and 23% lower probability). In addition, old small firms are significantly less likely to be "frontrunners". This confirms that old small firms are clearly lagging behind on the corporate digital divide grid.

Table 3. Probability to be "persistently non-digital" or "forging ahead"

	Persistently non-digital		**Forging ahead**		**Frontrunner**	
	Manuf.	Services	Manuf.	Services	Manuf.	Services
Age-size category (omitted category: large firms, young or old)						
Young small	0.155**	0.021	-0.199***	-0.166*	-0.063*	0.082
	(0.075)	(0.061)	(0.074)	(0.095)	(0.033)	(0.089)
Old small	0.191***	0.146***	-0.205***	-0.234***	-0.074***	-0.098**
	(0.039)	(0.043)	(0.044)	(0.056)	(0.022)	(0.042)
Country group (omitted category: US)						
EU	0.014	0.030	-0.020	0.016	-0.007	0.066*
	(0.037)	(0.033)	(0.048)	(0.051)	(0.029)	(0.039)
Sample size	773	770	773	770	773	770
Pseudo R-squared	0.038	0.060	0.024	0.035	0.022	0.021

Note: Marginal effects in a probit model. The coefficients can be interpreted as marginal effects on the probability to be "persistently non-digital", "forging ahead" or "frontrunner". Young: less than 10 years old. Small: less than 50 employees. *** p<0.01, ** p<0.05, * p<0.1. All firms are weighted using employment weights to make them representative of the business population.

Which companies escape the digital-non-active trap? Comparing the probability to be "persistent non-digital" versus "beginners" allows us to check, among the firms that have not implemented digital technologies, which firms are likely to "begin" to become digitally active in the next three years. The estimates in Table 4 confirm again that firm size matters: in particular, old small firms appear to be a problematic group. They are significantly less likely to begin to be digitally active if they were initially non-active (19% lower probability compared to large firms in manufacturing and 21% in services). Young small firms also have a lower probability to start investing but the differences are not statistically significant.

Similarly, the probability to "forge ahead" versus remaining "digital stable" is a way to check, among the firms that have already implemented digital technologies, which firms are likely to further increase their digital investments. Again, old small firms belongs to the problem category. Even when they are already digitally active, they are significantly less likely to increase their digital investments, both in manufacturing and services. In services, young small firms that are already digitally active are also less likely to increase their digital investments.

Table 4. Probability to start or increase investment in digital technologies, by digital intensity

	Beginner vs. persistently non-digital		**Forging ahead vs. digital stable**		**Frontrunner vs. fully digital stable**	
	Manuf.	Services	Manuf.	Services	Manuf.	Services
Age-size category (omitted category: large firms, young or old)						
Young small	-0.071	-0.098	-0.045	-0.189*	-0.256	-0.150
	(0.114)	(0.220)	(0.114)	(0.105)	(0.243)	(0.142)
Old small	-0.187**	-0.214*	-0.122**	-0.173***	-0.218*	-0.244**
	(0.074)	(0.126)	(0.058)	(0.063)	(0.128)	(0.098)
Country group (omitted category: US)						
EU	-0.018	-0.052	-0.023	0.050	-0.135	-0.001
	(0.078)	(0.113)	(0.056)	(0.055)	(0.123)	(0.094)
Sample size	322	160	451	610	92	235
R-squared	0.020	0.039	0.007	0.023	0.044	0.040

Note: Marginal effects in a probit model. The coefficients can be interpreted as marginal effects on the probability to be "beginner", "forging ahead" or "frontrunner". Young: less than 10 years old. Small: less than 50 employees. *** p<0.01, ** p<0.05, * p<0.1. All firms are weighted using employment weights to make them representative of the business population.

4. Firm performance and digital polarisation

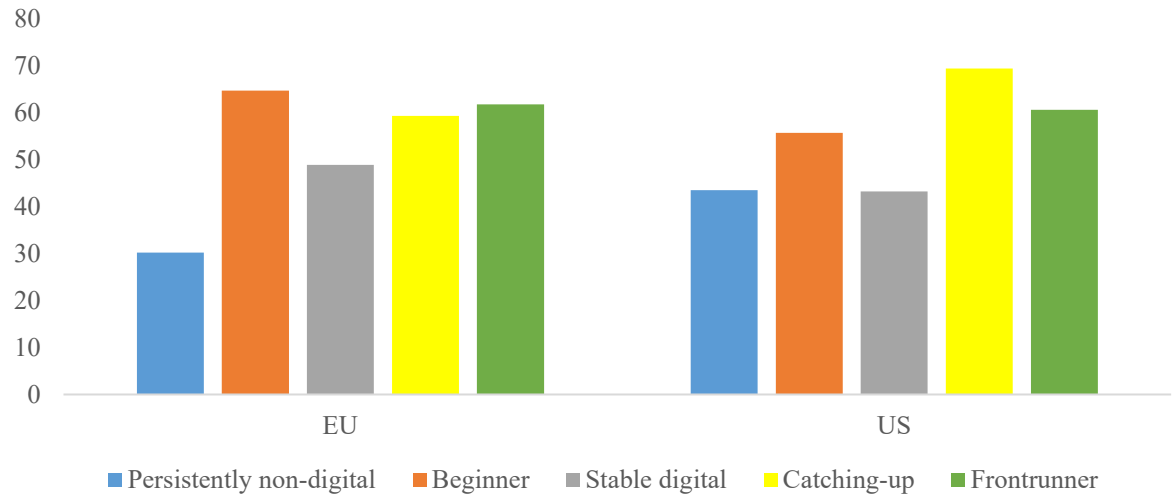
Why is it important to identify on which side of the digitalisation divide firms are? Does it matter for firm performance whether firms are falling behind or moving ahead? To address these questions, we looked at how firms with different positions relative to the digitalisation

divide perform in relation to employment growth, innovation and mark-ups. This analysis is purely correlational and cannot be interpreted as causal.

4.1 Employment Growth

The EIB Digital and Skills Survey asked firms about their current number of employees and the number of employees three years ago. Figure 7 shows that firms with no plans to start or increase their digital investments – "stable" digital firms but especially "persistently non-digital" firms – are less likely to increase employment. In contrast, companies that plan to increase their digital investments – "beginners" and "forgers ahead" (i.e. "catching-up" and "frontrunners") – are the companies, which are more likely to have increased employment. This holds both in the EU and the US, in the manufacturing and the services sector. Firms' positioning on the digitalisation divide thus matters for employment growth: those moving ahead are more likely to increase employment, while those left behind are less likely to grow. Job destruction effects from digitalisation thus seem more likely to be found in firms falling behind, rather than in firms that are forging ahead.

Figure 7. Share of firms (in %) with positive employment growth, by digital profile



Note: Digital profiles defined as in Figure 3. All firms are weighted using employment weights to make them representative of the business population.

The estimates reported in Table 5 confirm that all firms with an expanding digital investment outlook have increased employment over the past three years. It also shows that old small firms are less likely to increase employment.

Table 5. Digital divide and employment growth

	Employment growth
Digitalisation profiles (omitted category: non-digital)	
Beginner	0.199***
	(0.073)
Stable	0.094
	(0.061)
Catch-up	0.242***
	(0.057)
Frontrunner	0.228***
	(0.071)
Age-size category (omitted category: large firms, young or old)	
Young and small	-0.035
	(0.066)
Old and small	-0.169***
	(0.038)
Sector (omitted category: manufacturing)	
Services	-0.071*
	(0.037)
Country group (omitted category: US)	
EU	0.012
	(0.036)
Sample size	1,412
Pseudo R-squared	0.055

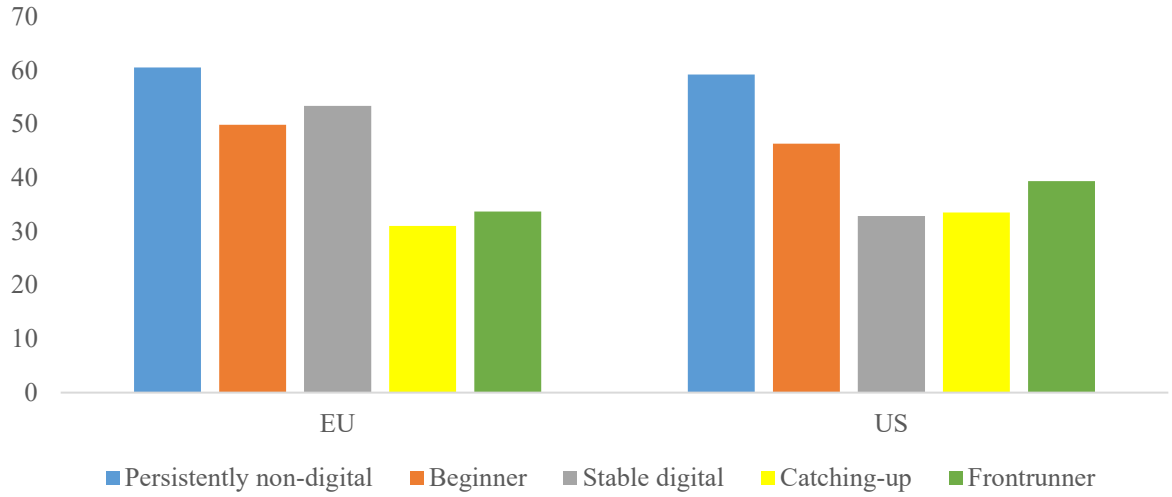
Note: Marginal effects in a probit model. The coefficients can be interpreted as marginal effects on the probability of positive employment growth over the past three years. Young: less than 10 years old. Small: less than 50 employees. *** p<0.01, ** p<0.05, * p<0.1. All firms are weighted using employment weights to make them representative of the business population.

4.2 R&D and Innovation

The data used in this paper also allow us to draw out innovation profiles. Following Veugelers et al. (2019), we identify companies as "non innovation-active" if they do not invest in R&D and do not invest in order to develop or introduce new products, processes and services. These firms are not engaged in incremental or radical innovation and are not adopting innovation developed elsewhere. We would expect digital technologies to empower innovation and therefore firms that are moving ahead with digitalisation to be also innovation-active.

Figure 8 confirms that those firms left behind on the wrong side of the digital divide are also more likely to be "non-innovation active". Firms moving ahead are significantly more likely than companies in other digitalisation categories to be leading innovators

Figure 8. Share of "non-innovation active" firms (in %), by digital profile



Note: "Non-innovation active" firms are firms that do not invest in R&D and do not introduce new products, processes or services (see Veugelers et al., 2019). All firms are weighted using employment weights to make them representative of the business population.

The estimates reported in Table 6 confirm these findings: with the exception of the "beginners", all other categories of firms are more likely to be innovation active than the "persistently non-digital" firms. In particular, the "forgers ahead", both "catching-up" and "frontrunners", are significantly more likely to be innovation active. "Frontrunners are also significantly more likely to be "leading innovators" (i.e. they invest in R&D and introduce innovations that are new to the market).

Table 6. Digital divide and innovation performance

	Non-innovator	Leading innovator
Digitalisation profiles (omitted category: non-digital)		
Beginner	-0.077	-0.010
	(0.081)	(0.043)
Stable	-0.182***	0.075
	(0.068)	(0.049)
Catch-up	-0.284***	0.076*
	(0.064)	(0.042)
Frontrunners	-0.292***	0.102*
	(0.081)	(0.059)
Age-size category (omitted category: large firms, young or old)		
Young and small	0.099	-0.081**
	(0.080)	(0.034)
Old and small	0.067	-0.060*
	(0.044)	(0.030)
Sector (omitted category: manufacturing)		
Services	0.203***	-0.158***
	(0.043)	(0.026)

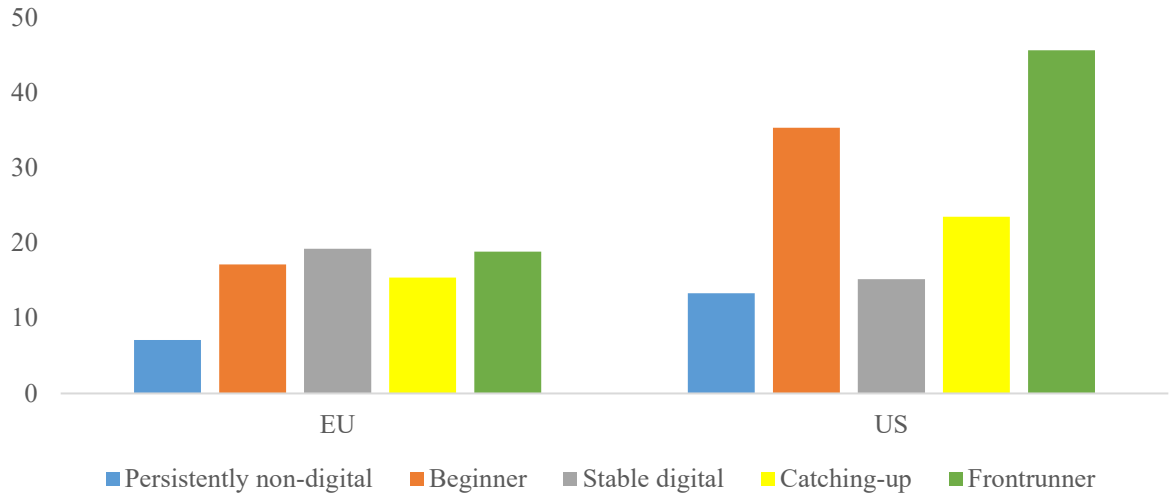
Country group (omitted category: US)		
EU	-0.023	-0.008
	(0.043)	(0.031)
Sample size	1,023	1,023
Pseudo R-squared	0.068	0.111

Note: Marginal effects in a probit model. The coefficients can be interpreted as marginal effects on the probability to be "non-innovator" or "leading innovator". Young: less than 10 years old. Small: less than 50 employees. Non-innovator: no investment in R&D in the previous financial year and no introduction of new products, processes or services. Leading innovator: significant investment in R&D in the previous financial year and introduction of new products, processes or services that are new to the market (not only new to the company). *** p<0.01, ** p<0.05, * p<0.1. All firms are weighted using employment weights to make them representative of the business population.

4.3 Mark-ups

Digitalisation is often linked to increasing market power and a concentration of big technology companies. We estimate mark-ups for the firms in our sample and correlate these with their digitalisation profiles.[12] In line with the literature (e.g. Calligaris, Criscuolo and Marcolin, 2018), we are interested in testing whether firms left behind on the wrong side of the digitalisation divide (i.e. "persistently non-digital" firms) have lower mark-ups and whether firms that are moving ahead have higher mark-ups. Figure 9 shows that "persistently non-digital" firms are also significantly less likely to be the firms with the top mark-ups in their sectors. Beginners and, even more so, "frontrunners" are likely to be in the top quintile of the distribution of mark-ups in their sector. This is most evident for US firms.

Figure 9. Share of firms (in %) in the top quintile of the distribution of mark-ups, by digital profile



Note: All firms are weighted using employment weights to make them representative of the business population.

[12] The estimation of mark-ups is based on the approach of De Loecker and Eeckhout (2017).

The estimates reported in Table 7 confirm that "persistently non-digital" profiles have a significantly lower mark-up compared to all other digital profiles. They are also significantly less likely to be the firms with the top mark-ups in their sector. Especially "beginners" but even more so "frontrunners" can command significantly higher mark-ups and are likely to be in the top quintile of the distribution of mark-ups in their sector. The results also show how US firms can command higher mark-ups and firms in services sectors. Taken together, US services frontrunners can command significantly higher mark-ups compared to other firms.

Table 7. Digital divide and mark-ups

	Mark-up	**Top quintile mark-up**
Digitalisation profiles (omitted category: non-digital)		
Beginner	0.161**	0.133**
	(0.066)	(0.064)
Stable	0.127***	0.102**
	(0.046)	(0.046)
Catch-up	0.103**	0.092**
	(0.042)	(0.040)
Frontrunners	0.149**	0.197***
	(0.070)	(0.070)
Age-size category (omitted category: large firms, young or old)		
Young and small	0.014	0.041
	(0.092)	(0.072)
Old and small	-0.054	-0.007
	(0.038)	(0.036)
Sector (omitted category: manufacturing)		
Services	0.217***	-0.061
	(0.048)	(0.038)
Country group (omitted category: US)		
EU	-0.086**	-0.073*
	(0.041)	(0.040)
Sample size	844	844
(Pseudo) R-squared	0.084	0.038

Note: "Mark-up": OLS regression, with robust standard errors in parentheses. "Top quintile mark-up": Marginal effects in a probit model. The coefficients can be interpreted as marginal effects on the probability to be in the top quintile of the sector-specific distribution of mark-ups. Young: less than 10 years old. Small: less than 50 employees. *** p<0.01, ** p<0.05, * p<0.1. All firms are weighted using employment weights to make them representative of the business population.

5. Barriers and pressure for investments along the digital divide map

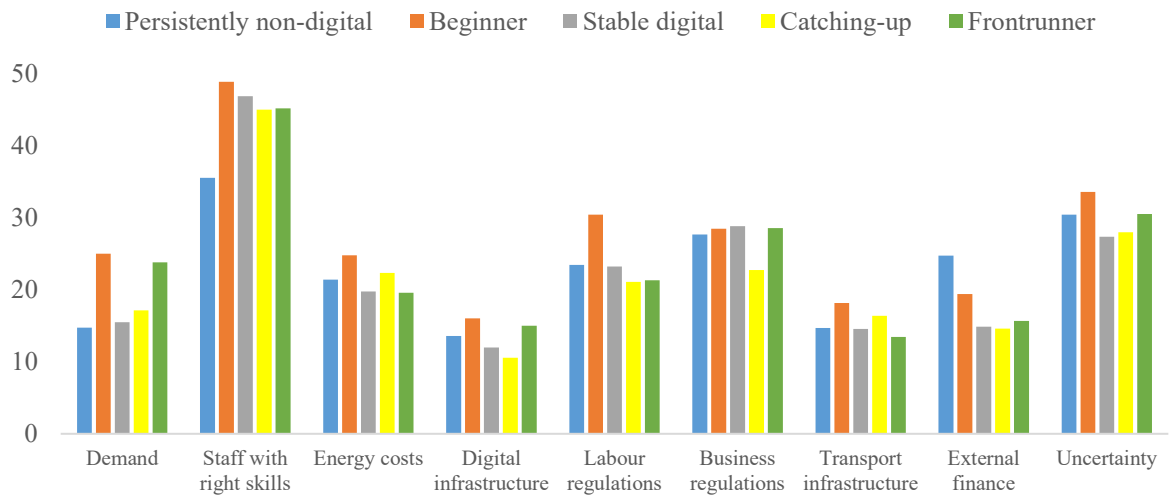
Our data also allow us to look at the different barriers and incentives firms perceive when contemplating investment decisions. Identifying any barrier to investment activities that specifically impedes firms that are left behind on the wrong side of the digital divide is relevant

for the identification of policy levers to help move these firms away from of their "persistently non-digital" status.

5.1 Perceived barriers to investment

Figure 10 shows that the "availability of staff with the right skills" is the most important barrier to investment activities: 44 percent of all firms report this as a major obstacle to investment. This finding supports the central role of skill formation in any digital policy mix. "Uncertainty about the future" and "business regulations (e.g. licences, permits, bankruptcy) and taxation" complete the top three major barriers. Perhaps surprisingly, "access to digital infrastructure" is the barrier identified least frequently as a major obstacle. Policies to ensure access to digital infrastructure do not seem to be the most pressing priority, at least from the perspective of the firms.

Figure 10. Share of firms (in%) that report an obstacle to investment to be major

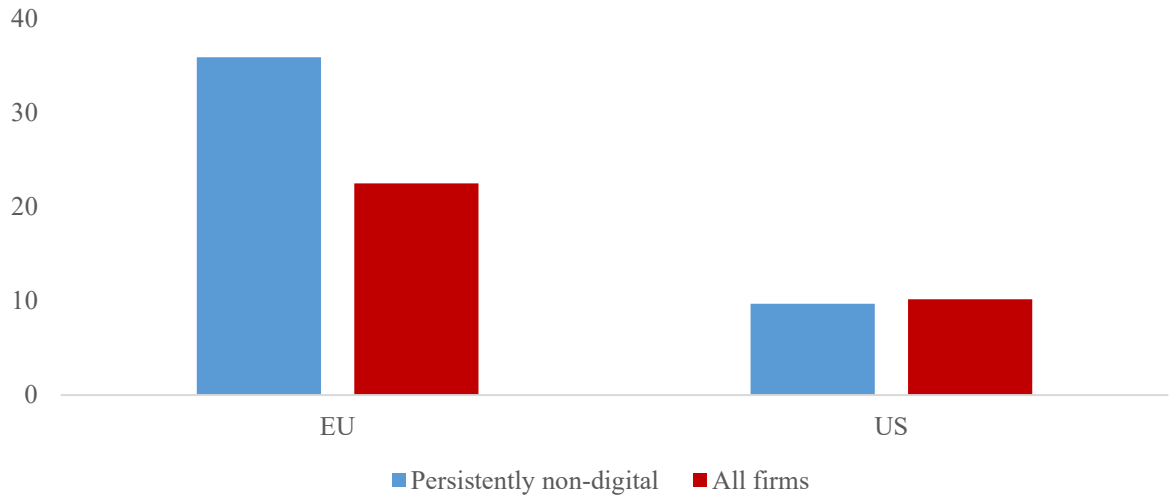


Note: All firms are weighted using employment weights to make them representative of the business population.

"Persistently non-digital" firms do not report that the barriers to investment affect them more severely than other firms. This evidence would suggest that the lack of digital investment is not so much a consequence of greater impediments, but of fewer incentives or less ambition. Lack of availability of external finance is the only barrier that is more often rated by persistently non-digital firms as a major impediment to investment: one out of four "persistently non-digital" firms rates this as a major barrier compared to one out of six for all firms.

Figure 11 shows that the availability of external finance seems to be a more severe barrier for EU firms than US firms. Unlike in the US, "persistently non-digital" firms in the EU are significantly more likely than other EU firms to report access to finance as a major impediment. This suggests that addressing the access to finance issue should be a primary focus for EU policymakers to lift their persistently non-digital firms into digitalisation.

Figure 11. Share of firms (in %) that report the availability of external finance as a major obstacle to investment



Note: All firms are weighted using employment weights to make them representative of the business population.

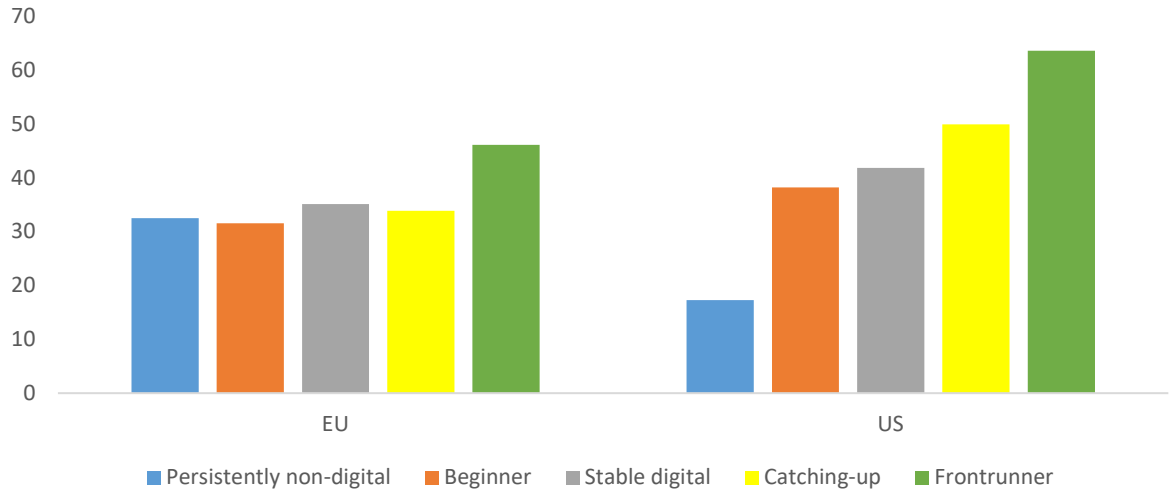
The estimates of regression analysis confirm that access to finance is rated significantly more often by "persistently non-digital" firms only in the EU and within the EU only in services sector (27% higher probability than other EU firms). In the US services sector, "persistently non-digital" firms rate access to finance significantly less often as major barrier (11% lower probability) compared to all other digital profiles.

6.2. Expected increase in competition because of digitalisation

The EIB Digital and Skills survey also asked about firms' expectations of future competitive pressure arising from digitalisation: whether they expect that digital technologies will lead to an increase in the number of firms competing in their sector or not. As escaping competition might be a major incentive for firms to engage in digital investment, we explore for which firms competition can work as incentive.

Overall, 40 percent of surveyed firms expected an increase in competition in their sector as a result of digitalisation. Figure 12 suggest that US firms are more likely than EU firms to expect an increase in competitive pressure, reflecting a more competitive US single market. "Persistently non-digital" firms seem to feel more shielded from competitive pressure, as they are less likely to expect an increase in competition arising from digitalisation. This perceived lack of competitive pressure contributes to a lack of incentives for persistently non-digital firms to engage in digitalisation. Competitive pressure seems to motivate in particular firms in the moving ahead category, especially in the US, to further advance in terms of digitalisation. This graphical evidence is also confirmed by the estimates of regression analysis.

Figure 12. Share of firms that expect further digitalisation to increase the number of firms competing in their market



Note: All firms are weighted using employment weights to make them representative of the business population.

6. Conclusions

The analysis of this paper confirms the trend towards a digitalisation divide between companies. A substantial share of firms does not implement any state-of-the-art digital technology and has no plans to start investing in digitalisation. However, a substantial share of firms already partially or even fully implements state-of-the-art digital technologies in their businesses, and has plans to further increase their digitalisation investments.

In terms of the types of firms that are more likely to be persistently non-digital, firm size and firm age matter. Small manufacturing firms and old small services firms are significantly more likely to be persistently non-digital. Economies with more old SMEs are therefore more vulnerable to corporate digital polarisation.

Taking into account sector and firm-size differences, our results do not provide any evidence that EU firms are more likely to be stuck on the wrong side of the digitalisation divide compared to their US counterparts. There are no significant differences between the EU and the US in terms of having more or fewer persistently non-digital firms. Our results show that it matters for firms' performance if they are falling behind and for economies if they have too many firms left behind on the wrong side of the digital divide. "Persistently non-digital" firms are less likely to be innovative, less likely to create new jobs and less likely to command high mark-ups, while digitalisation frontrunners are more likely to be innovative and increase employment, and can command significantly higher mark-ups. Lifting firms out of persistent digital non-activity should therefore be high on the policy agenda.

The EIB Digital and Skills Survey carried out in 2018 also looked at the barriers firms perceive when contemplating investment. Overall, our analysis shows that policymaking in the EU should be concerned about the lack, and particularly about the long-standing lack, of digital investment by some of its firms. SMEs in manufacturing and old SMEs in services are likely to be in the danger zone of permanent digital inactivity and deserve special policy attention. Addressing barriers to skills should be a priority for policymakers in order to support firms to digitalise further, irrespective of where they stand in relation to the digital divide. Similarly, addressing the regulatory burden and the uncertainties regulation can create should also be high on the digital policy agenda.

The higher sensitivity of US firms and frontrunners to competition when investing in digitalisation is a reminder for EU policymakers of the importance of a well-functioning EU integrated market. This underpins the call for an industrial policy at EU level, which should have the single market and competition policy as its core horizontal instruments, to ensure a large, competitive market environment that will push firms to invest in digitalisation (European Commission, 2020). The evidence reported in this paper also finds access to finance to be a more severe obstacle to investment for EU firms compared to their US counterparts, particularly for EU "persistently non-digital" firms. Addressing problems of access to finance may therefore go a long way to address the EU's corporate digitalisation divide.

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Appendix

Table A.1. Number of firms in the digital divide categories, by country and sector

	Manufacturing		Services	
	EU	**US**	**EU**	**US**
Persistently non-digital	85	103	53	40
Beginner	72	62	30	37
Stable digital	80	68	113	117
Catching-up	131	110	116	116
Frontrunner	37	25	96	52
All firms	405	368	408	362

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