



# The birth of new HGEs: internationalization through new digital technologies

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## Abstract

This paper explores the relationship between new digital technologies, internationalisation activity and its impact on High Growth Enterprises (HGEs), using the EIB Group Survey of Investment and Investment Finance and ORBIS data for 27 EU Member States and the United Kingdom. After controlling for sample selection bias, our results suggest that being a HGE is positively associated with the probability that a firm conducts international activities, particularly FDI. Conversely, the internationalisation process seems to trigger strong subsequent firm-growth only for FDI, not for exports. Furthermore, we show evidence on the positive association between firms that are internationalised and those adopting new digital technologies. The adoption of new digital technologies is indirectly related to the status of being a HGE via internationalisation activity in the current period. Our results highlight the complex influence of exporting and FDI on the capacity to become a HGE and the role of new digital technologies in this process.

**Keywords** Digital technologies · Export · FDI · HGE · Internationalisation

**JEL Classification** F14 · L21 · O31

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## 1 Introduction

The economic importance of high growth enterprises (henceforth HGEs) is well documented in the literature and has received increasing interest among policy circles (Flache-necker et al., 2020). In the European Union (EU), the creation and development of HGEs is embedded in its recent SME Strategy (European Commission, 2020) and is part of several recovery strategies across EU Member States. HGEs are found to be important contributors to macroeconomic employment growth (Brown et al., 2017; Ferrando et al., 2019; Hallak & Harasztosi, 2019), productivity increases (Decker et al., 2016), and innovative activities (Brown et al., 2017; Ferrando et al., 2019; Vértesy et al., 2017).

However, despite the large number of studies conducted on HGEs (Acs & Mueller, 2008; Coad et al., 2014; Davidsson & Henrekson, 2002; Henrekson & Johansson, 2010; Schreyer, 2000), there are some key aspects that have not been sufficiently researched. One of them concerns the role of internationalization strategies for HGEs, and another one is the interaction between these strategies and the adoption of new digital technologies. On the former topic, Brown and Mawson (2016) offer a relevant point of departure. While the literature has focused on exporting activity, Brown and Mawson (2016) find that outward foreign direct investment (henceforth FDI) is the chosen strategy for HGEs. As this work is based on a questionnaire of Scottish firms, it is highly interesting to consider the behaviour of European firms in general given the heterogeneity in the firm structure at country level. Finally, the analysis of the interaction of the effects of new digital technologies may facilitate policy-makers to guarantee the best policies to address the internationalisation strategies to enhance the competitiveness of firms, including promoting R&D and innovation. Since EU firms lag behind the US in R&D investment and the adoption of digital technologies, policymakers in the EU aiming to close this gap could focus on addressing structural barriers related to investment in digitalisation, remove disincentives to grow, and reduce market fragmentation, particularly in the service sector (Ebeke et al., 2019).

While differences in innovation-internationalisation modes have already been identified (Love & Roper, 2015), adopting new digital technologies (henceforth NDTs) may influence the characteristics of firms that go abroad and their way of internationalisation. The increasing speed in the processing of information and the increases in the capacity to store information greatly expands the field of action of NDTs. The use of technologies enables new marketing and sales channels and can also reduce costs related to entry and distance, factors particularly crucial for smaller firms with limited resources (Martens, 2013). Hence, the rate of incorporation of digital technologies by firms influences their competitiveness in international markets as well as affecting society and the economy more broadly (EU, 2017).

Against this backdrop, this paper analyses the relationship between HGEs, internationalisation and the incidence of digital technologies in all 27 EU Member States and the United Kingdom (UK). More concretely, we are investigating i) how a high growth spell is related to a firm's decision to start international activities, i.e. whether strong firm growth is a "pre-condition" for internationalisation, ii) how international activities do influence firm growth (the so-called "post-effect"), and iii) what role NDTs play in both processes. Recent work has shown that there are clear "learning-by-exporting" effects (Segarra-Blasco et al., 2020), which means that firms learn to improve their productivity after entering into international markets. Furthermore, we consider that the impacts of either an export or an FDI strategy on the probability of becoming a HGE may differ. Efficient incorporation of digital technologies by firms and economies enables international competitiveness, and

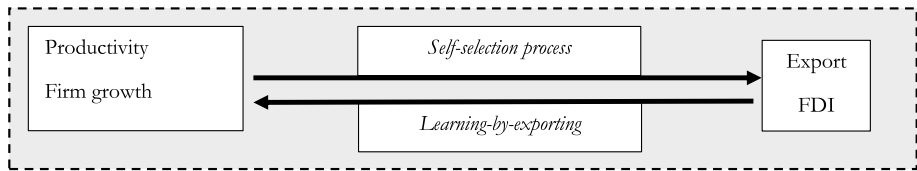
could thus have an influence on the chosen internationalisation activity and—ultimately—on firm growth. HGEs represent a small proportion of the business economy (5–15% of firms, depending on the definition applied) and the introduction of digital technologies still has a long way to go (Cathles et al., 2020). Despite that, their contribution to economic outputs is considerable. Our research questions are also important for policy makers since the interaction between internationalisation policies and the growth of HGEs relate directly to the key topics of international competitiveness and employment creation.

Up to now, we are not aware of any analysis that investigates the determinants of the different internationalisation options (i.e. exports and/or FDI) and their impact on the likelihood of being a HGE. A lack of data is one of the main reasons for this gap in the literature. Accordingly, this paper uses microdata from the European Investment Bank (henceforth EIB) Investment Survey to provide new evidence on the relationship between internationalisation strategies and HGEs, controlling for firm-level characteristics in EU-27 countries and the UK. We apply coarsened exact matching to mitigate the potential sample selection bias between internationalised and non-internationalised firms.

Our analysis provides interesting results. The descriptive statistics reveal that HGEs are more internationalised regardless of whether they export or invest directly in foreign markets. Furthermore, there is a higher adoption of NDTs by HGEs among internationalised firms. The results of the econometric analysis—that aims to show the direction of the relationship between the introduction of NDTs, the internationalisation process and the likelihood of being a HE—highlight four interesting points. First, HGEs are more likely to be present in foreign markets (in particular through FDI) than non-HGEs. Hence, the “pre-condition” is confirmed. Second, exporting activity does not show a significant relationship with being a HGE, while not being internationalised relates negatively to HGE status. Conversely, FDI activity influences positively the likelihood of a firm being a HGE. Therefore, our results point out that internationalisation activity does not guarantee that a firm is a HGE, but clearly non-internationalised firms are less likely to be HGEs. Third, our results also show that firms that are permanent FDI investors or stop investing in FDI are more likely to become HGEs in their domestic country. Hence, the “post-effect” is partially accepted. All these results are in line with previous literature, but the richness of the database allows us to see the influence of exporting and FDI activity. Finally, the results show that firms which adopt new digital technologies have a higher probability of being internationalised, especially via exporting. Conversely, we do not observe any significant relationship between implementing NDTs and being a HGE in the same period. However, our results are vulnerable to simultaneity concerns especially since both variables are only observed in a cross-section. Therefore, our initial results suggest that NDTs are related to HGEs indirectly through the FDI process, while the exporting activity does not have a significant impact.

Our paper contributes to the literature in the following ways. First, we explicitly take into account the two relevant types of firm internationalisation, i.e. exporting and FDI activities. Our research is in line with recent claims by Brown and Mawson (2016) that FDI activity may act as a trigger point which brings about a HGE episode or status. Our database differentiates between international activity and allows us to compare both strategies. Second, the rich database enables us to investigate this process for a broad set of countries. Finally, we contribute to the literature on HGEs and internationalisation status via the analysis of the effect of the adoption of NDTs.

The paper proceeds as follows. The next section defines the research questions and outlines the main hypotheses. Section 3 presents the database and descriptive statistics. Section 4 outlines the empirical methodology used to estimate the relationship between



**Fig. 1** Self-selection and learning-by-exporting effects

internationalisation activity and HGEs. Section 5 presents our main results, while Sect. 6 concludes.

## 2 Literature review and research questions

### 2.1 The internationalisation phenomena of HGEs

Few contributions are devoted to the analysis of HGEs and their internationalisation activity. Indirectly, a large number of studies have included the export activity as a control variable. Furthermore, FDI has also been signalled as a common strategy for HGEs that has lacked attention in the literature (Brown & Mawson, 2016) and most of the works analyse only the relationship of FDI on firm growth. This subsection presents the links between exporting, FDI and HGE. We will depart from the relevant trade literature and we will comment the results obtained for HGEs.

#### 2.1.1 Exporting, FDI and HGEs

The trade literature provides different explanations for the benefits of the exposure in the international markets may have on firms. On the one hand, the self-selection hypothesis suggests that only more productive firms are able to cover the sunk costs of exporting (Bernard et al., 2012; Melitz, 2003; Wagner, 2007). On the other hand, the learning-by-exporting hypothesis effects improve exporters' firm productivity (De Loecker, 2013). Figure 1 presents synthetically both processes. Therefore, a firm's internationalisation activity may affect its growth since it represents a learning process that improves firm productivity (Delgado et al., 2002).

Concerning the evidence between exporting and HGEs, different authors find a strong positive correlation between both variables. An early contribution by Chetty and Campbell-Hunt (2003) analysed the relationship between rapid growth and the internationalisation process of manufacturing firms in New Zealand. Through a case study methodology, they found that firms before internationalising had acquired a strong position in the market. Their results showed the importance of networks in the domestic market. For 16 countries, Hölzl (2009) used the export to sales ratio and concluded that exports are important for HGEs. More recently, Keen and Etemad (2012) for 1140 Canadian young SMEs show that HGEs tend to grow internationally early in their life and exhibit higher productivity growth. For a sample of technology intensive firms in Cambridge, Mohr et al. (2014) find that international operations are predictors of rapid growth. The authors consider a broad interpretation of international operations without distinguishing between exporting or FDI activity. For Spain, Segarra and Teruel (2014) show a positive impact of export

share on the probability of becoming a HGE regardless the measure of HGEs (employment or sales). Slimane and Baghdadi (2019) show that HGEs rather than the export intensity, it is the fact that the companies decide to export what fosters employment contribution to the economy for the Middle East and Northern African region. Finally, Moschella et al. (2019) analyse the persistence of Chinese HGEs. Their results confirm that firms engaged in exporting activity tend to be persistent HGEs as well.

While the FDI is directly associated to rapid employment growth in the destination market, with the purpose of serving directly foreign customers,<sup>1</sup> the impact that FDI exerts on firm growth in the local market is less clear. Pfaffermayr (2004) argues that it depends on the nature of FDI, i.e. if the FDI is horizontal or vertical. In this line, Brown and Mawson (2016) point out that FDI responds to a strategy of “client followership” or what it is similar to a horizontal FDI. The “client followership” responds to a demand-pull process rather than a planned corporate strategy (Bürgel et al., 2000<sup>2</sup>; Brown & Mawson, 2016<sup>3</sup>). Firms that are operating locally with multinational enterprises (henceforth MNEs) may start their FDI activity hand-in-hand with these MNEs. In other words, HGEs may become MNEs following their clients through a process known as ‘intermediated internationalisation’ (Acs & Terjesen, 2013). The entrance in the foreign markets via the intermediation of MNEs will give confidence to these firms to operate in the foreign markets (see Brown and Mawson (2016) for Scottish HGEs).

Concerning HGEs, evidence shows that entering in new geographical markets spurs rapid growth. The scarce evidence have considered both strategies of internationalization so we comment both results in order to facilitate their comparativeness. For the UK, Du and Temouri (2015) explore the relationship between TFP and the status of HGE. For manufacturing firms, their results show that exporting is a significant driving force of achieving HGE status, but only for firms older than 5 years. Being a MNE in the service sector significantly increases a firm’s likelihood to achieve HGE status, regardless of the age group. Furthermore, based on a sample of 198 (106 HGE and 92 non-HGEs) Scottish firms, Brown and Mawson (2016) identify HGEs and non-HGEs with the Financial Analysis Made Easy (FAME) database during the periods 2006–2009 and 2007–2010. Their results show that the share of exporting Scottish HGEs is slightly higher than non-HGEs. However, the most remarkable result is that HGEs are more likely to have a physical presence internationally and to expand their workforce overseas during their international expansion.

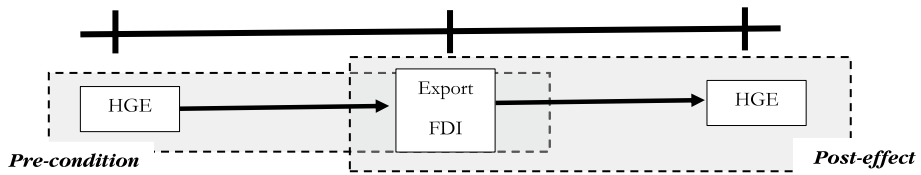
## 2.1.2 Research questions

Departing from Fig. 1, we define our research questions related to our first level of analysis: the relation between internationalisation and HGE. Therefore, as a preliminary descriptive question, we analyse if HGEs are more internationalized than non-HGEs. Obviously, this will depend on whether the country has internal conditions to foster these firms and whether firms operating in the market are competitive at international level.

<sup>1</sup> The evidence of the impact of FDI investments on the destination market is very broad. For a review and meta-analysis, see Bruno and Cipolla (2014). However, here we aim to analyse the impact in the domestic market.

<sup>2</sup> Bürgel et al. (2000) suggest that internationalisation often comes by chance.

<sup>3</sup> Their qualitative results show that internationalisation was not always a planned and logical process, but rather an opportunistic attempt to capitalize on a trigger for growth.



**Fig. 2** The relationship between internationalisation and HGEs

**RQ1:** Which type of internationalisation strategy do HGEs adopt?

The following research questions are related to the “pre-condition” of being internationalised and its “post-effect” (Fig. 2). As stated before, the decision to go abroad is characterised by large sunk costs. Hence, we may expect that firms will decide to internationalise once they have reinforced internally. This is identified as a “pre-condition” to internationalise and estimates the influence of the self-selection hypothesis (in other words the influence of productivity) and of past high-growth episodes on the decision that the firm enters foreign markets. Therefore, our second research question will be:

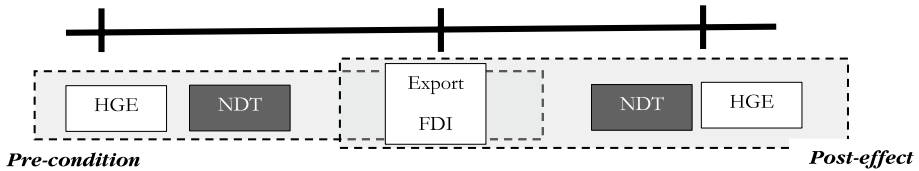
**RQ2:** Do high-growth episodes increase the probability of being internationalised?

Furthermore, we define a “post-effect” impact which captures the learning-by-exporting benefits which enhance firm growth. Consequently, we hypothesize that internationalized firms are able to grow more quickly. For firms that enter in the market thanks to reaching the “efficiency threshold” or those firms that are “born-global firms” (Knight & Cavusgil, 2005), internationalising may broaden their opportunities to reach more markets and become HGEs. In this situation, firms will “learn” from their competitors and will have access to different resources and assets. Improvement in competences affects the firms’ competitiveness positively and reinforces their capacity to internationalise and grow. Empirical studies confirmed the importance of trade for intrafirm learning lead to subsequent growth (Dosi et al., 1990).

**RQ3:** Does internationalisation facilitate firms to be HGEs?

Finally, an additional question is whether the impact of exporting and FDI differs. Both strategies differ on the barrier and difficulties assumed. Consequently, firms that export or invest in FDI exhibit different productive levels. Helpman et al. (2004) provide a theoretical framework based on Melitz’s (2003) study. Their model predicts that the least productive firms serve only the domestic market while more productive firms export, and the most productive firms engage in FDI. Considering these different characteristics between exporters and FDI investors, the impact that they may have on the likelihood of becoming HGEs may also differ.

**RQ4:** Do exporting and FDI activity have different relationship with the probability of becoming a HGE?



**Fig. 3** Influence of NDTs on the internationalisations and HGEs

## 2.2 New digital technologies, internationalisation and HGEs

In this framework a question that has—to the best of our knowledge—not been investigated in this literature is whether internationalised firms applying new digital technologies<sup>4</sup> have a larger probability of becoming HGEs. In particular, the adoption of new digital technologies may have affect the “pre-condition” and the “post-effect”. First, the in the may modify the propensity of firms to internationalize. For instance, the introduction of NDTs will cause a shift away from trade in physical goods to digital trade.<sup>5</sup> NDTs generates innovations in terms of new products and services, new processes but also new ways of interacting with providers and customers. Consequently, NDTs will affect the capacity of firms to internationalise since they may enhance their internal capabilities and their productivity. Hence, NDTs will be a “pre-condition” to internationalise a firm. Consequently, the self-selection hypothesis may be affected by the capacity of firms to introduce NDTs. Second, firms adopting these NDTs may improve their international competitive position and they will be able to reap the necessary benefits. Therefore, they will be a “post-effect” since these firms will have more opportunities to grow rapidly and become HGEs (Fig. 3). In this subsection, we present the main insights of the literature on the effect of NDTs on the internationalisation strategies and the effect on HGEs.

### 2.2.1 The relationship between NDTs and internationalisation strategies

NDTs have the potential to reduce the distance and entry costs and overcome commercial barriers by providing an additional channel for commercial relationships, marketing and sales and increasing knowledge on foreign markets and potential competitors (Bianchi & Mathews, 2016). NDTs improve the knowledge of foreign markets, thereby facilitating product customisation (Borges et al., 2009; Mathews & Healy, 2008). Furthermore, NDTs can increase information concerning potential competitors (Borges et al., 2009; Petersen et al., 2002) and reinforce the commercial relationships by means of closer and more direct links with customers, suppliers and distributors located abroad (Piercy et al., 1998; Samiee, 1998). Hence, NDTs offer new market opportunities at domestic level but also at international level.

<sup>4</sup> The concept of digital technologies involves all advances in networks, hardware, software, products and services, as well as communication processes triggered by digitisation (Burri and Cotier, 2012). However, NDTs corresponds to technologies such as the machine learning and data science, low-cost sensors and a new generation of industrial robotics, among others.

<sup>5</sup> The long-run figures show that trade in merchandise is in relative decline while trade in services is growing exponentially (Borchert et al., 2020).

Specifically, internet and e-commerce platforms facilitate market transactions including cross-border trade (see e.g. Borenstein and Saloner (2001)). E-commerce shrinks the distance between buyer and seller facilitating trade (Ahn et al., 2011; Clarke, 2008; Freund & Weinhold, 2004; Hortaçsu et al., 2009; Lendle et al., 2016). Furthermore, digital platforms reduce market failures such as adverse selection or search frictions and increase the number of markets (López & Jouanjean, 2017). Finally, additive technology (or 3D printing) could shift away from trade in physical goods to digital trade.

NDTs have also an influence on FDI. According to Rodrik (2018), improvements in NDTs have enabled large firms to divide the production chain into specific tasks that can then be dispersed around the world to take advantage of lower costs. Value chains rely on NDTs to improve flexibility in manufacturers' supply chains, reduce cycle time, and deliver products to customers in a timely manner (De Marchi et al., 2018). For instance, real-time routing in logistics and other digital technology-based operations improvements in transport (OECD, 2017). Conversely, traditional MNEs will face a more competitive environment due to the growth of digital trade, which has allowed new technology giants to enter into industries where they had not previously been viewed as competitors. These new entrants have different costs and new types of assets (big data and algorithms) that facilitate bypassing traditional value chains, reduce search costs and information asymmetries, and find new ways to source or deliver products and provide new services.

Hence, new digital technologies facilitate the entrance in international markets (Kuivalainen et al. 2013). Furthermore, they are likely to affect trade by lowering distribution costs, while broadening access to global commerce. Hence, the adoption of NDTs may facilitate to diminish the threshold to be present in international markets and, therefore, the self-selection imposed by the competition in the international markets may be bent.<sup>6</sup> Given this preliminary evidence, we expect that firms that adopt NDTs are more likely to internationalise. Therefore, we suggest that NDTs may influence the “pre-condition” of internationalisation.

**RQ5:** Are firms adopting digital technologies more internationalised?

## 2.2.2 NDTs as a determinant of HGEs

Additionally, NDTs may exert a “post-effect”. The adoption of NDTs are prompting radical new business models and innovations that promise productivity and sales gains. Improved products and services with more quality, more efficient logistics and supply-chain management will raise productivity and facilitate diversification by entering into new market segments (Cathles et al., 2020; Gal et al., 2019; Goldfarb & Tucker, 2019).

Specifically, Graetz and Michaels (2018), Autor and Salomons (2018) and Dauth et al. (2017) find a positive relationship between robots and productivity at country level. Additionally, Falk and Hagsten (2015) find a positive association between e-sales and productivity growth. Also, artificial intelligence have a transformative effect on how decisions are taken (Brynjolfsson & McAfee, 2011) and the innovation process (Aghion et al., 2019;

<sup>6</sup> Despite the evidences on the potential positive effects of the adoption of NDTs, the paths to reap the benefits are not so clear. First, new emerging sectors developed by new technologies are characterised by high uncertainty. At the beginning, markets, technology and users may not converge (Phaal et al., 2011). Second, exploiting the full potential of NDT involves a mix of factors. Internal factors such as the decision to adopt technologies or acquire skilled workers are crucial (Brynjolfsson 2011; Brynjolfsson and McElheran 2016).



Cockburn et al., 2018) that may foster productivity. “Aggregator” platforms which connect consumers to service providers facilitate firms identify consumers’ willingness to pay, allowing the firms to tailor pricing to ‘best-matched’ sales opportunities (Li et al., 2019). 3D printing lowers the cost of producing goods for markets with low volumes, or customized and high-value production chains (Gebler et al., 2014). Finally, the Internet of Things (IoT) is expected to create growth in profits for firms that adopt this technology (OECD, 2017).

Despite the positive relation between new digital technologies and the firm performance, the adoption of NDTs and its influence on the appearance of HGEs may not be simple. The appearance of HGEs is not exogenous to the system. Conversely, the market structure such as the presence of dominant incumbents will affect also the appearance of HGEs based on NDTs. Evidence of these difficulties come from Joensuu-Salo et al. (2018) and Cassetta et al. (2020). Joensuu-Salo et al. (2018) find that only if a firm takes strategic actions to capitalize their investments in NDT they will be able to grow. Furthermore, the effect of NDT on firm performance was significant with firms operating in their domestic markets. For Italian SMEs, Cassetta et al. (2020) find a positive role of internet-based technologies, but only when this investment is embedded within process and organisational innovations and investments in digital skills. Given the above evidence, our research questions are:

**RQ6:** Do HGEs use NDTs more frequently?

**RQ7:** Are firms adopting digital technologies more likely to be HGEs?

### 3 Data description

#### 3.1 Database description

Our analysis is based on the EIBIS dataset merged with the BvD ORBIS database. EIBIS is an EU-wide survey that gathers qualitative and quantitative information on investment activities by non-financial corporates, both SMEs (with 5 to 250 employees) and larger corporates (with more than 250 employees), their financing requirements and the difficulties they face. Using a stratified sampling methodology, EIBIS aims to be representative across all 27 Member States of the EU, the UK and the USA, within countries, four firm size classes (micro, small, medium, and large) and four sector groupings (manufacturing, services, construction, and infrastructure).<sup>7</sup> The survey is carried out through telephone (CATI) interviews in the local language. All interviewed firms are drawn from the BvD ORBIS database, which allows the survey answers to be linked to firms’ financials and other administrative information. Detailed methodology on the survey is available from IPSOS.<sup>8</sup>

We use four waves of EIBIS survey available for 2016 to 2019 with information on more than 34,500 firms on their previous financial year. More than 10,600 firms have participated in multiple waves of the survey resulting in more than 50,000 observations (see

<sup>7</sup> As presented in Brutscher et al. (2020), EIBIS sample is representative in comparison with other similar databases.

<sup>8</sup> <https://www.eib.org/attachments/eibis-methodology-report-2019-en.pdf>.

**Table 1** Distribution of firms according to FDI (invested in another country) and export status (directly exported goods and services to another country) (%). *Source:* own elaboration from EIBIS

	FDI status			Total
	No	Yes		
Export status	No	26,861 (53%)	595 (1%)	27,456 (54%)
	Yes	19,971 (40%)	3005 (6%)	22,976 (46%)
	Total	46,832 (93%)	3600 (7%)	50,432 (100%)

Export status	FDI status				Total
	Never	Permanent	Entrant	Exiter	
Never	46.1	0.2	0.4	0.5	47.2
Permanent	33.0	3.3	2.3	2.3	40.9
Entrant	5.0	0.2	0.3	0.2	5.7
Exiter	5.4	0.2	0.2	0.3	6.2
Total	89.5	3.9	3.3	3.3	100.0

Table 9 in Appendix 1 for the country and wave-level breakdown of observations from the surveys).

The merged EIBIS – ORBIS dataset allows for obtaining firm information on financial years when the firm does not participate in the survey (see Table 10 in Appendix 1 for a summary). In addition, more than 62,000 observations are available for firms from 2013 to 2018 for years when they are not participating the survey. Hence, whenever possible, we use the EIBIS database and supplement with ORBIS in a few cases where EIBIS data is missing. We must mention that causality is difficult to establish given the panel data is only available for three years.

### 3.2 Statistical description

We begin our statistical description with the analysis of the internationalisation status of firms, which we are able to measure by exporting activity and foreign direct investment at year “t”. For firms participating in the EIBIS survey in consecutive waves we also observe their direct export and FDI strategies in “t-1” and “t” to classify them into four different categories as follows. (1) “Never trader/FDI” if they were not adopting an internationalisation strategy in both periods; (2) “Permanent trader/FDI” if they were adopting an internationalisation strategy in both periods; (3) “Entrant” if they started any internationalisation strategy in “t”; and “Exiter” if they stopped their internationalisation strategy in period “t”.

Table 1 shows that around half of the firms have never exported (47.2%), while most declare not to have invested in another country (89.5%). Among exporters, a large share (40.9%) declare to be permanent exporters. These shares are in line with previous evidence and confirm that FDI is a more difficult internationalisation strategy than exporting. The shares of export entrants and exiters are rather low (5.7% and 6.2%, respectively). Finally, among permanent FDI investors, most firms are also permanent exporters. In short, exporters are less likely to also be FDI investors compared to FDI investors also exporting.

Subsequently, we consider firm growth measured as the log-difference of employment (see Törnqvist et al., 1985; Coad, 2009). Mainly, we rely on EIBIS data whenever available and complement it with ORBIS data whenever it is missing, in order to improve data

**Table 2** Firm growth (measured in employment and log difference) according to the international activity. *Source:* own elaboration from EIBIS

Export status	Mean	SD	Median
Never	-0.0096	0.3415	0.0000
Permanent	0.0017	0.3588	0.0000
Entrant	0.0584	0.5192	0.0000
Exiter	-0.0440	0.5373	0.0000
FDI status	Mean	SD	Median
Never	-0.0044	0.3481	0.0000
Permanent	-0.0043	0.5105	0.0175
Entrant	0.1051	0.6228	0.0198
Exiter	-0.0749	0.5374	0.0000

**Table 3** Share of firms according to their internationalisation status and their HGE status (%). *Source:* own elaboration from EIBIS

	Never	Permanent	Entrant	Exiter
<i>Export status</i>				
Non-HGE	48.02	40.14	5.74	6.10
HGE	38.83	48.58	6.53	6.06
<i>FDI status</i>				
Non-HGE	90.41	3.48	3.05	3.06
HGE	83.19	6.53	4.75	5.54

coverage. Looking at the relationship between internationalisation status and the growth rate in Table 2, we can observe that firms that are investing actively in foreign markets obtain larger growth rates according to the median values, suggesting that internationalisation may be a trigger point for firm growth.

In order to investigate the high growth status of the enterprises in relation to their internationalisation activity, first we need to define the HGEs. Several definitions of HGEs have been used in previous studies. According to the OECD-Eurostat definition (Petersen & Ahmad, 2007), a HGE is an enterprise with an average annualized turnover or employment growth greater than 10% (or alternatively 20%) per year over the past three years and having at least 10 employees at the beginning of the growth period. An alternative definition often used in the literature is based on the Birch-Schreyer indicator (Schreyer (2000) and Birch (1987)) that combines both relative and absolute growth, and defines as HGEs those firms that exceed the top 10% of the indicator. In order to have a heterogeneous focus across size groups, we prefer to follow the OECD-Eurostat definition of HGEs as the Birch-Schreyer indicator selects mainly large enterprises (see Ferrando et. al, 2019). We rely on the survey data offering both the current number of employees and the number of employees three years ago. In this way, we can overcome the panel limitation and more recent data are kept (given that ORBIS financial data are available with one-year lag). Nevertheless, we adopt the definition according to the data availability, by using the cumulative three years growth of more than 33%, which would correspond to an annual growth rate of 10%.

Table 3 presents the distribution of HGEs and non-HGEs according to internationalisation status. We observe that a lower share of HGEs are never exporters (-9.19%) or direct investors in foreign markets (-7.22%) while a significantly higher share of HGEs are permanent exporters (+8.44%) or FDI status (+3.05%). Smaller differences among entrants, but we must stand out a significantly larger share of HGEs are exiters of FDI strategies.<sup>9</sup> Hence, this statistical analysis shows evidence for RQ1 (“Which type of internationalisation strategy do HGEs adopt?”).

Next, we define the innovativeness of the company and its relationship with internationalisation activity. We use four alternative variables: (1) whether the company introduces or not new products, (2) the type of innovation, (3) the average share of machinery and equipment that firms perceive to be ‘state-of-the art’ and (4) the share of R&D investment from total investments. There are three types of innovation according to the introduced new products, processes or service: (1) globally new, (2) new for the country and 3) those less radical innovators with products new only to the company.

Table 4 shows the results for the distribution of firms according to their internationalisation activity with respect to these different types of innovation. According to the descriptive statistics, firms that are internationalised are more innovative. The share of firms that develop more radical innovations is higher for internationalised firms. Among innovative non-exporters, the share of firms that declare to develop innovations new to the world are equal to 9.2%, while for innovative exporters the value is equal to 25%. A difference of nearly 16 percentage points. We find the same pattern for FDI status, with difference between both groups of firms of nearly 20 percentage points for firms that develop innovations new to the world (16.2% versus 35.2%). Finally, we observe important differences in the mean values of the R&D investment. Internationalised companies invest around 10 times more in R&D than non-internationalised companies. Descriptive statistics suggest that internationalised firms develop more radical innovations but also make a larger R&D investment. The results of the share of state-of-the art machinery is higher for internationalised firms, especially for firms that invest in FDI (nearly 10 percentage points more).<sup>10</sup>

Additionally, for the year 2018 data on digitalisation is also available from EIBIS wave 2019. Data are obtained based on a survey question on different digital technologies: such as 3D printing, automation and robots, Internet of Things (IoT), Big data, Artificial Intelligence (AI), Virtual Reality (VR), platform technologies and drones. A firm is identified as ‘partially digital’ if at least one digital technology was implemented in parts of the business, and ‘fully digital’ if the entire business is organised around at least one digital technology. There are four different specific digital technologies in each of the four major sectors.<sup>11</sup>

According to descriptive statistics presented in Fig. 4, the share of firms adopting new digital technologies (NDTs) is higher among firms being permanently in foreign markets, regardless their strategy. However, the share is substantially higher among firms that are permanent FDI investors. Among entrants, exporters are also adopting more frequently NDTs than FDI entrants. In contrast, the share of adoption is higher among FDI exiters

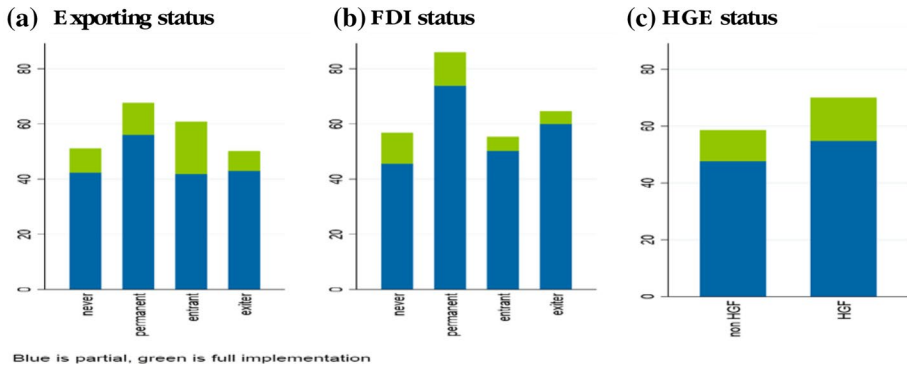
<sup>9</sup> Appendix 2 provides a country-level analysis.

<sup>10</sup> Appendix 3 provides a country-level analysis.

<sup>11</sup> Manufacturing: 3D Printing, Robotics, IoT, Big Data; Construction: 3D printing, Drones, Virtual Reality, IoT; Services: VR, Platforms, IoT, Big Data; and Infrastructure: 3D Printing, Platforms, IoT, Big data. For further details see also [www.eib.org/en/publications-research/economics/surveys-data/eibis-digitalisation-report.htm](http://www.eib.org/en/publications-research/economics/surveys-data/eibis-digitalisation-report.htm).

**Table 4** Internationalisation and innovation activity. *Source:* own elaboration from EIBIS

	Export activity		Innovators		Type of innovation (%)			R&D and high-tech intensity (mean)	
	Obs.	%	Obs.	%	New to the company	New to the market	New to the world	R&D investment	% state-of-the-art machinery
Non-exporter	27,456	54.21	6401	23.3	75.9	14.9	9.2	107,140.9	37.0
Exporters	22,976	45.36	8921	38.8	59.5	15.5	25.0	1,568,439.7	41.9
	FDI activity		Innovators		Type of innovation (%)			R&D and high-tech intensity (mean)	
	Obs.	%	Obs.	%	New to the company	New to the market	New to the world	R&D investment	% state-of-the-art machinery
Non-FDI investors	46,832	92.46	13,573	29.0	68.2	15.6	16.2	490,499.8	38.6
FDI investors	3600	7.11	1749	48.6	52.0	12.9	35.2	4,446,400.9	47.3



**Fig. 4** Share of firms that declare to implement (partially or fully) new digital technologies according to the internationalisation status and HGE status. *Source:* own elaboration from EIBIS wave 2019. A firm is identified as ‘partially digital’ if at least one digital technology was implemented in parts of the business, and ‘fully digital’ if the entire business is organised around at least one digital technology. Firms are weighted using value added

than export exiters. Finally, firms that declare to adopt fully the NDT are more frequent among export entrants. Therefore, RQ6 (“Do HGEs use NDTs more frequently?”) is confirmed since HGEs are characterized by adopting more NDTs than non-HGEs (Fig. 4). Furthermore, a larger share of permanent internationalised companies adopt more NDTs than their counterparts.

A closer look to the type of technology according to the internationalisation status is presented in Fig. 6 in Appendix 4. This reveals that permanent exporters usually adopt robots or platforms. Among entrants, platforms and IoT are the most common digital technologies. This confirms that entrants in foreign market may use commonly digital platforms as a way to improve their decision-making process. Conversely, VR and 3D are less common NDTs regardless the export status. By FDI status, we observe similar figures, but permanent FDI investors have larger shares of adoption of platforms and robots, drones, IoT, Big Data and 3D. FDI are more involved in global value chains and a larger complexity which might require more digital tools. Hence, the adoption of NDTs seems to be a tool to enter by exporting (platforms, IoT and drones), while NDTs are adopted by permanent FDI investors. These results may underline the different role that these NDTs may have on the internationalisation process of firms.

Finally, if we observe the degree of implementation according to the HGE status, presented in Fig. 6 in Appendix 4, we observe that HGEs adopt new digital technologies more often. We observe that the higher differences between both groups of firms appear for the adoption of robots (more than half of HGEs declare to adopt this technology). In addition, the platforms and IoT are two technologies adopted by more than 40% of HGEs.

## 4 Econometric approach

This section presents the applied econometric methodology. Section 4.1 presents the matching methodology that tries to mitigate the selection bias between internationalised and non-internationalised companies. The following subsection develops the general econometric framework in international trade based on the self-selection process and the

learning-by-exporting hypothesis [see Segarra-Blasco et al. (2020) for a recent analysis]. This econometric framework allow us to test our research questions related to the “pre-condition” and “post-effect” presented in Sect. 2 (RQ2, RQ3, RQ4, RQ5 and RQ7).

#### 4.1 Sample selection

Sample selection bias may appear because non-observable characteristics of internationalised firms are different from those which are not internationally active. Sample selection results in firms carrying out internalisation activities to have different characteristics, which in turn changes their growth capacity compared to non-internationalised companies.

To mitigate this potential bias, matching methodologies are widely used. Recently, coarsened exact matching (henceforth CEM) has been developed as a more powerful matching methodology than Generalized Propensity Score (Blackwell et al., 2009; Iacus et al., 2008).<sup>12</sup> CEM is a non-parametric methodology that establishes a covariate balance between treated and control units. There are several advantages from applying CEM in comparison with previous alternative methodologies such as GPS. First, CEM does not require assumptions about the data generation process; hence, users can make robust inferences without any such assumptions. Second, CEM allows establishing, *ex ante*, the bounds within which matched comparisons are to be made. This procedure may reduce the statistical bias associated with their estimates. Therefore, CEM meets the congruence principle and it restricts the matched data to areas of common empirical support (Iacus et al., 2011). In line with Segarra-Blasco et al. (2020), we apply the CEM methodology. This methodology controls for sample selection bias by matching treated (*i.e.*, internationalised) and untreated firms (*i.e.*, non-internationalised).

The covariates used to determine the strata are grouped into the following four categories:

1. Firm age and size. The firm size distribution is highly skewed, and this must be taken into account since it is well documented that firm age and size are determinants of internationalisation processes in firms. CEM allows us to create intervals for matching. We create four categories of firm size (*i.e.*, 10, 50 and 250 employees). Firm age is controlled by firms with more than 20 years.<sup>13</sup>
2. We capture a firm’s relative technological capacity introducing (i) an index of sectoral labour productivity (labour productivity with respect to the mean in the sector), (ii) the average salary per worker, and (iii) three innovation categories (non-innovative firm, innovator new to the firm, innovator new to the market).
3. We include a set of dummies identifying firms operating in manufacturing, construction and service sectors since the sector in which firms operate might also affect their internationalisation strategy.
4. We assume that firms located in a leading technologically country enjoy a different context—both in terms of enabling environment and competitive pressure—that may affect their capacity to internationalise. Consequently, we introduce a dummy for firms

<sup>12</sup> GPS was applied previously to analyse the relationship between exporting and firm growth (Eliasson et al., 2012; Fryges, 2009; Wagner, 1995), and exporting and profitability (Fryges and Wagner, 2010).

<sup>13</sup> Similar cut-offs have been applied in Segarra-Blasco et al. (2020).

in leading countries (i.e., Austria, UK, Finland, Germany, France, Ireland, Luxembourg, Sweden, Netherland and Denmark).<sup>14</sup>

From the total number of 8235 observations of untreated firms, 7913 observations belong to the matched sample and from the 7,038 observations of treated firms, we obtain 6919 matched observations. Afterwards, CEM removes unmatched observations and a ‘matched’ sample is subsequently refined for post-matching analysis.

Table 14 in Appendix 5 reports on the multivariate distance with CEM for our main variables, indicating the imbalance of the variable between the distribution of all respondents and the matched sample. The remaining columns present the different values of the mean in order to compare the initial sample and the matched sample. The results are quite positive, as both the multivariate distances and mean-differences (with the exception of the variable salary) are very small. Our results show that the distribution of every variable is balanced. Our estimations in Sect. 5 include only the estimates of the matched sample of firms.

## 4.2 Econometric estimation

This subsection presents the econometric approach to address our main research questions. First, we analyse the “pre-condition” departing from the self-selection literature (Melitz, 2003). Here, we modify the equation by including a dummy that identifies HGEs in order to analyse RQ2. Equation (1) estimates the probability of internationalising and it takes the following form:

$$Prob(Int)_{i,t} = x_{1it}\beta_{11} + \beta_{11}LabProd_{it} + \beta_{12}HGE_{it} + \varepsilon_{1i,t} \quad (1)$$

where *Int* are different dummies which indicate the internationalisation status (permanent exporter or FDI investor). *LabProd* is the labour productivity and measures the potential self-selection in the market. Finally, *HGE* is a dummy variable indicating if the firm is a high-growth enterprise. The empirical estimation takes into account the differences with respect to never exporters or never FDI investors.

Afterwards, we estimate the “post-effect” of internationalisation on the probability of becoming a HGE (RQ3) and the different impact of each internationalisation strategy (RQ4). Here, the key factor is the effect of the internationalisation activity on the probability of being a HGE in the following period. Formally:

$$Prob(HGE)_{i,t} = x_{2it-1}\beta_{21} + Int_{i,t-1}\beta_{22} + \varepsilon_{2i,t} \quad (2)$$

*HGE* is a dummy variable indicating if the firm is a HGE and *Int* are dummies which indicate the internationalisation status (permanent exporter or FDI investor).

Finally, we analyse the role that NDTs exert on both relations, the “pre-condition” and the “post-effect”. Similar to Cassetta et al. (2020), we analyse the incidence of NDTs on internationalisation activity (RQ6). Our initial equation takes the following form:

$$Prob(Int)_{i,t} = x_{3i}\beta_{31} + LabProd_{i,t}\beta_{32} + HGE_{i,t}\beta_{33} + NDT_{i,t}\beta_{34} + \varepsilon_{3i} \quad (3)$$

<sup>14</sup> We consider as leading countries those that they classified by the European Innovation Scoreboard as leading innovators or strong innovators above the EU average.



where *Int* indicates if the firm is an exporting firm or if it invests in FDI, *LabProd* represents the level of labour productivity, *HGE* is a dummy variable identifying high-growth enterprises and *NDT* captures the degree of adoption of new digital technologies (*digital\_adopt* is a dummy equal to 1 if the firm adopts partially or totally any NDT; *partialAdopt* is equal to 1 if the firm adopts partially any NDT; and *totalAdopt* is equal to 1 if the firm adopts totally any NDT). After, we assume that NDTs exert heterogeneous effects on firms' capacity to become HGEs (RQ7) and estimate the model:

$$Prob(HGE)_{i,t} = x_{4i}\beta_{41} + Int_{i,t}\beta_{42} + NDT_{i,t}\beta_{42} + \varepsilon_{4i} \quad (4)$$

*HGE* indicates if the firm is a high-growth enterprise, *Int* are different dummies which indicate the internationalisation status (permanent exporter or FDI investor), *NDT* is a vector according the adoption of NDTs similar to Eq. (3).

We must remark that due to data limitations of the information on NDT, the sample will correspond to a cross-section belonging to year 2018 with a diminished number of observations. Finally, Eq. (4) takes into account the internationalization dynamics (permanent or never), hence the sample not only concerns firms that responded to the questionnaire from 2018, but also those that were present in the previous year. For that reason, the number of observations between Tables 7 and 8 decreases.

$x_1$ ,  $x_2$ ,  $x_3$  and  $x_4$  are a set of explanatory variables and  $\beta$  are the estimated coefficients and all equations include random errors denoted by  $\varepsilon_i$  which we assume is normally distributed. The equations are estimated with a probit econometric model using robust standard errors.

As explanatory variables, we use different sets of variables.<sup>15</sup> We include dummy variables identifying the innovation degree of the firm (if the firm has developed innovations new to the firm, market and the world), the investment in machinery state-of-the-art and R&D. As firm characteristics, we identify firm age and firm size. We also include different variables such as: dummy variables for profit; salary expenditures; a dummy indicating if the firm is a subsidiary of another company; dummy variables if the investment in the last financial year decreased, stayed the same or increased compared to the previous year; and a dummy variable if investment in the current year is expected to decrease, stay the same or increase. Furthermore, we include investment barriers (demand, lack of skilled workforce, energy cost, availability of digital infrastructure, labour market regulation, business regulations, availability of adequate transport infrastructure, availability of finance, and uncertainty about the future). As additional control variables, all equations include time, sector and country dummies.<sup>16</sup>

We must also comment on the complexity of the interlinkages between all the key variables, which could be a symptom of endogeneity. The short temporal window of our panel data does not allow us to apply some more sophisticated econometric tools such as the Wooldridge methodology (Wooldridge, 2005), and it might introduce a certain degree of simultaneity bias in the case of the cross-sectional estimations. However, the CEM methodology alleviates the potential endogeneity due to the fact that internationalised and non-internationalised firms have different characteristics. We are aware that we may not be able to control completely for potential endogeneity between our key variables. Therefore, we

<sup>15</sup> Check Table 15 in the Appendix 5 for a table with the descriptive statistics.

<sup>16</sup> Finally, we must mention that the estimations for entrants and exiters have not been included due to the few observations. Results are available upon request to the authors.

**Table 5** The influence of HGE in the international activity. Matched sample

Variables	(1)		(2)	
	Permanent versus never exporters		Permanent versus never FDI	
	Coeff	SD	Coeff	SD
LabProd	0.196***	[0.0521]	-0.0331	[0.0627]
HGE	0.294***	[0.0708]	0.319***	[0.0938]
Machinery state-of-the-art	0.0012	[0.0008]	0.0015	[0.0011]
R&D investment	1.445***	[0.202]	1.131***	[0.131]
From 2 to 5 years	-0.265	[0.498]	-0.334	[0.529]
From 5 to 10 years	-0.141	[0.473]	-0.0432	[0.477]
From 10 to 20 years	-0.0474	[0.468]	-0.0155	[0.456]
More than 20 years	-0.125	[0.466]	-0.0075	[0.452]
Sales	0.204***	[0.0171]	0.361***	[0.0231]
Loss	0.271***	[0.0970]	0.137	[0.114]
Break even	-0.190**	[0.0956]	0.0394	[0.134]
Salary	-0.0287	[0.0380]	0.153***	[0.0428]
Non-subsidiary company	-0.0214	[0.0633]	0.337***	[0.0760]
Similar investment	-0.0003	[0.0537]	-0.0313	[0.0764]
Less investment	-0.0533	[0.0753]	-0.119	[0.0928]
Similar sector expectations	-0.128**	[0.0566]	-0.206***	[0.0726]
Less sector expectations	0.0470	[0.0809]	-0.0306	[0.101]
Constant	-4.312***	[0.743]	-7.054***	[0.804]
Pseudo-R <sup>2</sup>	0.190		0.261	
Observations	6296		5853	

Robust standard errors in brackets \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ . Notes: Benchmark dummy variables are: (1) less than 2 years; (2) Profit; (3) subsidiary company; (4) more investment; (5) improvement of business prospects specific to your sector or industry. Sector, country and year dummies are included

must be cautious since our results may present statistical relationships that may not reflect causal effects.

## 5 Results

The following section presents the results of our research questions. First, we analyse the “pre-condition” of being a HGE on the internationalisation status. Second, we present the estimations for the “post-effect” of the internationalisation status on the probability that the company becomes a HGE. Finally, we present the effect of NDTs in our results.

### 5.1 Do high growth episodes affect internationalisation activity?

Table 5 presents the estimates of the incidence of HGEs on the internationalisation activity. Columns (1) presents the results for permanent exporters, while columns (2) shows similar results for the FDI activity. We must have in mind that all the results are in comparison

with the category “never internationalised” companies.<sup>17</sup> The main results are the following ones:

- HGE activity shows a positive coefficient with the export and FDI activity. We confirm that firms that are growing are those that also engage in internationalised activities. In comparison with non-internationalised firms, internationalised firms are characterised by high growth episodes, and this characteristic is more prominent for FDI activities. Hence, the results suggest the existence of a “pre-condition” effect of the HGE to be internationalised.
- Labour productivity is positively associated with the probability of being a permanent exporter, while the results are not significant for the FDI activity. Therefore, we confirm the self-selection hypothesis for exporting activity partly for just a group of firms.
- Concerning the innovation variables, firms with higher shares of R&D investment have a higher probability of operating in international markets, regardless the type of strategy. Finally, among both strategies, the incidence is higher for the probability of being a permanent exporter.

To sum up, our empirical results show the importance of having a rapid growth episode given the high impact on the presence in the international activity. We must also remark the importance of the R&D investment, in particular for being permanently exporting. To conclude, we confirm that internationalised firms are more prone to have been growing recently (RQ2). Therefore, with a certain caution the results confirm the “pre-condition” hypothesis. Concerning other firm characteristics, we observe:

- Firm size has a significant positive sign which indicates the need of scale economies to be present in foreign markets. The coefficients are higher for FDI status which suggest that firms achieve a certain dimension before investing in FDI.
- Firms that are non-subsidiary are positively associated with permanent FDI investors. Also, our proxy of salary has a positive and significant relationship with permanent FDI investors. A potential explanation is that firms want also to externalize some costs (cheaper labour) if they internationalise (and salaries at home may be very high).
- Firms that perceive demand barriers are more prone to be permanent exporters and permanent FDI. A potential explanation is that they export permanently because there is not domestic demand of their products, or maybe they perceive more barriers due to the higher complexity of the international demand. Furthermore, permanent traders or FDI investors perceive less obstacles of uncertainty than non-internationalised firms. Finally, permanent FDI perceive less obstacles of costs but more financial obstacles (these results are available upon request to the authors).

## 5.2 Does internationalisation increase the probability of being a HGE?

After estimating the “pre-condition” equation, Table 6 presents the results of the “post-effect” incidence of the internationalisation activity on being a HGE. In this equation, we

<sup>17</sup> Similar estimations were used with the whole sample. These results were rather similar to those presented in Table 5.

**Table 6** The influence of internationalisation activity on the probability of being a HGE in the following period. Matched sample

Variable	Export		FDI					
	(1)		(2)		(3)		(4)	
	Coeff	s.d	Coeff	s.d	Coeff	s.d	Coeff	s.d
Permanent	0.134	[0.0955]			0.378**	[0.166]		
Never			-0.228**	[0.0981]			-0.331***	[0.111]
LabProd	-0.256***	[0.0766]	-0.261***	[0.0771]	-0.239***	[0.0776]	-0.243***	[0.0778]
Growth expectations	0.152	[0.160]	0.147	[0.159]	0.157	[0.162]	0.142	[0.154]
Innovation firm	0.0266	[0.0959]	0.0268	[0.0963]	0.0110	[0.0969]	0.00780	[0.0967]
Innovation market	0.437*	[0.226]	0.443*	[0.228]	0.427*	[0.223]	0.422*	[0.224]
Innovation world	-0.0537	[0.169]	-0.0507	[0.169]	-0.0634	[0.170]	-0.0803	[0.171]
Machinery state-of-the-art	0.0019	[0.0013]	0.0019	[0.0013]	0.0018	[0.0013]	0.0018	[0.0013]
R&D investment	0.317	[0.260]	0.281	[0.264]	0.346	[0.254]	0.315	[0.256]
From 2 to 5 years	0.598***	[0.230]	0.610***	[0.230]	0.596***	[0.228]	0.576**	[0.227]
From 5 to 10 years	0.277*	[0.150]	0.262*	[0.149]	0.279*	[0.150]	0.264*	[0.150]
From 10 to 20 years	0.206**	[0.0985]	0.204**	[0.0987]	0.213**	[0.0996]	0.204**	[0.100]
Sales	0.0814***	[0.0268]	0.0756***	[0.0269]	0.0738**	[0.0287]	0.0713**	[0.0282]
Loss	-0.434***	[0.162]	-0.453***	[0.162]	-0.408**	[0.164]	-0.410**	[0.165]
Break even	-0.140	[0.173]	-0.134	[0.174]	-0.154	[0.171]	-0.155	[0.172]
Salary	0.0817	[0.0571]	0.0887	[0.0573]	0.0679	[0.0576]	0.0724	[0.0574]
Non-subsiidiary company	-0.105	[0.0914]	-0.104	[0.0915]	-0.119	[0.0919]	-0.125	[0.0916]
Similar investment	-0.148*	[0.0886]	-0.150*	[0.0885]	-0.150*	[0.0888]	-0.152*	[0.0889]
Less investment	-0.426***	[0.116]	-0.426***	[0.116]	-0.413***	[0.117]	-0.419***	[0.116]
Similar sector expectations	-0.173*	[0.0920]	-0.166*	[0.0925]	-0.174*	[0.0917]	-0.177*	[0.0917]
Less sector expectations	-0.169	[0.139]	-0.163	[0.140]	-0.162	[0.141]	-0.185	[0.140]
Constant	0.249	[0.961]	0.532	[0.956]	0.197	[0.982]	0.562	[0.995]
Pseudo-R <sup>2</sup>	0.1134		0.1171		0.1158		0.1174	
Wald $\chi^2$	184.34		192.45		181.80		187.50	

Table 6 (continued)

Variable	Export		FDI	
	(1)	(2)	(3)	(4)
	Coeff	s.d	Coeff	s.d
Prob > $\chi^2$	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Observations	2491	2491	2491	2491

Robust standard errors in brackets \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ . Notes: Benchmark dummy variables are: (1) non-innovator; (2) less than 2 years; (3) Profit; (4) subsidiary company; (5) more investment; (6) improvement of business prospects specific to your sector or industry. Sector, country and year dummies are included

compare the internationalisation activity with the performance of all the firms.<sup>18</sup> Columns (1)–(2) analyse the impact of being permanent exporter or never exporter while columns (3)–(4) introduce the FDI status. The main results are the following ones:

- Concerning the incidence of the internationalisation activity on the probability of becoming a HGE, the results show that never-exporters have a significantly lower probability of becoming a HGE. These first results highlight that firms that have never ventured abroad are less likely to become HGEs. However, being internationalised is not enough to be a HGE. Hence, we may conclude that export activity is a necessary but not sufficient condition for high growth.
- Conversely, column (3) shows that permanent FDI investors have a higher probability to be HGEs. Due to data limitations, we are not able to explore this interesting point. Therefore, we confirm partially the “post-effect” of internationalisation on the likelihood of being a HGE.
- This contributes to Brown and Mawson’s (2016) previous results. The authors pointed out that HGEs adopt more aggressive forms of international expansion (e.g., overseas acquisitions), than their non-HGEs. We must have in mind that FDI activity is more risky and firms that apply this strategy must cover more sunk costs than those adopting export strategies (Helpman et al., 2004).

To sum up, our results highlight the particularly negative incidence of not being internationalized in our post-effect estimation with an incidence on the likelihood of being HGE. These results involve that firms that are not exposed to international markets are less likely of being HGEs. Hence, RQ3 (“Does internationalisation facilitate firms to be HGEs?”) is confirmed partially.

Concerning RQ4 (“Do exporting and FDI activity have different relationship with the probability of becoming a HGE?”), our results confirm that different internationalisation strategies have heterogeneous effects. First, exporting does not have a significant impact on the likelihood of becoming a HGE. A possible interpretation is that export is a necessary condition but not sufficient and it must be accompanied with the development of internal capabilities such as R&D investment and innovation. Alternatively, it can be that the impact of export on the likelihood of being a HGE may not involve a short-term effect. Second, our estimations show a strong impact of permanent FDI on the probability of becoming a HGE. Interestingly, FDI is a direct mode of growth in the foreign market which also facilitates the growth in the domestic market, at least for certain firms. We must remark that our results are not able to show which type of FDI fosters HGE since horizontal and vertical FDI investments may cause different impact for firms in their home market. Our results seems to point out that engaging in FDI may be a trigger point for firm growth.

Concerning other explanatory variables, we find also the following results:

- Labour productivity has a negative and significant coefficient. Hence, the less productive firms will be more likely to become a HGE. It might be the case that highly

<sup>18</sup> The number of observations are substantially lower in comparison with observations in Table 5 due to two reasons. First, the explanatory variables are lagged one period and additionally. Second, to generate the internationalization dynamics we must have two periods of observations. Therefore, the sample belongs to firms observed during three consecutive periods.

productive firms have less growth potential compared to low-productive firms that are catching up.

- Firms that develop innovations new-to-the-market are more prone to become HGEs. This result contributes to our previous result on the effect of R&D investment on the probability to export or investing in FDI (Table 5). Our results suggest that the joint strategy of developing an innovation (not need to be new to the world) may be more effective to become a HGE than only exporting. For the case of the FDI, there seems that innovating domestically reinforces the strategy of investing abroad.
- We observe an inverted U-shaped impact of firm age, where firms between 2 and 5 year have larger coefficients. Furthermore, larger firms have more probability to become a HGE. Hence, young firms may be more likely to become HGEs, but it seems also necessary to have a minimum experience to reach the scale-up phase, rather than just grow old.
- Firms with profit loss, that have invested less or have lower expectations are less prone to be HGEs.
- Furthermore, barriers related to the uncertainty are the main obstacle that affect the probability of becoming a HGE. Hence, uncertainty deters the existence of HGEs. Additionally, the perception of major demand barriers also may affect negatively to the probability but the coefficient is not always significant (in particular for our estimations controlling for the FDI strategy). Finally, the obstacles related to the skills present in general a positive and significant coefficient (results are available upon request to the authors).

### 5.3 Do new digital technologies matter for internationalising and becoming a HGE?

After disentangling the relationship between internationalisation and HGEs, we estimate the interaction that NDTs may exert in the relationship between both variables. As presented in Fig. 3 in Sect. 2, the so-called “pre-condition” and the “post-effect” will interact with the decision of the firm to adopt NDTs.

Table 7 presents the main results of the relationship between the adoption of new digital technological and the internationalisation activity. Columns (1)-(2) show the results only for the internationalisation activity, columns (3)-(4) show the results for firms that export, and columns (5)-(6) show the results for the probability of being a FDI investor. The main results are the following:

- The general results show that the internationalisation activity of European firms is linked with the adoption of new digital technological (model 1). We must remark that we obtain higher coefficient for the exporting activities than for FDIs.
- The degree of digitalization seems also an important variable. On the one hand, the influence of a total adoption seems to be significant, but the coefficient is larger for the partial level of adoption (model 2). On the other hand, results show that when we differentiate between the types of internationalisation, only those firms that declare having adopted partially NDT are more likely to be exporting or investing in FDI.<sup>19</sup>

<sup>19</sup> The interaction between NDTs and the dummy variable of HGE is not significant. Results are available upon request. We give thank you the suggestion of one referee for testing the interaction.

**Table 7** Effect of the adoption of new digital technologies on the probability of internationalising. Matched sample

	International activity		Exporting activity		FDI activity	
	(1)	(2)	(3)	(4)	(5)	(6)
LabProd	0.0484 [0.0471]	0.0503 [0.0472]	0.0615 [0.0471]	0.0633 [0.0471]	-0.0579 [0.0514]	-0.0551 [0.0514]
HGE	0.245*** [0.0845]	0.244*** [0.0850]	0.231*** [0.0831]	0.230*** [0.0835]	0.162* [0.0835]	0.161* [0.0838]
Digital_adopt	0.176*** [0.0579]		0.201*** [0.0578]		0.182*** [0.0686]	
PartialAdopt		0.191*** [0.0558]		0.184*** [0.0557]		0.190*** [0.0650]
TotalAdopt		0.168* [0.0907]		0.153* [0.0895]		0.137 [0.0892]
Machinery state-of-the-art	0.0006 [0.0010]	0.0005 [0.0010]	0.0006 [0.0010]	0.0004 [0.0010]	0.0009 [0.0010]	0.0008 [0.0010]
R&D investment	0.704*** [0.183]	0.686*** [0.184]	0.695*** [0.180]	0.678*** [0.181]	0.987*** [0.126]	0.973*** [0.127]
From 2 to 5 years	0.158 [0.573]	0.178 [0.575]	0.106 [0.565]	0.126 [0.565]	0.194 [0.185]	0.197 [0.185]
From 5 to 10 years	0.169 [0.555]	0.181 [0.556]	0.11 [0.547]	0.123 [0.547]	-0.0536 [0.122]	-0.062 [0.122]
From 10 to 20 years	0.34 [0.550]	0.358 [0.552]	0.271 [0.542]	0.289 [0.543]	0.0622 [0.0774]	0.0631 [0.0775]
More than 20 years	0.146 [0.548]	0.166 [0.550]	0.086 [0.540]	0.106 [0.540]		
Sales	0.183*** [0.0253]	0.180*** [0.0252]	0.170*** [0.0248]	0.168*** [0.0247]	0.246*** [0.0217]	0.244*** [0.0218]
Loss	0.098 [0.0990]	0.102 [0.0989]	0.0775 [0.0981]	0.0816 [0.0981]	0.0742 [0.0967]	0.0776 [0.0970]
Break even	-0.118 [0.0998]	-0.12 [0.0996]	-0.109 [0.0993]	-0.110 [0.0991]	-0.0123 [0.132]	-0.0145 [0.132]
Salary	-0.0416 [0.0367]	-0.0449 [0.0367]	-0.0513 [0.0364]	-0.0546 [0.0364]	0.0658* [0.0355]	0.0640* [0.0356]
Non-subsidiary company	-0.0732 [0.0723]	-0.0736 [0.0723]	-0.0852 [0.0713]	-0.0856 [0.0713]	0.147** [0.0670]	0.147** [0.0669]
Similar investment	-0.118* [0.0672]	-0.117* [0.0671]	-0.107 [0.0668]	-0.106 [0.0665]	-0.172** [0.0674]	-0.172** [0.0673]
Less investment	-0.0007 [0.0762]	-0.000597 [0.0765]	0.0125 [0.0757]	0.0124 [0.0759]	-0.164** [0.0832]	-0.165** [0.0835]
Similar sector expectations	-0.0973 [0.0657]	-0.0936 [0.0654]	-0.0988 [0.0653]	-0.0956 [0.0650]	-0.0466 [0.0676]	-0.0424 [0.0675]
Less sector expectations	0.0147 [0.0851]	0.0145 [0.0848]	0.0070 [0.0848]	0.0066 [0.0845]	-0.0076 [0.0890]	-0.0064 [0.0886]
Constant	-2.904*** [0.779]	-2.897*** [0.781]	-2.815*** [0.769]	-2.809*** [0.770]	-4.758*** [0.616]	-4.747*** [0.617]



**Table 7** (continued)

	International activity		Exporting activity		FDI activity	
	(1)	(2)	(3)	(4)	(5)	(6)
Pseudo-R <sup>2</sup>	0.13	0.131	0.127	0.128	0.183	0.184
Observations	4,954	4,954	4,954	4,954	4,885	4,885

Robust standard errors in brackets \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$  Notes: Benchmark dummy variables are: (1) non-digital adopters; (2) less than 2 years; (3) Profit; (4) subsidiary company; (5) more investment; (6) improvement of business prospects specific to your sector or industry. Sector, country and year dummies are included

- Other variables that show significant positive coefficients are being a HGE, the R&D investment and the firm size.
- Firms with higher salary ratios, being non-subsidiaries and those that they have invested more have more probability to be FDI investors. Finally, all internationalised firms perceive obstacles of demand and less obstacles of business regulations and taxes. However, firms that export do not perceive more obstacles to finance (results of the barriers are available upon request to the authors).

To sum up, our results suggest that having experienced a HGE episode characterises internationalised firms, in particular exporting activity. The adoption of new digital technologies has a lower incidence (with coefficients equal to 0.201 and 0.182 for exporting and FDI activity) but RQ5 (“Are firms adopting digital technologies more internationalised?”) is confirmed. Firms that adopt NDTs are more prone to be internationalised. For FDI investors we confirm it regardless their level of adoption, while for the exporters the relationship is significant for partial adopters.

Similar to the previous post-effect analysis, the adoption of new digital technologies may be an important factor that allows, on the one hand, the transformation of traditional sectors and their renewal and, on the other hand, facilitate the appearance of HGEs. For this last step, we analyse the relationship between the adoption of NDT and the likelihood of being a HGE (Table 8) according to the trader/FDI status. The main results are the following:

- HGEs are more likely to be permanent exporters. Conversely, firms that are non-exposed to foreign markets via the exporting activity will be less likely to become a HGE. Similarly, firms that never invest in FDI stop investing directly in foreign markets growth in the domestic market as a process of recovery of their profits and investments abroad.
- However, the incidence of the NDT is not significantly related to the probability of being a HGE, regardless the adoption intensity. Several reasons may explain this behaviour. First, our regressions does not consider the temporal effect but just the correlation between our variable. Therefore, our results cannot respond to the question of which is the impact of the adoption of NDT to the probability of becoming a HGE in the near future. Second, HGEs is a rare event and NDT is still in the inception phase of implementation among firms. Third, NDTs seem to be more an instrument that facilitate the internal operations of firms. Hence, the adoption of NDTs will facilitate the transforma-

**Table 8** Effect of the adoption of new digital technologies on the probability of being a HGE. Matched sample

Variables	Trader status			FDI status				
	Permanent		Never	Permanent		Never		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Trader/FDI status	0.228** [0.102]	0.227** [0.102]	-0.318*** [0.100]	-0.318*** [0.100]	-0.0194 [0.187]	-0.0233 [0.186]	-0.356*** [0.120]	-0.354*** [0.120]
Digital_adopt	-0.089 [0.110]		-0.0925 [0.110]		-0.0746 [0.110]		-0.0837 [0.110]	
PartialAdopt		-0.0465 [0.107]		-0.0481 [0.107]		-0.028 [0.106]		-0.0357 [0.107]
TotalAdopt		-0.0386 [0.123]		-0.0563 [0.122]		-0.0273 [0.123]		-0.0284 [0.123]
LabProd	-0.235*** [0.0811]	-0.233*** [0.0809]	-0.249*** [0.0829]	-0.246*** [0.0826]	-0.221*** [0.0801]	-0.219*** [0.0800]	-0.21*** [0.0796]	-0.209*** [0.0794]
Innovation firm	0.0765 [0.103]	0.072 [0.103]	0.0805 [0.104]	0.0761 [0.103]	0.0658 [0.103]	0.0606 [0.103]	0.0721 [0.104]	0.0667 [0.104]
Innovation market	-0.248 [0.179]	-0.251 [0.179]	-0.239 [0.180]	-0.241 [0.181]	-0.279 [0.179]	-0.283 [0.180]	-0.263 [0.180]	-0.268 [0.180]
Innovation world	0.186 [0.167]	0.179 [0.167]	0.179 [0.169]	0.172 [0.170]	0.195 [0.171]	0.188 [0.171]	0.167 [0.169]	0.160 [0.170]
Machinery state-of-the-art	0.0019 [0.0015]	0.0019 [0.0015]	0.0018 [0.0015]	0.0018 [0.0015]	0.0022 [0.0015]	0.0022 [0.0015]	0.0021 [0.0015]	0.0020 [0.0015]
R&D investment	0.157 [0.223]	0.154 [0.222]	0.165 [0.228]	0.165 [0.227]	0.242 [0.227]	0.236 [0.226]	0.136 [0.228]	0.13 [0.227]
From 2 to 5 years	-0.121 [0.649]	-0.132 [0.650]	-0.013 [0.640]	-0.0265 [0.645]	-0.0993 [0.670]	-0.107 [0.670]	-0.142 [0.672]	-0.15 [0.672]
From 5 to 10 years	-0.0544 [0.592]	-0.0714 [0.594]	0.054 [0.585]	0.035 [0.590]	-0.0421 [0.612]	-0.0542 [0.613]	-0.0999 [0.616]	-0.112 [0.617]

Table 8 (continued)

Variables	Trader status			FDI status				
	Permanent		Never	Permanent		Never		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
From 10 to 20 years	-0.268 [0.580]	-0.283 [0.583]	-0.169 [0.572]	-0.186 [0.578]	-0.242 [0.601]	-0.251 [0.601]	-0.293 [0.604]	-0.303 [0.605]
More than 20 years	-0.646 [0.574]	-0.655 [0.575]	-0.549 [0.566]	-0.561 [0.572]	-0.626 [0.595]	-0.63 [0.595]	-0.692 [0.599]	-0.696 [0.599]
Sales	0.148*** [0.0275]	0.146*** [0.0275]	0.144*** [0.0270]	0.141*** [0.0270]	0.158*** [0.0284]	0.154*** [0.0285]	0.138*** [0.0282]	0.135*** [0.0283]
Salary	0.243*** [0.0607]	0.241*** [0.0608]	0.246*** [0.0611]	0.243*** [0.0612]	0.231*** [0.0607]	0.228*** [0.0609]	0.233*** [0.0602]	0.230*** [0.0604]
Non-subsidary company	0.228** [0.109]	0.228** [0.109]	0.230** [0.108]	0.229** [0.108]	0.229** [0.110]	0.229** [0.110]	0.217** [0.110]	0.217** [0.110]
Similar investment	-0.351*** [0.103]	-0.350*** [0.102]	-0.357*** [0.104]	-0.357*** [0.103]	-0.364*** [0.103]	-0.363*** [0.102]	-0.361*** [0.103]	-0.360*** [0.102]
Less investment	-0.273* [0.144]	-0.275* [0.145]	-0.280** [0.141]	-0.282** [0.142]	-0.285** [0.143]	-0.287** [0.144]	-0.271* [0.145]	-0.273* [0.146]
Constant	-0.410 [1.003]	-0.404 [1.006]	-0.0744 [1.006]	-0.0641 [1.010]	-0.585 [1.013]	-0.581 [1.014]	-0.0298 [1.048]	-0.0281 [1.049]
Pseudo-R <sup>2</sup>	0.118	0.117	0.121	0.121	0.113	0.113	0.12	0.119
Observations	2,091	2,091	2,091	2,091	2,091	2,091	2,091	2,091

Robust standard errors in brackets. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ . Notes: Benchmark dummy variables are: (1) non-digital adopters; (2) non-innovator; (3) less than 2 years; (4) Profit; (5) subsidiary company; (6) more investment; (7) improvement of business prospects specific to your sector or industry. Dummy identifying the profit, types of barriers, sectoral expectations, sector, country and year dummies are included

tion of firms and this transformation will improve the firm performance and the capacity of being HGEs in the future.

Concerning RQ7 (“Are firms adopting digital technologies more likely to be HGEs?”), our results do not show any significant impact. Several explanations may respond to this fact. First, some of the NDTs are labour-saving or even the specific services may be outsourced. Consequently, in the short-term we may not capture the impact on the rapid employment growth. Second, it can be the case that there is a certain indivisibility of labour. Consequently, the labour tasks of adopting NDTs are absorbed by current employees. Third, despite firms may introduce NDTs, the service may be outsourced to technologies firms. Hence, rapid employment growth may be absorbed by these technological firms instead of the company that adopts it, at least in the short-term. Finally, we must also take into account our data limitation since we have just a cross-section.

Concerning the other control variables, we find that the labour productivity has a negative relationship with being a HGE while firm size has a positive and significant effect. Firms that are HGE have a larger salary and are usually non-subsidiary companies, while those that invested similarly or less were less likely to be HGEs. Finally, firms that are HGE usually perceive obstacles related to employees’ skills.

Despite all the caveats in our database, the results seem to point out that HGEs may be permanent exporters. We must say that firms in the service sectors seem to have a larger probability of being HGEs.

To conclude our results of the trilateral relationship, our preliminary estimation does not show a direct relationship between NDTs and HGEs. However, an indirect effect of NDTs on the HGE probability seems possible. Since there is a positive association between NDTs and internationalisation status, NDTs generate internal capabilities that strengthen the international position of firms in the international markets. Therefore, these internationalised companies with NDTs may have more capacity to become HGEs. As stated previously, our estimations are based on cross-sectional data that might not allow to fully capture the dynamic employment growth potential of NDT.

## 6 Concluding remarks

The phenomenon of HGEs has attracted the attention of policy-makers and scholars. Nevertheless, the phenomena stills needs a deeper analysis to understand the role of different dimensions. First, the geographical dimension still needs a systematic analysis of the relationship between the internationalisation strategy and the consequences in the likelihood of being a HGE. There are studies analysing the HGEs in the context of exporting activity and the multinational activity in foreign markets. However, the evidence is not systematic and is not focused on the interlinkages between both variables. Second, new digital technologies facilitate the emergence of digital companies but more importantly the transformation of non-digitalized firms. This adoption generates new capabilities to improve their competitiveness. Therefore, it is expected that firms adopting new digital technologies have more capacity to internationalise but also to be a HGE.

In this paper we address the triadic relationship between new digital technologies, the internationalisation strategies and the likelihood of becoming a HGE for 27 EU Member States and the United Kingdom, using the EIB Group Survey of Investment and Investment

Finance survey and ORBIS data. First, we identify a “pre-condition” when firms that have experienced high-growth episodes are also internationalised. The idea is that firms growing rapidly will have more incentives to go abroad. Second, we identify a “post-effect” that relates to the effect of internationalisation activities on the probability of being a HGE.

After controlling for sample selection, we show evidence that HGEs are more internationalised, regardless of whether they export or invest directly in foreign markets. Furthermore, we found a higher adoption of NDTs among internationalised firms and those that are HGEs. Moreover, we bring further evidence on the direction of the relationship between the introduction of NDTs, the internationalisation process and the likelihood of being a HGE, by disentangling what we call the “pre-condition” to internationalize and the “post-effect” on the likelihood of being a HGE. Our results highlight three interesting points. First, HGEs are more likely to be active in foreign markets (in particular through FDI). Second, the exporting activity does not show a significant impact on being a HGE. Conversely, FDI activity influences positively the capacity of firms of being HGEs. Clearly, non-internationalised companies are less likely of being HGEs. Finally, the results show that firms which adopt new digital technologies are also more likely to be internationalised. This relationship is more relevant for the exporting activity. Conversely, we do not observe any significant relationship between having adopted NDTs and being a HGE. However, permanent exporters show positive relationships with the likelihood of being a HGE. Therefore, our results seem to point out that new digital technologies are related to HGEs indirectly through the internationalisation process. To sum up, we observe that being a HGE is a “pre-condition” to internationalize while the “post-effect” is partially accepted. We must take into account that HGEs is not a similar concept to high-technological companies. Hence, both typologies of firms may be related but they are different.

Our estimation results provide several policy insights. First, it would be consistent with policies incentivising firms to internationalise (e.g., direct aid for export, export guarantees, tax advantages, cost subsidies) with other policy measures that enhance the competitiveness of firms, including promoting R&D and innovation. Second, our results indicate the importance of addressing obstacles related to the uncertainty about the future, and demand for products and services. To this end, EU policies ensuring stable trends of growth would support the emergence and development of HGEs. Third, the results suggest policies to simultaneously enhance adopting NDTs and facilitating firms to internationalise. Since EU firms lag behind the US in R&D investment and the adoption of digital technologies, policymakers in the EU aiming to close this gap could focus on addressing structural barriers related to investment in digitalisation, remove disincentives to grow, and reduce market fragmentation, particularly in the service sector (Ebeke et al., 2019). Addressing these structural factors is important to increase the adoption of NDTs, the rate of innovation and human capital accumulation that is likely to ultimately increase total factor productivity. Finally, our results suggest potential synergies between digitalisation strategies, sectoral specialisation and the internationalisation strategy leading to rapid growth.

There are some caveats to the analysis. First, we have a rich database with interesting variables related to the firm performance. However, the temporal window is short. Consequently, we are not able to capture medium-term effects. For instance, the investment in NDTs and its impact on employment growth may appear several years later. Clearly, the access to longitudinal database will facilitate the evaluation of the impact. Second, causality is difficult to establish given our data limitations. In particular, the data related to the adoption of new digital technologies is available only at one point in time. The coarsened exact model and the lagged variables are supposed to mitigate this problem. Third, our definition of “being digitalised” is very wide. The partial adoption of NDTs in the firm

may be strategically well-developed and have a large impact on the firm. Conversely, firms may answer as they have introduced partially NDTs which may have a superficial capacity of transformation of the company. These differences are not captured with our information. Forth, HGEs are not the same as unicorns. HGEs include a larger sample of firms that may not be technologically advanced. However, to distinguish both typologies we would require more disaggregated sectoral information. Finally, we ignore other relevant information to disentangle the effects of the internationalisation activity. For instance, we have just the status (whether a firm exports or invests in FDI) but not quantitative information (number of markets where the firm is active or share of exports over total sales). This is important to determine the returns from different international markets.

Finally, our study highlights some interesting paths for the future research agenda in HGE. First, our measure of HGE is in terms of employment. Some NDTs are labour-saving and, consequently, we may not capture the potential that they may have in terms of sales or assets. Second, another future research line should pay more attention to the interaction of some key variables such as the intangible assets. The transformation generated by new technologies impact over the nature of the capital, the productive methods, humans and logistic procedures, mechanical techniques, among others firm's areas. The current technological revolution driven by NDTs entails a radical change in the nature of capital and the strategic role of intangible resources. However, the absorption of NDTs requires that, at individual and aggregate level, European firms can adapt new technologies through the development of adequate capabilities to improve their competitive advantages in their markets. Third, at firm level, the adoption of NDTs promotes productivity, in the short and long term. Conversely, firms with a high productivity level will be able to invest and adopt the new technologies. Future research lines can analyse the recursive links between NDTs and productivity and their incidence on the capacity of firms to become HGEs. Forth, our results show strong sectoral differences on the probability of becoming a HGE. We may expect that the internationalisation strategy of service firms is different from manufacturing firms. Similarly, we may expect differences on the adoption of NDTs and their capacity to capture economic returns and grow. A final research line may be devoted to differences according to firm size. On the one hand, larger firms have higher rates of digital adoption than their smaller peers, and digital firms have better management practices and show more dynamism (Revoltella et al., 2020). On the other hand, small firms may benefit more from diminishing trade costs (Melitz, 2003). Hence, the distinction between small and large firms may be relevant in order to analyse the barriers that EU firms have to reduce the technological gap with USA.

## Appendix 1: Main statistics

See Tables 9, 10, and 11.

**Table 9** Number of firms and number of observations in EIBIS

Countries	Number of firms	Waves				Observations
		2016	2017	2018	2019	
Austria	1449	477	479	477	483	1916
Belgium	1365	480	475	476	486	1917
Bulgaria	1178	476	475	476	481	1908
Croatia	1227	487	536	490	480	1993
Cyprus	418	150	150	150	180	630
Czech Republic	1408	479	416	401	482	1778
Denmark	1157	476	428	425	481	1810
Estonia	1104	400	408	401	405	1614
Finland	1217	477	480	476	487	1920
France	1772	602	600	603	602	2407
Germany	1824	605	601	601	601	2408
Greece	1145	425	461	460	403	1749
Hungary	1342	476	475	475	480	1906
Ireland	891	400	400	400	405	1605
Italy	1310	622	600	602	600	2424
Latvia	1117	400	401	394	389	1584
Lithuania	1246	407	400	400	413	1620
Luxembourg	461	150	177	150	198	675
Malta	370	160	178	170	182	690
Netherlands	1358	506	475	477	491	1949
Poland	1354	479	476	473	486	1914
Portugal	1211	480	535	535	484	2034
Romania	1456	476	475	474	482	1907
Slovakia	1211	385	286	400	400	1471
Slovenia	963	416	400	413	401	1630
Spain	1337	515	475	478	601	2069
Sweden	1334	476	476	476	488	1916
United Kingdom	1493	601	600	602	601	2404
USA	803				803	803
Total	34,521	12,483	12,338	12,355	13,475	50,651

**Table 10** Number of observations in the merged EIBIS-Orbis dataset

Survey year	Financial year	EIBIS only	Both EIBIS and ORBIS	Total EIBIS	ORBIS only
	2013				28,721
	2014				30,070
2016	2015	1479	11,004	12,483	19,185
2017	2016	1419	10,919	12,338	19,421
2018	2017	1779	10,576	12,355	18,020
2019	2018	9306	4169	13,475	6356
		13,983	36,668	50,651	62,982

**Table 11** Variables statistics

Variables	Observations	Mean	SD	p10	p50	p90
Sales growth	109,513	0.05	0.21	-0.21	0.04	0.34
Employment growth	104,242	0.02	0.14	-0.15	0.00	0.22
Profit growth	85,953	0.07	0.55	-0.67	0.06	0.82
Value added growth	65,278	0.04	0.35	-0.43	0.04	0.49
Investment growth	84,022	-0.01	0.41	-0.52	0.00	0.47
Employment size	50,651	295.4	4288.4	7.0	39.0	398.0
Labour productivity	40,536	10.16	1.02	8.86	10.24	11.29
Salary/sales	32,477	0.27	0.32	0.06	0.21	0.50
Log sales	40,945	15.50	2.10	12.97	15.38	18.20
Dummy: high growth	47,777	0.1028	0.3037	0	0	1
Dummy: subsidiary	50,644	0.7406	0.4383	0	1	1
Dummy: Exporter	50,432	0.4556	0.498	0	0	1
Dummy: FDI	50,432	0.0714	0.2575	0	0	0

When firms' growth is measured over one year, the log-difference is the preferred way to calculate a growth rate (Coad, 2009; Törnqvist et al., 1985). Growth of  $X$ , where  $X \in \{Sales, Employment, Profit, ValueAdded\}$ , for firm  $i$  at time  $t$ , is calculated as  $GR_{X_{i,t}} = \log(X_{i,t}) - \log(X_{i,t-1})$ .



## Appendix 2: HGEs and the internationalisation activity at country level

See Tables 12 and 13.

**Table 12** Exporting status for HGEs and non- HGEs at country level. (%). *Source:* own elaboration from EIBIS

	Non-HGE				HGE			
	Never	Permanent	Entrant	Exiters	Never	Permanent	Entrant	Exiters
Austria	29.01	52.49	9.67	8.84	18.6	58.14	6.98	16.28
Belgium	41.23	43.51	8.66	6.61	26	58	10	6
Bulgaria	54.15	32.21	6.72	6.92	43.82	41.57	10.11	4.49
Croatia	44.21	47.19	3.51	5.09	32.5	58.75	5	3.75
Cyprus	71.95	18.29	3.66	6.1	70	15	10	5
Czech Republic	31.27	59.28	4.56	4.89	31.58	47.37	10.53	10.53
Denmark	39.5	47.71	7.25	5.53	43.84	45.21	5.48	5.48
Estonia	36.62	47.27	6.75	9.35	16.67	73.33	3.33	6.67
Finland	52.86	37.32	4.75	5.07	49.09	41.82	3.64	5.45
France	58.27	30.77	4.62	6.35	57.45	31.91	4.26	6.38
Germany	53.37	33.33	6.34	6.95	33.33	51.28	0	15.38
Greece	43.76	39.6	8.91	7.72	37.7	39.34	8.2	14.75
Hungary	51.46	37.53	4.27	6.74	28.85	51.92	11.54	7.69
Ireland	51.76	35.99	6.12	6.12	32.74	51.33	8.85	7.08
Italy	58.01	32.87	4.45	4.67	41.67	44.05	7.14	7.14
Latvia	41.39	48.04	3.63	6.95	30.56	55.56	8.33	5.56
Lithuania	45.04	44.68	3.55	6.74	26.92	65.38	7.69	0
Luxembourg	30.06	53.99	8.59	7.36	25	62.5	8.33	4.17
Malta	59.26	24.28	8.23	8.23	44.44	33.33	18.52	3.7
Netherlands	38.48	48.26	8.04	5.22	34.29	58.57	1.43	5.71
Poland	54.21	38.5	3.42	3.87	32.5	60	2.5	5
Portugal	45.15	43.82	5.15	5.88	32.94	52.94	7.06	7.06
Romania	62.08	26.91	5.81	5.2	47.62	47.62	2.38	2.38
Slovakia	39.02	37.56	7.8	15.61	44.44	44.44	11.11	0
Slovenia	38.63	49.72	6.1	5.55	31.48	59.26	3.7	5.56
Spain	42.73	45.5	5.71	6.06	37.66	54.55	3.9	3.9
Sweden	50.32	41.51	4.52	3.66	47.27	43.64	5.45	3.64
United Kingdom	60.26	30.92	4.48	4.34	62.96	28.7	6.48	1.85

**Table 13** FDI status for HGEs and non-HGEs at country level (%). *Source:* own elaboration from EIBIS

	Non-HGE				HGE			
	Never	Permanent	Entrant	Exiter	Never	Permanent	Entrant	Exiter
Austria	78.73	9.12	6.63	5.52	55.81	18.6	6.98	18.6
Belgium	85.42	4.33	4.78	5.47	76	12	10	2
Bulgaria	98.42	0.2	0.59	0.79	98.88	0	0	1.12
Croatia	97.37	0.53	1.4	0.7	88.75	1.25	2.5	7.5
Cyprus	97.56	0	0.61	1.83	85	15	0	0
Czech Republic	93.81	2.93	1.3	1.95	100	0	0	0
Denmark	76.34	12.6	5.53	5.53	71.23	13.7	4.11	10.96
Estonia	96.36	0.52	1.56	1.56	93.33	0	0	6.67
Finland	87.89	7.2	2.45	2.45	63.64	21.82	9.09	5.45
France	93.46	1.15	2.5	2.88	89.36	8.51	0	2.13
Germany	88.55	3.89	3.68	3.89	84.62	2.56	5.13	7.69
Greece	91.09	1.78	2.77	4.36	88.52	1.64	8.2	1.64
Hungary	95.06	0.67	2.02	2.25	92.31	0	5.77	1.92
Ireland	87.94	4.08	3.9	4.08	80.53	7.96	7.96	3.54
Italy	87.8	5.09	3.39	3.71	78.57	9.52	3.57	8.33
Latvia	96.98	2.11	0	0.91	91.67	5.56	0	2.78
Lithuania	94.33	2.13	1.77	1.77	84.62	0	7.69	7.69
Luxembourg	81.6	4.29	6.75	7.36	66.67	8.33	16.67	8.33
Malta	95.47	1.65	1.65	1.23	100	0	0	0
Netherlands	83.7	6.52	4.78	5	67.14	10	11.43	11.43
Poland	95.9	1.37	1.37	1.37	92.5	5	2.5	0
Portugal	89.12	3.24	4.26	3.38	82.35	8.24	3.53	5.88
Romania	97.55	0.31	1.83	0.31	97.62	0	0	2.38
Slovakia	93.66	1.46	0	4.88	100	0	0	0
Slovenia	96.49	0.74	1.85	0.92	92.59	3.7	0	3.7
Spain	84.43	6.75	4.15	4.67	74.03	6.49	9.09	10.39
Sweden	88.17	4.3	4.52	3.01	76.36	14.55	3.64	5.45
United Kingdom	90.75	2.75	3.18	3.32	88.89	2.78	2.78	5.56

### Appendix 3: HGEs and the innovation activity at country level

See Fig. 5.

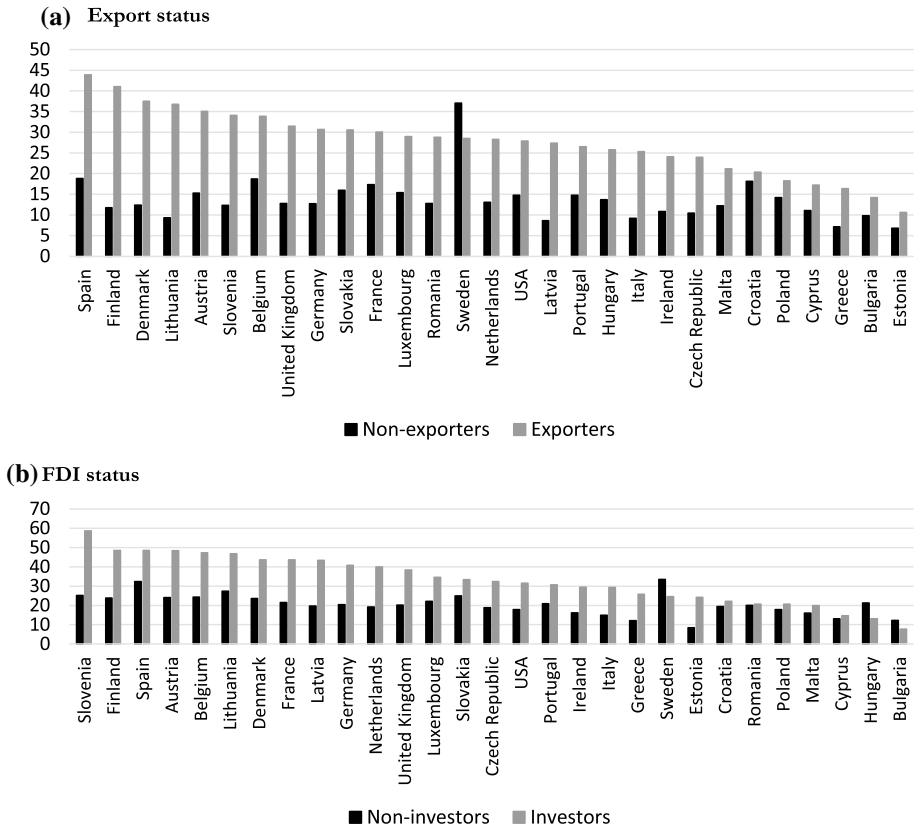
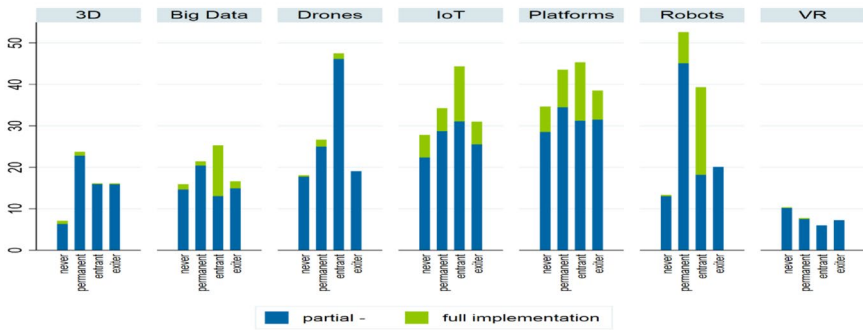


Fig. 5 Share of firms that declare to introduce innovations new to the world (%). Source: own elaboration from EIBIS

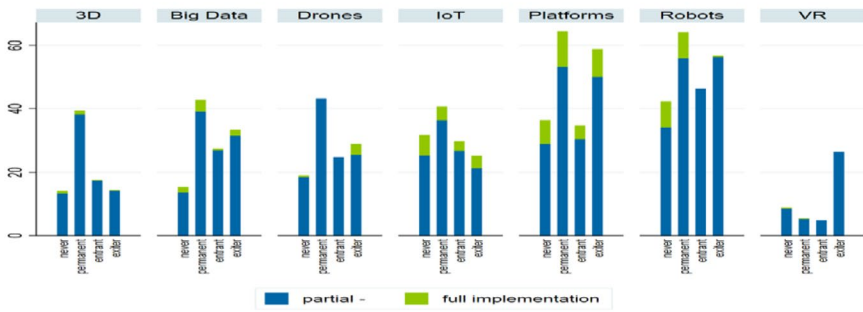
### Appendix 4: Adoption of new digital technologies

See Fig. 6.

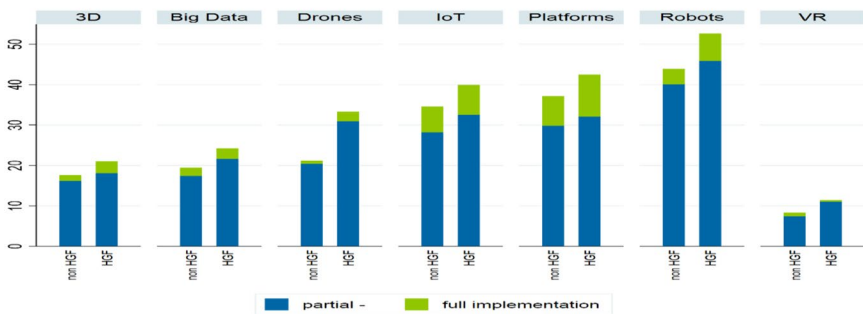
(a) Export status



(b) FDI status



(c) HGE status



**Fig. 6** Share of firms that declare to implement NDTs according to the internationalisation status and HGE status. *Source:* own elaboration from EIBIS wave 2019. A firm is identified as ‘partially digital’ if at least one digital technology was implemented in parts of the business, and ‘fully digital’ if the entire business is organised around at least one digital technology. Firms are weighted using value added

## Appendix 5: Econometric appendix

See Tables 14 and 15.

**Table 14** Multivariate distance with CEM methodology. *Source:* own elaboration from EIB and ORBIS

	Multivariate distance with CEM	All respondents Mean	Matched respondents Mean
More than 20 years	$5.3 \times 10^{-15}$	0.5955	0.6313
Sales	0.0133	$3.4 \times 10^{-8}$	$1.4 \times 10^{-8}$
Salary	0.1228	1.6863	0.4951
Non-innovative firm	$4.8 \times 10^{-15}$	0.6133	0.6174
Innovation new to the firm	$5.1 \times 10^{-14}$	0.2605	0.2649
Innovation new to the market	$1.8 \times 10^{-15}$	0.0582	0.0527
Index production	0.132	0.9813	0.9771
Manufacturing	$3.4 \times 10^{-15}$	0.2874	0.2971
Construction	$2.0 \times 10^{-15}$	0.2183	0.2081
Services	$2.7 \times 10^{-15}$	0.2555	0.2463
Leather countries	$4.6 \times 10^{-15}$	0.3985	0.3796
Multivariate L1 distance:	0.5357		
Number of observations		50,432 (23,571 internat. vs 26,861 non-internat.)	50,112 (23,359 internat. vs 26,753 non-internat.)

**Table 15** Description of variables

Name	Description
<b>Digitalization</b>	
HGE	Dummy equal to 1 if the firm is a HGE
<i>digital_adopt</i>	Dummy equal to 1 if the firm is an adopter of digital technologies
<i>partialAdopt</i>	Dummy equal to 1 if the firm has adopted partially digital technologies
<i>totalAdopt</i>	Dummy equal to 1 if the firm has adopted totally digital technologies
<b>Internationalisation</b>	
<i>LabProd</i>	Value added per employee (in logs)
<i>Entrant</i>	Dummy equal to 1 if the firm enters in the foreign markets (export or FDI) in the current period, but it was not operating in the previous year
<i>Exiter</i>	Dummy equal to 1 if the firm exits from the foreign markets (export or FDI) in the current period, but it was operating in the previous year
<i>Permanent</i>	Dummy equal to 1 if the firm operates in the foreign markets (export or FDI) in the current period and it was operating in the previous year
<b>Firm characteristics</b>	
<i>From 2 to 5 years, From 5 to 10 years, From 10 to 20 years, More than 20 years</i>	Dummy equal to 1 if the firm operates from 2 to 5 years, from 5 to 10 years, from 10 to 20 years and more than 20 years (reference = less than 2 years)
<i>Sales</i>	Turnover of the company (in logs)
<i>Growth expectations</i>	Growth expectations due to firm's investment
<b>Innovation</b>	
<i>Innovation firm, Innovation market, Innovation world</i>	Dummy equal to one if the firm has developed an innovation new to the firm, to the market or to the world, respectively (reference = non-innovator)
<i>R&amp;D investment</i>	Share of total R&D investment
<i>Machinery state-of-the-art</i>	Share of new developed machinery and equipment
<b>Sectors</b>	
<i>Services, Construction, Infrastructure</i>	Dummy equal to one if the firm belongs to service sector, construction or infrastructure (reference = manufactures)
<b>Other firm's performance characteristics</b>	
<i>Loss, Break even</i>	Dummy variable if the firm declares to have a lost or break even income, respectively (reference = profits)
<i>Salary</i>	Ratio of wages over turnover (in logs)
<i>Non-subsidiary company</i>	Dummy variable if the firm is not a subsidiary of another firm
<i>Similar investment</i>	Dummy variable if the firm declares that a similar or less amount of investment compare to previous year, respectively (reference = more investment)
<i>Similar sector expectations, less sector expectations</i>	Dummy variable that indicates if the firm perceives similar or less sector expectations for the next year (reference = higher expectations)

**Table 15** (continued)

Name	Description
Country dummies	
Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, UK	Dummy variables identifying the country (reference = Austria)
Time dummies	
Year 2017, Year 2018	Time dummies (reference = Year 2019)
Obstacles	Dummy variable if the firm perceives major obstacles of
Obs. demand	Demand for products or services
Obs. skills	Availability of staff with right skills
Obs. costs	Energy costs
Obs. digital infrast	Access to digital infrastructure
Obs. Labour market	Labour market regulations
Obs. business regulations and tax	Business regulations and taxation
Obs. transport	Availability of adequate transport infrastructure
Obs. finance	Availability of financial resources
Obs. uncertainty	Uncertainty about the future

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### Declarations

**Conflict of interest** The authors declare they not have any conflict of interest.

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