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Exploring the contribution of micro firms to innovation: does competition matter?

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Abstract With a special focus on firms with fewer than 10 employees, we examine how small businesses participate in innovation and how perceived competition affects their innovative behavior. Statistics from a large sample of European micro-, small-, and medium-sized enterprises document a relevant share of innovative firms, including micro ones. We empirically explore the relationship between competition and the likelihood of being innovative, the degree of complexity of the innovation strategy, and its frequency. Estimates provide evidence of an inverted-U-shaped relationship, whereby innovation initially increases with competition and then it slightly declines. The results hold for all firms, regardless of their size, but the negative effect seems to be more marked for smaller firms. Competition shows a stronger relationship with technical and external innovation. By including micro firms, this paper contributes to the understanding of innovative patterns and activities in firms of all size.

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Plain English Summary Are micro firms marginal players in innovation? It seems not. Exploring a large sample of small European businesses, we find a non-negligible share of innovative firms with fewer than 10 employees. How does competition affect their innovative behavior? We find that as competition increases, innovation also increases if the initial level of competition is low, but innovation declines if the initial level of competition is high. The results hold for all firms regardless of size. Our findings have two important implications for research and policy. First, micro firms must be considered as significant players in innovation and more comprehensive innovation data should be collected from them. Second, competition fosters small businesses' innovation, but excessive competition can hamper it. Thus, policies aimed at promoting well-balanced competitive markets are crucial if micro firms are to exploit their full innovation potential.

Keywords Innovation · Competition · Micro firms · EU economy

JEL Classification L10 · L26 · O30 · O52

1 Introduction

Since Schumpeter (1942), the question of how firm size and market structure affect innovation has drawn the attention of many economists. The main

Schumpeterian tenet states that large firms operating in a concentrated market are the main engine of technological progress. Initially such belief drove ever greater attention to the innovative behavior of large firms. Indeed, prior to the early 1970s, only a relatively low share of innovation activities was associated with small firms (Pavitt et al., 1987). A stronger interest on smaller businesses emerged after the influential works of Acs and Audretsch (1987, 1988) and Pavitt et al. (1987), who illustrate the significant role played by smaller enterprises in specific sectors of the UK and the USA, respectively. Nevertheless, micro firms with fewer than 10 employees are still an understudied category and are often assumed to be marginal businesses with no innovation capacity (Baumann and Kritikos, 2016). Very little is known about their innovative behavior and their innovation drivers (Tu et al., 2014; Roper & Hewitt-Dundas, 2017; Audretsch et al., 2020; Henley & Song, 2020). This is particularly true in Europe, due to the scarcity of comprehensive innovation data on micro firms.[1] For that reason, an overall outlook of the innovation activities of European micro, small, and medium enterprises (MSMEs) is still missing in the literature. Moreover, the literature regarding the relationship between market structures and firm innovation is mainly focused on large companies. To the best of our knowledge, studies about the effect of competition on microbusinesses' innovative behavior are completely missing. In this regard, we ask whether the evidence acknowledged for larger companies and SMEs are valid also for the substantial population of micro firms. Enterprises with less than 10 employees are considered to be the backbone of the EU-28 economy, being the 93 percent of all firms in the non-financial business sector (European Commission, 2019). Thus, having a deeper understanding of microbusinesses' innovative activity is crucial to test the generality of the findings confirmed for the population of larger companies. Moreover, this would help not only small businesses' owners to improve their performance, but also policy makers to promote the growth and the development of the whole economic system.

The aim of this paper is twofold. First, we want to investigate whether micro firms with fewer than 10 employees, together with larger SMEs, contribute to the creation of innovation within the EU economy and, if yes, how. Secondly, we want to explore how competition affects their innovative activity. To do this, we rely on the Survey on the Access to Finance of Enterprises (SAFE), a jointly run survey by the European Commission (EC) and the European Central Bank (ECB). It collects a large sample of firm-level data from all the EU countries, including a significant share of firms with fewer than 10 employees. Although innovation and competition are not the core issues of the survey, useful information is collected. To the best of our knowledge, SAFE is the only database that, together with small (10–49 employees) and medium (50–249 employees) ones, includes firm-level data on innovation and competition also on a large sample of micro (1–9 employees) enterprises across all the EU countries.

The first part of the paper provides descriptive statistics about the innovation activity of European small businesses, including micro firms. In the second part, we develop an empirical analysis to study how competition affects such activity. We do not limit based on the firms' innovation status (whether they innovate or not), rather we focus on the different categories of innovation (technical, non-technical, external, and internal), on the complexity of the innovation strategy (the number of innovation types introduced), and on the frequency of innovation (the number of years a firm has been innovative). The estimates show an inverted-U-shaped relationship, whereby European MSMEs' innovation activity initially increases and then declines slightly with competition. The results hold for all firms, regardless of their size.

The rest of the paper is organized as follows. The next section highlights the related literature and the main contributions of the paper. Section 3 describes the data and the constructions of our main variables of interest. Section 4 provides sample descriptive statistics aimed at exploring the main characteristics of the European MSMEs' innovation activity. Section 5 develops the empirical analysis to investigate the effect of competition on innovation and discusses the main results. Section 6 contains two complementary analyses on the complexity and the frequency of innovation. Section 7 concludes the paper.

[1]For instance, the Community Innovation Survey (CIS) excludes companies with fewer than 10 employees.

2 Related literature and contributions

This paper contributes to two strands of the literature: the nascent one about the innovative activity of micro firms and the more advanced one about the relationship between market structure and innovation. In the 2010s, the availability of new data on microbusinesses is facilitating progresses in the understanding of their innovative behavior. Baumann and Kritikos (2016), for instance, analyze the link between R&D, innovation and productivity in micro-, small-, and medium-sized enterprises in the German manufacturing sector. They find that around 50% of German micro firms engage in innovation activities, below the share of larger SMEs as expected in theory, but far above zero. Similarly, Audretsch et al. (2020) find that German micro firms in knowledge intensive sectors are willing to engage with similar probabilities in innovation activities as larger firms and that they have a similar ability of transforming innovation inputs into innovation output. Roper and Hewitt-Dundas (2017) add to this literature using data from a survey of 1000 microbusinesses in Northern Ireland. Their findings underline the significant role of these firms as sources of new-to-the-market innovation and the potential value of including them in future innovation studies. Finally, Henley and Song (2020) use British microbusinesses survey data to explore the link between innovation, productivity, and exporting activities in firms with fewer than 10 employees. Again, a non-negligible innovative activity of these firms emerges. Despite limitations, these works suggest that micro enterprises should not be considered marginal: although smaller than that of larger companies, their contribution to innovation might be significant. Nevertheless, the aforementioned studies focus on single countries and the samples of micro firms are consequently limited. Moreover, none explore the role of competition. Thus, our paper offers a primary and overall overview of the EU micro firms' innovation activity and the link with competition. In industries with many firms, small enterprises often seek the protection of a market niche of little or no interest to the larger companies (Cooper et al., 1986). This might lead to the belief that the pressure of competition and its impact on innovation are weak for small firms. In our sample, the existence of a potential "niche effect" is suggested by the fact that the average level of perceived competition increases with firm size. Nevertheless, we show that the relationship between competition and innovation also matters for very small businesses.

Studies on the relationship between market structure and innovation are more advanced. A great effort has been made to shed light on this issue, but a consensus is not yet reached. The three dominant theories are originally attributable to Schumpeter (1942), Arrow (1962) and Scherer (1967). The first theorizes a monotone negative relationship, whereby an increase in the level of competition diminishes the incentive to innovate: the higher the number of competitors, the lower the appropriability of the innovation and, consequently, the incentive to innovate. On the contrary, Arrow proposes a monotone positive relationship by showing that the incentive to invest in innovation is lower under monopolistic conditions than under competitive ones: being innovative helps the enterprises to escape competition and gain competitive advantages. To Scherer can be attributed the first evidence of a non-linear and concave relationship between competition and innovation. Until the beginning of the 2000s, the debate mainly played around the Schumpterian and Arrowian views, leaving Scherer as a marginal consideration. Indeed, the literature strongly focused on providing theoretical backgrounds and empirical evidence supporting the first (Dasgupta and Stiglitz, 1980; Spence, 1984; Kraft, 1989; Romer, 1990;, Aghion & Howitt, 1992; Vives, 2008; Hashmi, 2013) and the second (Porter, 1990; Geroski, 1990; Geroski & et al., 1995; Nickell, 1996; Blundell et al., 1999; Galdon-Sanchez & Schmitz, 2002) positions. Kamien and Schwartz (1976) were the only ones who followed Scherer by providing a theoretical model to address the empirical finding that innovative activity increases with the intensity of rivalry up to a point, then declines thereafter as the competitiveness of the industry further increases. The seminal paper of Aghion et al. (2005) returns the findings of Scherer to the fore. Building a step-by-step innovation model, they theorize an inverted-U relationship between product market competition and innovation, where the *escape competition* (or *Arrowian*) and the *Schumpeterian effects* coexist. Their main prediction is that rising competition has a positive impact on innovation effort when the initial degree of competition is low (i.e., when a larger equilibrium fraction of sectors involves neck-and-neck competing incumbents) and negative when the initial level is high (i.e., when a larger fraction of sectors in equilibrium counts a large share of laggard firms with low initial profits).

The findings of Aghion et al. (2005) led researchers to investigate the relationship between competition and innovation from a new perspective and empirical studies aimed at testing such inverted-U curve grew substantially. Askenazy et al. (2013) and Mulkay (2019), for instance, do this for French firms. The former finds clear evidence of an inverted-U for largest firms, but such evidence does not occur when the sample is extended to smaller ones. The latter, considering a sample of both large and small firms over the 2000–2013 period, does not find econometric evidence of the inverted-U-shaped relationship. Tingvall and Poldhal (2006), using a sample of manufacturing Swedish firms with a minimum of 50 employees, show that the inverted-U curve is supported by the Herfindahl index and not by the price cost margin indicator, suggesting that the results are sensitive with respect to the choice of the measure of competition. Hashmi (2013), replicating Aghion et al. (2005) using a richer dataset from publicly listed manufacturing firms in the USA, finds a mildly negative relationship among competition and innovation. He argues that such a result might be driven by the fact that US firms are less neck-and-neck, inducing the Schumpeterian effect to dominate the escape-competition one. Castellacci (2011) argues that competition may have different impacts on the various stages of the innovation chain, with the Schumpeterian effect prevailing in early innovation stages and the escape-competition effect in the late ones. An inverted-U relationship is instead detected by Peneder and Wörter (2014) and Halpern and Muraközy (2015), respectively, for Swiss and Hungarian firms. Friesenbichler and Peneder (2016) and Crowley and Jordan (2017) also find a quadratic effect using a sample of firms from Eastern Europe and Central Asia. Moen et al. (2018) do the same for Norwegian SMEs, but their results do not provide strong evidence of an inverted-U relationship. Subsequently, Cornett et al. (2019) find an overall U-shaped relation between industry concentration (inversely related with competition) and innovation for a large set of US firms.

A general consensus on the impact of competition on innovation is not yet reached. We contribute to the current debate by providing evidence of an inverted-U-shaped relationship for the surveyed firms. Our findings seem then to support the theories proposed by Scherer and Aghion. Moreover, while analyses on large companies are more common, those about smaller enterprises are rarer and, as far as we know, completely missing for micro firms. Our paper also extends the existing literature by developing a cross-country analysis, rather than single-country ones. In this regard, given the EU single-market structure, we find it valuable to focus on a sample including MSMEs of all the 28 EU countries. To the best of our knowledge, the only others linking competition and innovation in a cross-country framework are Ayyagari et al. (2011), who do not check for quadratic effects, Karaman and Lahiri (2014), Friesenbichler and Peneder (2016) and Crowley and Jordan (2017), who focus on developing countries in Eastern Europe and Central Asia. However, a large sample of European MSMEs is still unexplored. We also contribute by exploring the effect of competition not only on the innovation intensive and extensive margins, but also on the complexity and the different types of firms' innovation strategy. Finally, we add to recent studies using perception-based measures of competition rather than structural indicators based on firms' financial statistics. The main traditional indices of competition normally refer to market concentration, like the Herfindahl-Hirschman Index (HHI), or to firms' market power, such as the Lerner Index (LI). The HHI has a sectoral dimension and it does not allow to measure competition at the firm level. In addition, the HHI normally stresses the importance of larger firms by assigning them a greater weight than smaller ones (OECD, 2021). Using this indicator in a sample of MSMEs might then be misleading. The LI, computed as the difference between price and marginal cost over price, can be firm's specific. However, the fact that marginal costs are not directly observable introduces some difficulties in the computation and the empirical estimation of the LI (OECD, 2021). Moreover, firms' innovation strategy, and particularly that of small businesses, is not always based on account data only (Acs & Audretsch, 2005). The critical role of managerial perceptions in organizational decision-making and strategy formulation processes has long been acknowledged (Anderson & Paine, 1975; Beyer et al., 1997). That is also why, along with these traditional indicators of competition, in recent years alternative and complementary measures based on survey data and self-perception have been proposed (Tang, 2006; Peneder & Wörter, 2014; Friesenbichler & Peneder, 2016; Crowley & Jordan, 2017; Moen et al., 2018). Although the subjective nature of these perception-based indicators might raise measurement issues, the main argument in favor of their use is that they allow to better capture firm-specific competition and to account for the fact that firms in the same sector may perceive competition differently. They also better include rivalry from both domestic and international competitors.

In light of these arguments, the use of a perception-based competition indicator looks particularly suitable for our context.

3 Data and variables definitions

We rely on the firm-level Survey on the Access to Finance of Enterprises (SAFE). It is an ongoing survey conducted jointly by the European Commission (EC) and the European Central Bank (ECB) every six months since 2009. As far as we know, it is the only database containing information on innovation and competition for a large number of micro-sized (1–9 employees), small-sized (10–49 employees), and medium-sized (50–249) enterprises across all the EU countries. The survey waves conducted by the ECB (ECB round) cover a limited number of euro area countries, while the more comprehensive survey, run in cooperation with the EC (Common round), covers all EU countries. The ECB round is conducted in April and the Common round in October of each year. The interviewed firms are randomly selected from the Dun and Bradstreet database and the sample is stratified by firm size class, economic activity, and country. The replies are voluntary and the interviews are predominantly conducted by telephone, but respondents are given the opportunity to fill in the online questionnaire. A top-level executive (general manager, financial director or chief accountant) is interviewed from each company and the questionnaire is administered in the local language. Sample replies are anonymous and statistical disclosure procedure is applied to preserve the anonymity in the micro dataset. The sample is developed to offer comparable precision for micro, small, and medium-sized companies. Concerning the economic activity, firms are grouped into four main sectors: industry, construction, trade, and services. Enterprises in the financial, agricultural, and public administration sectors are not included in the sample.[2]

For our analysis, we select micro, small, and medium-sized enterprises of the 28 EU countries interviewed in the five Common round waves between 2014 and 2018.[3] The time horizon is driven by the fact that we want to keep the structure of the sample as stable as possible and because the questionnaire was significantly changed in 2014. The final repeated cross section sample includes 75,673 firm-level observations. Table 10 in the Appendix shows the total number of observations and the number of micro, small, and medium firms in each country. The most represented countries are Italy (6,994), France (6,509), Germany (6,375), Spain (5,959), and Poland (5,827). It is worth highlighting the remarkable share of micro firms included in the sample. The coverage of a large sample of MSMEs for all the 28 EU countries represents a relevant novelty of our dataset.

As the name suggests, the main objective of the SAFE is to collect detailed information about the conditions of access to finance for European small businesses. Therefore, as innovation and competition are not the core issues of the questionnaire and the number of questions on these topics is limited, we are somewhat constrained. However, to the best of our knowledge, we are not aware of other datasets including such a large sample of micro enterprises and firm-level information on innovation and competition for all EU countries. In this regard, expanding the SAFE with additional questions would be helpful to further investigations. Despite this limitation, we consider the available information a valuable starting point.

Measuring innovation We use the following SAFE question to measure whether firms are innovative or not: “During the past 12 months have you introduced:

[2]For a deeper overview of the methodological information on the survey see https://www.ecb.europa.eu/stats/ecb_surveys/safe/html/index.en.html.

[3]Wave 11 (reference period April–September 2014), wave 13 (reference period April–September 2015), wave 15 (reference period April-September 2016), wave 17 (reference period April–September 2017), and wave 19 (reference period April–September 2018). We include the UK since it was still part of the EU during this period.

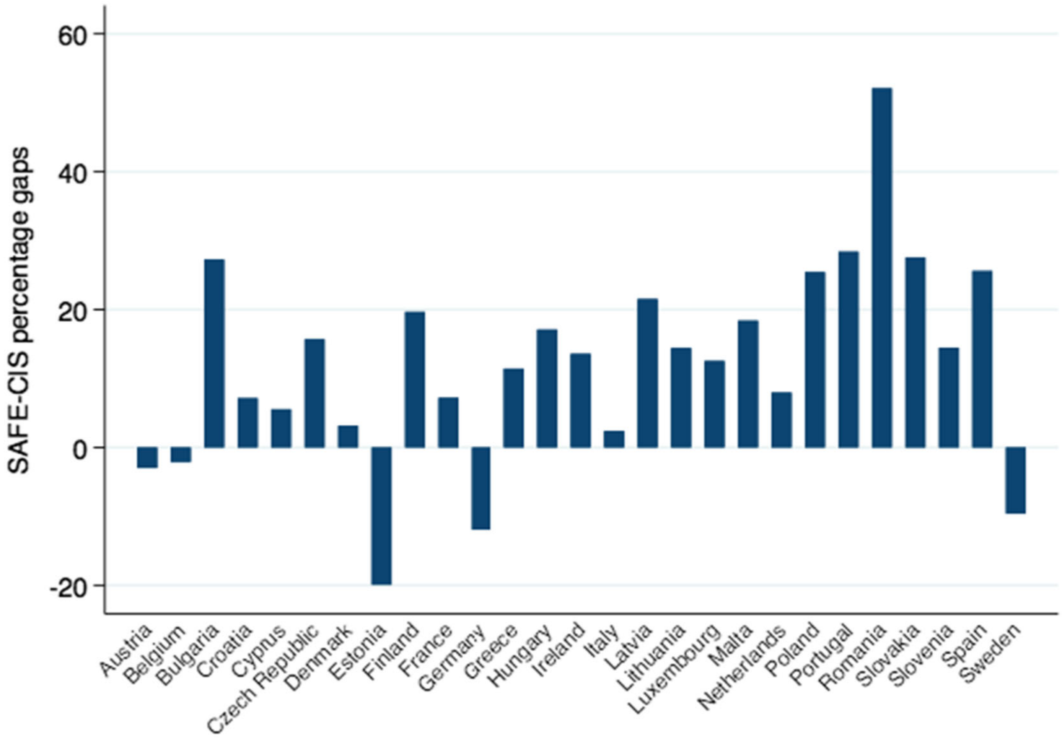


Fig. 1 SAFE-CIS percentage gaps. Notes: Authors' calculations on SAFE (2016–2018) and CIS (2018). The figure reports the differences between the countries percentage of innovative firms resulting from the two surveys. Only firms with at least 10 employees are considered

a) a new or significantly improved product or service to the market; b) a new or significantly improved production process or method; c) a new organization of management; or d) a new way of selling goods or services?" Following a similar approach to Mairesse and Mohnen (2010), Ferrando et al. (2019), Ferrando et al. (2020) and Santos and Cincera (2021), we define as innovative those firms that answer "Yes" for at least one of the four options.[4] We also consider separate dummies to disentangle the four types of innovation (product, process, organization, and marketing innovation). This allows us to measure not only whether a firm innovates or not, but also how. Thus, we focus on the output side of the innovation process. Existing literature points out that smaller firms might often report innovation without formal R&D engagement or under-report R&D activities (Pavitt et al., 1987; Symeonidis, 1996; Baumann & Kritikos, 2016). Relying on R&D investments might then lead to under-estimate the number of innovative MSMEs (Acs & Audretsch, 2005). Another advantage is that the survey question under consideration allows to disentangle the different types of innovation. Along with these pros, our measure shows some limitations. First, it only provides information on the extensive margin (whether the firm innovates or not) but not on the intensive margin (how much the firm innovates). It is not then possible to measure the degree of innovation embedded in products or processes that firms have developed. Second, the decision to report an innovation stays completely with the surveyed firms, which can intentionally misreport their answers (Siepel & Dejardin, 2020). This caveat should be taken into account, even though, given the anonymity of respondents, there are no reason to think that firms might falsely respond to the question either to overstate or to downstate their innovation capacity. For the sake of comparison, we select from the CIS 2018 results reported in Eurostat the

[4]These options correspond to the four types of innovations defined by the Oslo Manual (OECD, 2018).

country percentages of firms with innovation activities.[5] In Fig. 1, we plot the differences between the SAFE country percentages of innovative firms and the CIS ones.[6] Overall, SAFE seems to over-estimate firms' innovative activity, particularly for Romania. However, Table 11 in the Appendix, reporting the correlations coefficients between the SAFE and CIS percentages, shows that, despite the over-estimation, the two measures are positively and significantly correlated.[7]

Measuring Competition To measure the level of competition, we rely on the following question: "How important has the problem of competition been for your enterprise in the past six months?" Surveyed firms can answer on a scale of 1–10, where 1 means "not at all important" and 10 means "it is extremely important." This is the only information about competition that we can access and, as before, it implies pros and cons. First, competition here is very broadly defined, with no distinction among *ex ante*/*ex post* or product/credit market competition. Firms might then interpret the question differently and refer to different types of competition. Moreover, we do not have information on the number of competitors, even though we find it reasonable to assume that the pressing problem of competition increases with the number of competitors. On the one hand, we are then aware that our continuous variable is only an imperfect proxy for the intensity of competition and that its subjective nature may add some noise to the data. On the other hand, as anticipated in Section 2, using subjective measures rather than industry indicators provides some advantages (Tang, 2006; Peneder & Wörter, 2014; Friesenbichler & Peneder, 2016; Crowley & Jordan, 2017). First, perception-based measures can more properly capture firm-specific competition. This accounts for the fact that firms in the same industry might actually produce different products and compete in different markets. Even considering narrow industry classifications, relevant markets are typically further segmented. In this case, firm-specific competition may not be correctly detected by the traditional industry measure. Second, despite being in the same sector, firms may have different perceptions regarding the degree of competition they face. In this respect, survey respondents are top-level executives, whose decision significantly affect firms' performance, particularly in small businesses: their activity is strongly influenced by a single person's decisions and the top-executive's perception is a key determinant of their strategy. Finally, the perception-based measure captures rivalry from both domestic and international competitors. Given the broad sectors classification (firms are divided into only four sectors), the size of the surveyed firms, and the cross-country nature of our analysis, accounting for these issues appears crucial.

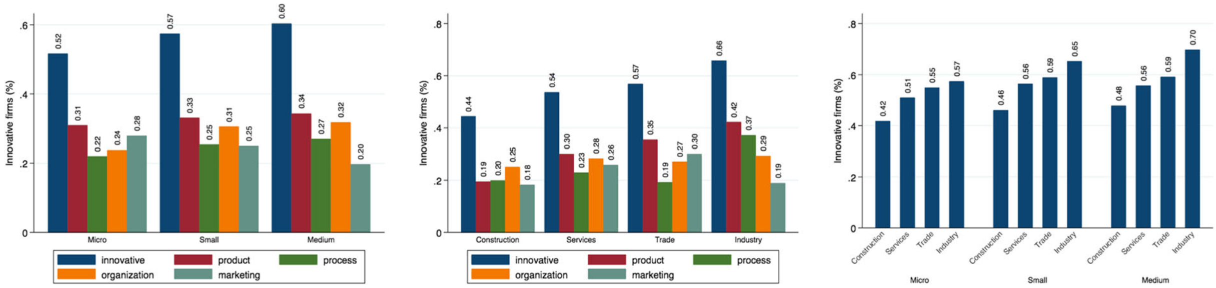
4 An overview of European MSMEs' innovative activity

The first objective of the paper is to investigate whether and how European small businesses, including those with fewer than 10 employees, participate in innovation. In this section, we report several descriptive statistics aimed at providing an overview of the innovative activity and the perceived level of competition of the surveyed firms. Table 12 in the Appendix reports descriptive statistics for the main variables of interest. More than half of the surveyed MSMEs (57%) declared to have introduced at least one type of innovation over the 2014–2018 period. The average EU percentage of innovative firms in the 2018 Community Innovation Survey (CIS) is around 50%, slightly below, but close to, our value. Looking at the four different typologies, product innovation prevails with 34%, while process, organization, and marketing innovations show similar and still not negligible values. These numbers show an overall active contribution of European MSMEs to innovation. Panel (a) of Fig. 2 shows that the percentage of innovative enterprises increases with firms' size, as expected from the

[5] In CIS, an innovation-active enterprise is one that has had innovation activities during the period under review. Innovation activities are all scientific, technological, organizational, financial, and commercial steps that actually, or are intended to, lead to the implementation of innovations. An innovation is defined as a new or significantly improved product (good or service) introduced to the market, or the introduction within an enterprise of a new or significantly improved process. For more details we refer to https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210115-2.

[6] Given the reference period of CIS 2018 (2016–2018), to make things comparable we compute the SAFE country percentages of innovative firms considering the 2016–2018 period only. Moreover, since the CIS excludes enterprises with fewer than 10 employees, we compute the SAFE country averages excluding micro firms.

[7] See Table 11 in the Appendix for further details.



(a) By size **(b)** By sector **(c)** By sector and size

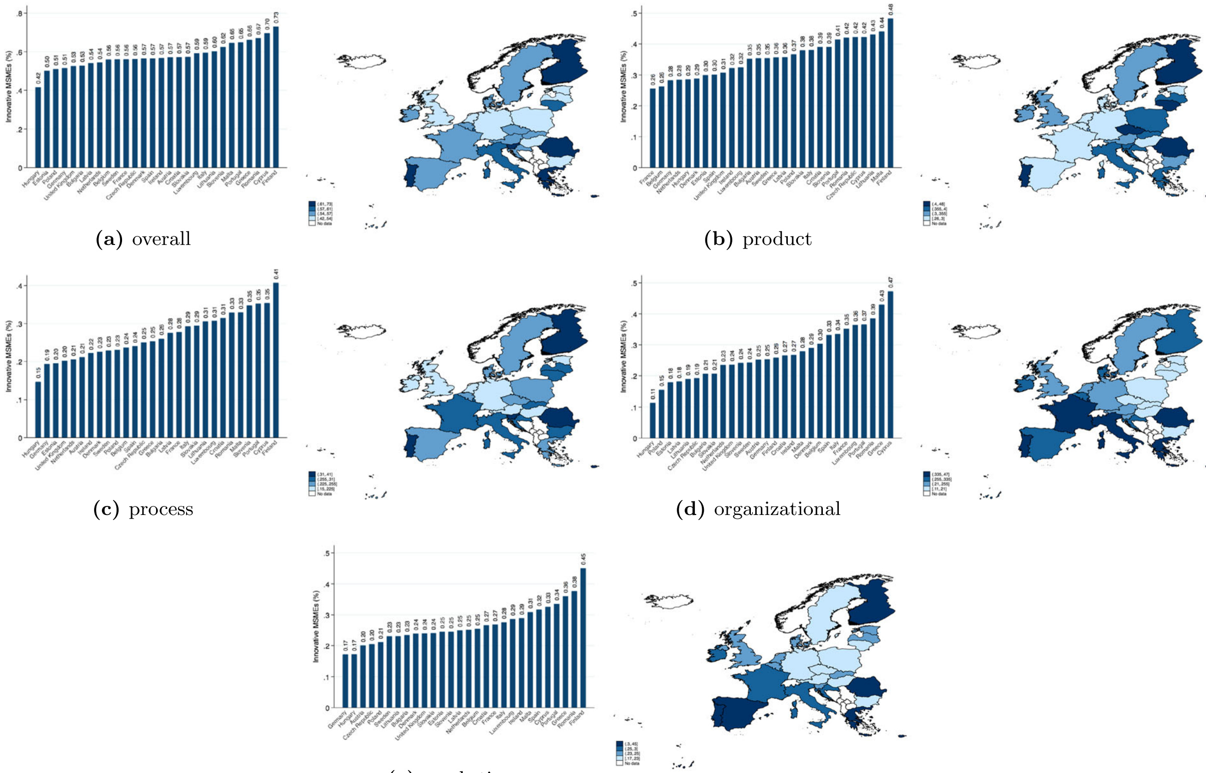
Fig. 2 Innovative firms by size and sector. Notes: Authors' calculations on SAFE data. The figure reports the weighted percentage of firms that introduced at least one type of innovation (innovative) and product, process, organization, or marketing innovation. It does so by size (a), sector (b), and both sector and size (c). The statistics refer to the five Common round waves from 2014 to 2018

literature, and a remarkable share of innovative micro firms. Around half of these micro firms declared having introduced at least one innovation. Moreover, the firms' percentage introducing a product, process, or organizational innovation increases with size, while that for marketing innovation declines. Micro firms seem to be more marketing innovative than small and medium firms. As panel (b) illustrates, the industry sector has the highest percentage of innovative firms, followed by trade, services, and construction. A similar trend characterizes product innovation, which is the most introduced type in the industry, trade, and services sectors. In construction, organizational innovations dominate. In panel (c), we disentangle firms' size and industries. In all sectors, the share of innovative enterprises increases with firms' size. Overall, Fig. 2 confirms the fact that innovation grows with companies' size, but it also shows that the innovative activity of smaller SMEs, including micro firms with fewer than 10 employees, is far from negligible.

Panel (a) of Fig. 3 reports the percentage of innovative MSMEs in each country of the survey. The values go from a minimum of 42% (Hungary) to a maximum of 73% (Finland), with a gap of around 30 points. If we exclude these two countries, the distance between the second worst (Estonia) and the second best (Cyprus) is of 20 points. Such range suggests a certain level of heterogeneity in the MSMEs innovative activity across EU countries. This is further highlighted by the geographical distribution in the right panel. The quantile distribution distinguishes four different country groups: 42–53% (Hungary, Estonia, Poland, Germany, UK, Bulgaria), 54–57% (Latvia, Netherlands, Belgium, Sweden, France, Czech Rep., Denmark, Spain, Ireland, Austria, Croatia, Slovakia), 58–61% (Luxembourg, Italy, Lithuania), and 62–73% (Slovenia, Malta, Portugal, Greece, Romania, Cyprus, Finland). The low position of Germany might be surprising. However, recent studies signal a slowdown of German SMEs' innovativeness rate.[8]

Figure 3 also reports the percentage of surveyed MSMEs that introduced a product (panel b), process (panel c), organization (panel d), or marketing innovation (panel e) in each country. This allows us to collect more details on the between country innovation heterogeneity and also to investigate which types of innovation are more developed than others in each country. The largest gap between the worst and the best performing country is observed for organization innovation (36%), followed by marketing (28%), process (26%), and product (22%). Looking at the maps, Eastern Europe seems to be more innovative than Western Europe in terms of product innovation, while the opposite is true for organization and marketing types. For process innovation, there is not a clear trend. Focusing on the within countries patterns, we highlight some interesting findings. France, for instance, is in the lowest group for product innovation and in the highest for organizational. Germany is last for marketing innovation and among the last for product and process, gaining some position for organizational innovation. Finland is supreme for all types except type 3. Italy has a stable position for the

[8] See, for instance, Rammer and Schubert (2018), the KfW SME Innovation Report (2019), and the Germany-SBA Fact Sheet 2019 (European Commission). The OECD (2019) SME and Entrepreneurship Outlook states that German SMEs with fewer than 250 employees spend less on R&D than the OECD median.



(a) overall (b) product (c) process (d) organizational (e) marketing

Fig. 3 Innovation activity by country. Notes: Authors' calculations on SAFE data. The figure reports the weighted percentages of MSMEs that introduced at least one innovation (**a**) and that introduced a product (**b**), process (**c**), organization (**d**), and marketing (**e**) type in each country. The statistics refer to the five Common round waves from 2014 to 2018

four types. Belgium is very low in terms of product innovation and higher in terms of organizational.

In Fig. 4, we replicate the same exercise focusing only on micro firms. Except for Hungary, in all the countries the percentage of innovative enterprises exceeds 40 percent, suggesting active participation in innovation. The gap between the maximum (Romania) and the minimum (Hungary) value is around 30 points, still indicating a certain heterogeneity among countries.[9] Organization and marketing innovations show the largest ranges, while the geographical distribution seem to confirm a stronger activity of Easter Europe for product and weaker for organizational and marketing innovations than Western Europe. Overall, Fig. 4 documents the active participation of microbusinesses in innovation.[10]

Figure 5 reports descriptive statistics related to our measure of competition. As panel (a) illustrates, almost 18% of the interviewed MSMEs over the 2014–2018 period declared a low level of competition (values 1, 2, 3), 47% medium (values 4, 5, 6, 7), and 35% high (values 8, 9, 10). Looking at the distribution by firm size category, the percentage of firms declaring medium and high values of competition increases with firms size, while it decreases for low values. This suggests that competition is seen as a pressing problem more by larger SMEs. It might also be a signal of a "niche effect", whereby small businesses often enter niche markets that protect them from competition. Such findings seem to be confirmed by panel (e), where the weighted perceived average competition increases with firms' size. This value does not

[9] Again, the penultimate place of Germany might seem unusual. In this regard, Baumann and Kritikos (2016) shows that around 50 percent of German micro firms engaged in innovative activities between 2005 and 2012. If we combine this information with the reported decline in the innovativeness rate of German SMEs, our value (43%) looks less astonishing. See also note 8.

[10] Figures 8, 9, and 10 in the Appendix provide more details in terms of MSMEs innovative behavior according to the size and sector of activity for each of the 28 countries.

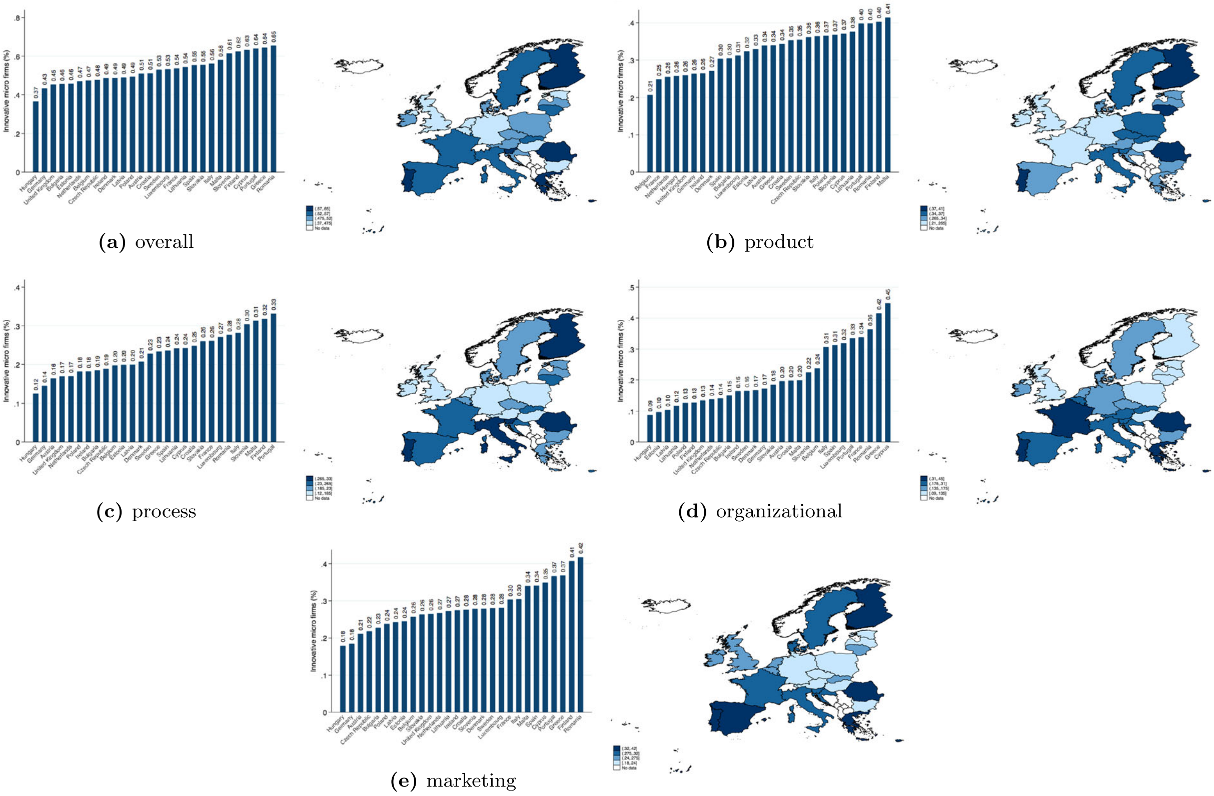


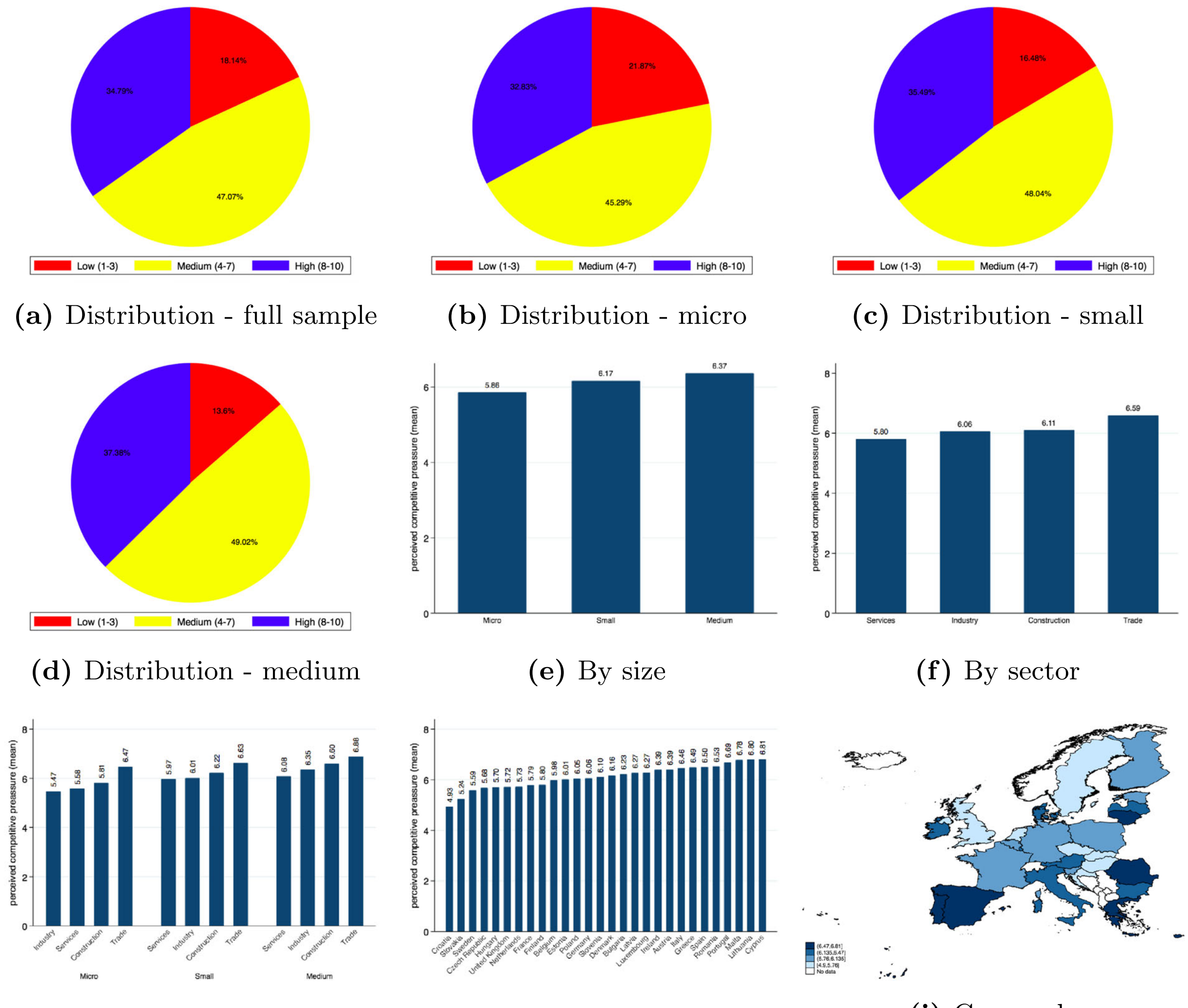
Fig. 4 Innovation activity by country — micro firms. Notes: Authors' calculations on SAFE data. The figure reports the weighted percentages of firms with fewer than 10 employees that introduced at least one innovation (**a**) and that introduced a product (**b**), process (**c**), organizational (**d**) and marketing (**e**) type in each country. The statistics refer to the five Common round waves from 2014 to 2018

differ markedly across sectors (panel f), with trade showing the highest level and services the lowest in almost all the categories (panel g). Looking at single countries (panel h), the average perceived competitive pressure shows a quite small range, varying from 4.93 (Croatia) to 6.81 (Cyprus). These quite homogeneous values can be partly explained by the fact that EU countries are subject to a common legislation on competition implemented at the European Union level. The map in panel (i) distinguishes four country groups: those with values from 4.9 to 5,7 (Croatia, Slovenia, Sweden, Czech Rep., Hungary, UK, Netherlands), 5.78–6.13 (France, Finland, Belgium, Estonia, Poland, Germany, Slovenia), 6.14–6.47 (Denmark, Bulgaria, Latvia, Luxembourg, Ireland, Austria, Italy), and 6.48–6.81 (Greece, Spain, Romania, Portugal, Malta, Lithuania, Cyprus). Overall, Southern European countries seem to perceive a higher (even though slightly) level of competitive pressure than Continental and Northern European ones.

5 The relationship between innovation and competition

Statistics in section 4 document an active participation of MSMEs in innovation and show the non-negligible contribution of micro firms. We now want to address our second question about the relationship between MSMEs' innovation and competition. In 2018, there were slightly more than 25 million of MSMEs in the EU-28, of which 93% were micro firms, and they accounted for 99.8% of all enterprises in the non-financial business sector (European Commission, 2019). Given the large number, the issue of competition should be relevant for this type of firm. To our best knowledge, evidence is ambiguous for SMEs, while completely missing for microbusinesses.

Figure 6 reports preliminary evidence about the relationship between competition and innovation in our sample. Panel (a) shows the percentage of innovative firms for different level of competition: low



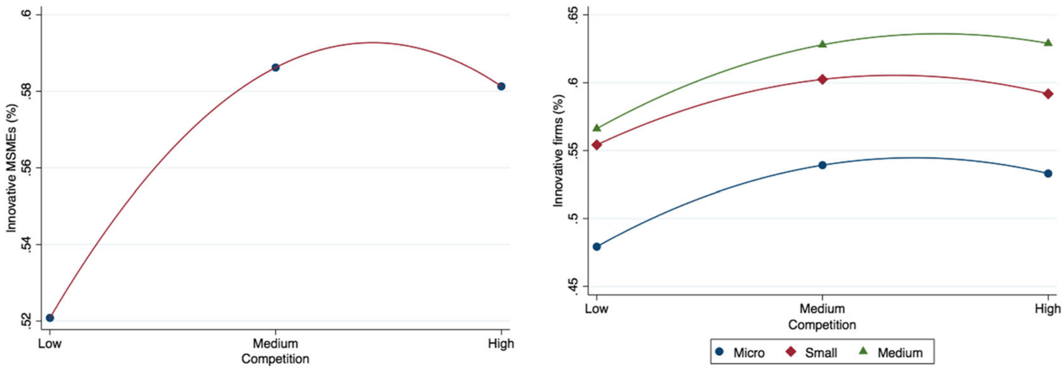
(a) Distribution - full sample (b) Distribution - micro (c) Distribution - small (d) Distribution - medium (e) By size (f) By sector (g) By sector and size (h) By country (i) Geography

Fig. 5 Perceived competition. Notes: Authors' calculations on SAFE data. The figure reports weighted statistics about firms' perceived level of competition: the full sample and subsamples distributions (**a**–**d**), the weighted mean by size (**e**), sector (**f**), by sector and size (**g**) and by country (**h** and **i**). The statistics refer to the five Common round waves from 2014 to 2018

(values 1, 2, 3), medium (values 4, 5, 6, 7), and high (values 8, 9, 10). Panel (b) does the same for the three firms' categories subsamples. The overall percentage of innovative firms initially increases and then it slightly declines, following an inverted-U curve. This trend seems to be confirmed for all the categories (panel b). Comparing the three curves, the turning point comes earlier for micro and small firms, where we also observe a steeper negative side. This suggests that, although the patterns look similar, the negative effect of competition on innovation arrives earlier and it is more marked for smaller enterprises. This preliminary evidence suggests the existence of an inverted-U-shaped relationship.

5.1 Benchmark specifications

Equation (1) describes our baseline regression. The dependent variable is the dummy for innovative firms, equal to 1 if the firm has introduced at least one type of innovation. Following Askenazy et al. (2013), Peneder and Wörter (2014), Karaman and Lahiri (2014), Friesenbichler and Peneder (2016), Crowley and Jordan (2017) and Cornett et al. (2019), to detect



(a) **(b)**

Fig. 6 Competition and innovation. Notes: Authors' calculations on SAFE data. The binned scatterplot in panel (a) reports the percentage of innovative firms for different level of competition: *Low* (values 1, 2, 3), *Medium* (values 4, 5, 6, 7), and *High* (values 8, 9, 10). Panel (b) does the same for the separate subsamples of micro, small, and medium firms. The statistics refer to the five Common round waves from 2014 to 2018

non-linearities, we include both the linear and the quadratic terms of competition. The basic specification looks as follows:

$$Innov_{i,c,s,t} = \alpha + \beta_1 Comp_{i,c,s,t} + \beta_2 Comp^2_{i,c,s,t} + \beta_j X_{i,c,s,t} + \eta_c + \theta_s + \gamma_t + \epsilon_{i,c,s,t} \quad (1)$$

Vector $X_{i,c,s,t}$ contains a set of characteristics of firm i, in country c, sector s, at time t. It includes size, age, turnover, ownership type, legal status, and past growth.[11] We include sector dummies (θ_s) to control for technological opportunities, as long as they are crucial determinants of firms' innovative behavior and they can differ substantially across industries (Nickell, 1996). Country (η_c) and time (γ_t) dummies are also considered to eliminate unobserved heterogeneity across countries and time periods. Standard errors are clustered at the country level. Following Ayyagari et al. (2011), we estimate regression (1) using a logit model and a linear probability model (LPM) as validation test.[12] Table 1 provides preliminary estimates. Panel (a) reports the logit average partial effects (APEs); panel (b), the odds ratios; and panel (c), the LPM estimates. Columns from (1) to (3) consider the full sample, including neither firms controls nor fixed effects (col.1), firms' controls only (col.2), as well as both firms controls and fixed effects (col.3).[13] Columns (4), (5), and (6) consider separately the subsamples of micro, small, and medium firms, respectively. All the specifications show a quadratic effect of competition on the likelihood of being innovative. The positive linear term and the negative quadratic one, both statistically significant, suggest an inverted-U relationship. The odds ratios go in the same direction. These findings hold for all the three firm category subsamples, including firms with fewer than 10 employees. For an initial low level of competition, the likelihood of being innovative increases with competition, while it slightly declines if the initial level is high.

Thus, this preliminary evidence seems to support the findings of Scherer (1967) and Aghion et al. (2005). However, though necessary, a statistically significant coefficient of the squared term is not sufficient alone to establish a quadratic relationship (Haans et al., 2016), since it does not allow for reasonably rejecting the hypothesis that the true relationship is monotone. Lind and Mehlum (2010) propose a four-step procedure to test for quadratic relationships. In order to be reasonably sure that an inverted-U relationship exists, the following conditions must hold: (a) the squared coefficient must be negative and statistically significant; (b) the curve turning point needs to

[11] See Table 12 in the Appendix for descriptive statistics.

[12] We also compared the logit and probit estimates of the full sample model with all regressors including time, country, and sector fixed effects. Since the former shows a lightly higher log-pseudolikelihood, we preferred to use logit. Results are available in Table OA1 in the Online Appendix.

[13] Including a wide set of individual controls and dummies should mitigate potential omitted variable bias. Nevertheless, they can act as bad controls if they are determined simultaneously with our measure of innovativeness (see Angrist and Pischke, 2008). Thus, we estimate regression (1) with and without those controls.

Table 1 Innovation status

Dependent variable: Innovative	(1) Full sample	(2) Full sample	(3) Full sample	(4) Micro	(5) Small	(6) Medium
Firms controls	No	Yes	Yes	Yes	Yes	Yes
Time, country, sector FE	No	No	Yes	Yes	Yes	Yes
Panel (a): APEs						
Competition	0.044***	0.036***	0.033***	0.031***	0.028***	0.036***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.008)	(0.005)
Competition^2	−0.003***	−0.002***	−0.002***	−0.002***	−0.002***	−0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Observations	75673	71833	71833	28033	22414	21386
Pseudo R^2	0.02	0.04	0.04	0.04	0.03	0.04
Wald test — H0: all coefficients = 0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Panel (b): Odds ratios						
Competition			1.150***	1.141***	1.128***	1.169***
			(0.027)	(0.030)	(0.040)	(0.026)
Competition^2			0.990***	0.990***	0.992***	0.990***
			(0.002)	(0.002)	(0.003)	(0.002)
Observations			71833	28033	22414	21386
Pseudo R^2			0.04	0.04	0.03	0.04
Wald test — H0: all coefficients = 0			0.0000	0.0000	0.0000	0.0000
Panel (c): LPM						
Competition			0.033***	0.031***	0.028***	0.036***
			(0.005)	(0.006)	(0.008)	(0.005)
Competition^2			−0.002***	−0.002***	−0.002**	−0.002**
			(0.000)	(0.000)	(0.001)	(0.000)
Observations			71833	28033	22414	21386
Adj. R^2			0.05	0.06	0.04	0.05
F test — H0: all coefficients = 0			0.0000	0.0000	0.0000	0.0000
Lind-Mehlum test						
Extreme point			7.26	6.83	7.22	7.76
Lower bound slope			0.12	0.11	0.10	0.14
			[6.24; 0.000]	[5.02; 0.000]	[3.51; 0.000]	[7.31; 0.000]
Upper bound slope			−0.05	−0.06	−0.05	−0.04
			[−3.07; 0.001]	[−4.34; 0.000]	[−1.72; 0.043]	[−2.80; 0.002]
Overall test			[3.07; 0.001]	[4.34; 0.000]	[1.72; 0.043]	[2.80; 0.002]
90% Fieller CI			[6.80; 8.11]	[6.34; 7.38]	[6.48; 9.70]	[7.20; 8.71]

Notes: Authors' calculations on SAFE data. Cluster robust standard errors in parentheses. Cluster level: country. T-values, and p-values in square brackets. ***p<0.01, **p<0.05, *p<0.1. Panel (a) reports the logit average partial effects (APEs); panel (b) the odds ratios; panel (c) the LPM estimates. All the regressions use sampling weights. The dependent variable is *innovative* dummy. Columns from (1) to (3) consider the full sample, while Columns (4), (5), and (6) the subsamples of micro (1 to 9 employees), small (10 to 49 employees), and medium (50 to 249 employees) firms, respectively. The set of firms' controls includes size (only in col. 1,2,3), turnover, age, legal status, ownership types, and past growth. Each column estimates regression (1) by including neither firms' controls nor FE (col.1), firms' controls only (col.2), both firms' controls and time, country, sector FE (col. 3,4,5,6). The Lind and Mehlum test uses logistic regressions be located well within the data range; (c) the slopes at the lower and upper bound need to be significant and of the expected sign; and (d) the confidence interval of the turning point must be within the data range. Performing this test, we find that all the specifications satisfy these conditions. The turning point in the full sample is around 7 and it increases with firm size. This means that the negative effect dominates for high levels of competition and it arrives earlier for smaller firms. The lower and upper bound slopes suggest that the increasing side of the curves are steeper than the decreasing one.

5.2 Econometric issue: dealing with reverse causality

Our empirical approach involves methodological issues that might produce inconsistent estimates of the true relationship between innovation and competition or could affect the interpretation of the estimates. Competition and innovation are, indeed, mutually endogenous and dependent (Aghion et al., 2005; Hall & Harhoff, 2012). Reverse causality might then be a potential driver of endogeneity, with the perceived competition affecting innovation and vice-versa. Moreover, there is a period discrepancy between the two survey questions defining innovation and competition that might increase the overlap risk between the two variables: the former considers a 12-month period while the latter a 6-month period. Such simultaneity might introduce some bias in the estimation of the contemporaneous effect of competition on innovation. Removing this bias would have been possible through a suitable instrumental variable (IV) or exogenous shock, such as a policy change. Unfortunately, the dataset does not provide adequate firm-level instruments and we found no shocks affecting all the countries at the same time. Another strategy we can pursue to deal with reverse causality is to use past values of competition (Askenazy et al., 2013; Mulkay, 2019). Lagged values may not eliminate the simultaneity bias, but they allow to lessen it by estimating the impact of past exogenous values rather than the endogenous contemporaneous one (Reed, 2015). To do this, we isolate the panel component of the SAFE dataset and we restrict the sample to those firms interviewed at least twice over the period 2014–2018.[14]

[14]A firm is classified as a panel if it participated in the survey at least twice, though not necessarily in consecutive waves. A one-period lag may not then correspond to a one year lag.

The result is an unbalanced panel of 43,961 observations, 16,524 (37.59%) for micro, 13,939 (31.71%) for small, and 13,498 (30.70%) for medium firms.[15] We then amend the baseline regression (1) by replacing the current values of competition with one-period lags:

$$Innov_{i,c,s,t} = \alpha + \beta_1 Comp_{i,c,s,t-1} + \beta_2 Comp^2_{i,c,s,t-1} + \beta_j X_{i,c,s,t} + \eta_c + \theta_s + \gamma_t + \epsilon_{i,c,s,t} \quad (2)$$

Table 2 reports the logit APEs (panel a), the odds ratios (panel b), and the LPM estimates (panel c) of regression (2). It considers the full sample (col.1) and the separate subsamples of micro (col. 2), small (col.3), and medium (col.4) enterprises. Sectors, time, and country dummies are always included. Overall, Table 2 confirms previous findings. From the Lind and Mehlum test, we observe a general lowering of the turning points, mostly for micro and small firms, for which an increase in the slope of the negative side of the curve also occurs. As anticipated in panel (b) of Fig. 6, the negative effect of competition on innovation seems to come earlier and to be more marked for smaller firms.

5.3 Further robustness

In Table 3 we provide further robustness.[16] Following Haans et al. (2016), we first add the cube term of competition to test whether the relationship is S-shaped rather than U-shaped (col.1). Second, we run two linear regressions on the sample before and after the turning point of the curve (col.2 and 3). As expected, we obtain a positive relationship between competition and innovation in the former, while negative in the latter. To check that the results are not driven by the most represented countries, we run model (2) excluding Italy, Germany, France, Spain, and Poland (col. 4). We also want to consider the fact that the rigorous policy interventions and the international financial aids addressed to Cyprus and Greece during and after the sovereign debt crisis might have altered firms' innovative activity in these countries.[17] Finally, we want

[15]See Table 14 in the Appendix for details of the distribution among countries for the observations.

[16]We run these checks considering the full sample unbalanced panel.

[17]Cyprus received financial assistance from the European Stability Mechanism (ESM) of €6.3 billion over the 2013–2015

Table 2 Innovation status — panel component

Dependent variable: Innovative	(1) Full sample	(2) Micro	(3) Small	(4) Medium
Firms controls	Yes	Yes	Yes	Yes
Time, country, sector FE	Yes	Yes	Yes	Yes
Panel (a): APEs				
Competition(t-1)	0.034***	0.034***	0.029**	0.036***
	(0.009)	(0.012)	(0.013)	(0.007)
Competition^2(t-1)	−0.003***	−0.003***	−0.003**	−0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	25428	9261	8176	7991
Pseudo R^2	0.04	0.04	0.04	0.04
Wald test — H0: all coefficients = 0	0.0000	0.0000	0.0000	0.0000
Panel (b): Odds ratios				
Competition(t-1)	1.155***	1.154***	1.131**	1.174***
	(0.044)	(0.057)	(0.061)	(0.034)
Competition^2(t-1)	0.989***	0.988***	0.989**	0.989***
	(0.003)	(0.004)	(0.004)	(0.002)
Observations	25428	9261	8176	7991
Pseudo R^2	0.04	0.04	0.04	0.04
Wald test — H0: all coefficients = 0	0.0000	0.0000	0.0000	0.0000
Panel (c): LPM				
Competition(t-1)	0.034***	0.033***	0.029**	0.037***
	(0.009)	(0.012)	(0.013)	(0.007)
Competition^2(t-1)	−0.003***	−0.003***	−0.003**	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	25428	9261	8176	7991
Adj. R^2	0.05	0.05	0.05	0.05
F test — H0: all coefficients = 0	0.0000	0.0000	0.0000	0.0000
Lind-Mehlum test				
Extreme point	6,24	5.98	5.49	7.43
Lower bound slope	0.12	0.12	0.10	0.14
	[3.57; 0.000]	[2.81; 0.002]	[2.21; 0.013]	[5.63; 0.000]
Upper bound slope	−0.09	−0.10	−0.10	−0.06
	[−3.56; 0.000]	[−3.41; 0.000]	[−2.68; 0.004]	[−2.67; 0.004]
Overall test	[3.57; 0.000]	[2.81; 0.002]	[2.21; 0.013]	[2.64; 0.004]
90% Fieller CI	[5.85; 6.68]	[4.78; 6.82]	[4.03; 6.26]	[6.72; 8.58]

Notes: Authors' calculations on SAFE data. Cluster robust standard errors in parentheses. Cluster level: country. T-values and p-values in square brackets. ***p<0.01, **p<0.05, *p<0.1. Panel (a) reports the logit average partial effects (APEs); panel (b) the odds ratios; panel (c) the LPM estimates. All the regressions use sampling weights. The dependent variable is *innovative* dummy. Columns (1) considers the full sample, while columns (2), (3), and (4) the subsamples of micro (1 to 9 employees), small (10 to 49 employees), and medium (50 to 249 employees) firms, respectively. The set of firms' controls includes size (only in col.1), turnover, age, legal status, ownership types, and past growth. Each column includes firms' controls and time, country, sector FE. The Lind and Mehlum test uses logistic regressions

Table 3 Further robustness

Dependent variable: Innovative	(1) Full sample	(2) *comp* < 7	(3) *comp* >= 7	(4) Excluding Italy, Germany, France Spain and Poland	(5) Excluding Greece, Cyprus and Romania
Competition(t-1)	0.055***	0.004***	−0.005**	0.028***	0.035***
	(0.021)	(0.002)	(0.002)	(0.009)	(0.009)
$Competition^2$(t-1)	−0.007**			−0.002***	−0.003***
	(0.004)			(0.001)	(0.001)
$Competition^3$(t-1)	0.000				
	(0.000)				
Firms controls	Yes	Yes	Yes	Yes	Yes
Time, country, sector FE	Yes	Yes	Yes	Yes	Yes
Observations	25428	12279	13149	14043	23798
Pseudo R^2	0.04	0.05	0.04	0.05	0.04
Wald test — H0: all coefficients = 0	0.0000	0.0000	0.0000	0.0000	0.0000
Lind-Mehlum test					
Extreme point	3.85			6.10	6.20
Lower bound slope	0.17			0.10	0.13
	[2.96; 0.001]			[3.10; 0.000]	[3.84; 0.000]
Upper bound slope	−0.38			−0.08	−0.09
	[−1.68; 0.05]			[−2.71; 0.003]	[−3.74; 0.000]
Overall test	[1.68; 0.05]			[2.71; 0.003]	[3.74; 0.000]
90% Fieller CI	[3.19; 9.33]			[5.56; 6.90]	[5.81; 6.60]

Notes: Authors' calculations on SAFE data. Cluster robust standard errors in parentheses. Cluster level: country. T-values and p-values in square brackets. ***p<0.01, **p<0.05, *p<0.1. The table reports the logit average partial effects (APEs). All the regressions use sampling weights and consider all the MSMEs together. The dependent variable is *innovative* dummy. The set of firms' controls includes size, turnover, age, legal status, ownership types, and past growth. Each column estimates Eq. (2) by including both firms' controls and time, country, sector FE

to be sure that the over-reported innovation activity in Romania does not affect our results. Thus, we exclude Greece, Cyprus, and Romania from the sample (col. 5). Overall, estimates in Table 3 confirm the evidence of an inverted-U relationship.

We are aware that the proposed specifications, with the Lind and Mehlum test and the aforementioned robustness checks, do not guarantee a causal interpretation of the results. Nevertheless, our findings provide a first helpful contribution to assess the link between competition and innovation for MSMEs, including micro firms. Indeed, estimates suggest that the initial level of competition might determine the direction of the effect on small businesses' innovation. Competition fosters innovation, but excessive competition might also hamper it. This is valid for all firms,

period. Greece obtained a total of €245.7 billion over the 2010–2018 period from three different programs: €52.9 billion from bilateral EU and IMF loans (2010–2012), €130.9 billion from the European Financial Stability Facility (EFSF) (2012–2015), and €61.9 billion from the ESM (2015–2018). See https://www.esm.europa.eu/financial-assistance for further details about the ESM-EFSF financial assistance programs. Figure 12 in the Appendix shows that the introduction of the assistance programs (2013 in Cyprus and 2010 in Greece) corresponds to the beginning of an upward trend in R&D expenditures in both countries.

Table 4 Pairwise correlation — innovation types

	Type 1	*Type 2*	*Type 3*	*Type 4*
Product (type 1)	1.00			
Production process (type 2)	0.42*	1.00		
Organization (type 3)	0.18*	0.25*	1.00	
Marketing (type 4)	0.29*	0.24*	0.31*	1.00

Notes: Authors' calculations on SAFE data. Significance level: 1%

regardless of the size, but the negative effect seems to come earlier for smaller firms.

6 Complementary analyses: innovation strategy and frequency of innovation

Thus far, we investigate the relationship between competition and firms' innovation status, which is the likelihood to introduce at least one innovation. As a complementary analysis, we reproduced the same exercise for innovation strategy and frequency of innovation.

6.1 Innovation strategy

The four listed innovation types (product, process, organization, and marketing) have different characteristics and they emanate from distinct sources of knowledge (Demircioglu et al., 2019). As the Oslo Manual states in its 2005 edition, "It is not enough to know whether firms are innovative or not; it is necessary to know how firms innovate and what types of innovations they implement" (OECD, 2005, p. 13). The literature normally proposes two ways to distinguish innovation: on the one hand, between technical and non-technical as well as, on the other, between internal and external. Table 4 reports the pairwise correlation for the four types.

All the coefficients are positive and significant at the 1% level. The highest correlations occur between product and process (technical innovations) and between organization and marketing (non-technical innovation). A non-negligible correlation also emerges between product and marketing (external innovation) and between process and organization (internal innovation). Past literature documents the existence of complementarities between innovation strategies, particularly for product and process innovations (Cabagnols and Le Bas, 2002; Martínez-Ros & Labeaga, 2002; Miravete & Pernias, 2006; Mulkay, 2019). Our results appear to confirm this.[18] Following Santos and Cincera (2021), we also distinguish between simple innovation (firms introduce only one type of innovation among the four listed) and complex innovation (firms introduce more than one type). As a measure of innovation complexity, we build a normalized firm-level indicator by summing the number of types introduced by the firm and dividing it by four (the total number). According to Table 5, the 23% of the surveyed firms developed a simple innovation strategy (one type only) and the 34% a complex one (more than one type). Concerning technical/non-technical and external/internal innovation, the percentages are quite similar. Figure 11 in the Appendix illustrates the average level of complexity by firm sector, size, sector and size, and country. Industry is the sector with the highest complexity index, followed by trade, services, and construction. Firms with fewer than 10 employees have an average index below, but close to, that of small- and medium-sized firms, or even equal in services sector. This suggests that the innovation divergence between micro firms and larger SMEs is limited not only in terms of being innovative, but also in terms of innovation strategy.

Here, we want to explore whether the way competition affects innovation is unique or some differences occur depending on the class of innovation. As long as technical and external innovation are more visible and accessible, thus more imitable by competitors, we expect to find some differences. This should

[18] Tang (2006) finds a similar correlation coefficient (0.40) between product and process innovation using a sample of Canadian firms.

Table 5 Innovation strategy

One type	23%	Technical	43%
Two types	19%	Non-technical	40%
Three types	10%	External	45%
Four types	5%	Internal	42%

Notes: Authors' calculation on SAFE data

strengthen both the escape (positive) and the Schumpeterian (negative) effect. On the one hand, neck-and-neck firms must introduce more of these innovations to escape competition; on the other, laggard firms can more easily replicate the innovations of the leaders and, therefore, be less motivated to innovate by themselves. Thus, we expect to observe a steeper curve for these two innovation categories. We also want to see the impact on firms' innovation complexity. Thus, in Table 6 we reproduce regression (2) by innovation class and complexity. Given the correlation between the four types of innovation (Table 4), the error terms of the regressions could also be somewhat correlated, introducing potential bias in the estimates. Following Demircioglu et al. (2019), we then estimate a seemingly unrelated regressions (SUR) model (panel b). Given the continuous nature, for the complexity index (col.5), we use OLS. Panel (a) of Table 6 seems to confirm our prediction. The size and significance of the coefficients suggest a stronger relationship between competition, technical, and external innovations. For these typologies, the lower and upper bound slopes of the curve look steeper than those of non-technical and internal ones. Innovation complexity (col.5) also increases initially with competition, then it declines slightly. The stronger relationship with technical and external innovations is also confirmed by the SUR model in panel (b), where the correlation matrix of residuals does not show worryingly high correlation values.

We replicate the same exercise focusing only on micro firms. Panel (a) of Table 7 shows that the inverted-U curve is there for all the innovation types and for the complexity index.[19] We also observe a general increase in the coefficient significance. Again, looking at the lower and upper bound slopes, technical and external innovations have a steeper positive and negative side of the curve comparing to non-technical and internal innovations. The size and significance of the coefficients are confirmed by the SUR model in panel (b). Overall, these findings suggest that the intensity of the effect of competition is not unique, but it varies based on the type of innovation.

6.2 Frequency of innovation

We develop a second complementary analysis to study how perceived competition affects the frequency of MSMEs' innovative activity. To do this, we further restrict our sample to those panel firms interviewed in at least three waves. After selecting three periods for those companies present more than trice, we obtain a weakly balanced panel with 19,970 observations. Firms appear the same number of times but not necessarily in the same years. With this restricted sample, we can observe the innovation status for a certain number of firms over time (at least three periods). We build a normalized index for the frequency of innovation by dividing the number of years in which the firm declared to be innovative by three (the total number of years in which the firm was interviewed).[20] Since this measure is an average value, to make things comparable we also compute the firm-average perceived competition level over the three years. Table 8 reports the number of enterprises that, at the end of the three-year period, have been innovative in zero, one, two, or three years. Although they are observed over a limited number of years and not necessarily in the same years, a certain heterogeneity in the frequency of innovation emerges.

[19] For innovation complexity, since the normalized index has values between 0 and 1, we replicate the estimation using a fractional logistic regression model. We also develop a Poisson regression with a count dependent variable indicating the number of types of innovation a firm has introduced. The inverted-U relationship is confirmed both for the full sample and for micro firms. Results are available in Table OA2 in the Online Appendix.

[20] See Table 13 in the Appendix for a more detailed definition.

Table 6 Innovation typology and complexity — full sample

Firms controls	Yes	Yes	Yes	Yes	Yes
Time, country,	Yes	Yes	Yes	Yes	Yes
sector FE	(1)	(2)	(3)	(4)	(5)
	Technical	Non-technical	External	Internal	Complexity
Panel (a): logit model					(OLS)
Competition(t-1)	0.028***	0.015*	0.034***	0.012**	0.010***
	(0.004)	(0.008)	(0.009)	(0.006)	(0.004)
Competition^2(t-1)	−0.003***	−0.001	−0.003***	−0.001**	−0.001**
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
Observations	25204	25340	25381	25254	23,298
Pseudo (Adj.) R^2	0.05	0.03	0.04	0.05	(0.06)
Wald (F) test — H0: all coefficients = 0	0.0000	0.0000	0.0000	0.0000	(0.0000)
Lind-Melhum test					
Extreme point	5.44	8.24	6.43	5.66	6.43
Lower bound slope	0.10	0.06	0.13	0.04	0.009
	[6.42; 0.000]	[2.02; 0.02]	[3.76; 0.000]	[2.04; 0.02]	[2.86; 0.004]
Upper bound slope	−0.10	−0.01	−0.08	−0.04	−0.006
	[−9.97; 0.000]	[−0.65; 0.25]	[−3.51; 0.000]	[−2.04; 0.02]	[−2.33; 0.014]
Overall test	[6.42; 0.000]	[0.65; 0.25]	[3.51; 0.000]	[2.04; 0.02]	[2.33; 0.014]
90% Fieller CI	[4.96; 5.83]	[−Inf; +Inf]	[6.11; 6.81]	[4.37; 6.87]	[5.67; 7.73]
Panel (b): SUR model					
Competition(t-1)	0.025***	0.015***	0.033***	0.008	
	(0.005)	(0.005)	(0.005)	(0.005)	
Competition^2(t-1)	−0.002***	−0.001**	−0.003***	−0.001**	
	(0.000)	(0.000)	(0.000)	(0.000)	
Observations	25116	25116	25207	25207	
R^2	0.08	0.04	0.06	0.07	
F test — H0: all coefficients = 0	0.0000	0.0000	0.0000	0.0000	
Correlation matrix of residuals					
Technical	1.00				
Non-technical	0.30	1.00			
External			1.00		
Internal			0.37	1.00	

Notes: Authors' calculations on SAFE data. Cluster robust standard errors in parentheses. Cluster level: country. T-values and p-values in square brackets. ***$p<0.01$, **$p<0.05$, *$p<0.1$. The dependent variables are technical (col.1), non-technical (col.2), external (col.3), internal (col.4), innovation dummies and innovation complexity (col.5). The set of firms' controls includes size, turnover, age, legal status, ownership types, and past growth. Each column includes firms' controls and time, country, sector FE

Table 7 Innovation typology and complexity — micro firms

Firms controls	Yes	Yes	Yes	Yes	Yes
Time, country, sector FE	Yes	Yes	Yes	Yes	Yes
	(1)	(2)	(3)	(4)	(5)
	Technical	Non-technical	External	Internal	Complexity
Panel (a): logit model					(OLS)
Competition(t-1)	0.027***	0.022**	0.031***	0.020***	0.015***
	(0.005)	(0.009)	(0.008)	(0.007)	(0.003)
Competition^2(t-1)	−0.003***	−0.002**	−0.002***	−0.001**	−0.001***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
Observations	9161	9221	9252	9164	8271
Pseudo (Adj.) R^2	0.04	0.04	0.05	0.06	(0.07)
Wald (F) test — H0: all coefficients = 0	0.0000	0.0000	0.0000	0.0000	(0.0000)
Lind-Melhum test					
Extreme point	5.34	7.04	6.33	5.93	6.49
Lower bound slope	0.10	0.06	0.11	0.08	0.013
	[5.61; 0.000]	[2.38; 0.008]	[3.64; 0.000]	[2.65; 0.004]	[4.48; 0.000]
Upper bound slope	−0.11	−0.04	−0.07	−0.067	−0.008
	[−4.08; 0.000]	[−1.65; 0.04]	[−3.89; 0.000]	[−3.23; 0.000]	[−2.90; 0.004]
Overall test	[4.08; 0.000]	[1.65; 0.04]	[3.64; 0.000]	[2.65; 0.004]	[2.90; 0.004]
90% Fieller CI	[4.47; 6.04]	[5.71; 9.95]	[5.27; 7.24]	[4.42; 6.99]	[5.36; 7.96]
Panel (b): SUR model					
Competition(t-1)	0.024***	0.021***	0.030***	0.017**	
	(0.008)	(0.008)	(0.008)	(0.008)	
Competition^2(t-1)	−0.002***	−0.001**	−0.002***	−0.001**	
	(0.001)	(0.001)	(0.001)	(0.001)	
Observations	9121	9121	9155	9155	
R^2	0.06	0.06	0.06	0.07	
F test — H0: all coefficients = 0	0.0000	0.0000	0.0000	0.0000	
Correlation matrix of residuals					
Technical	1.00				
Non-technical	0.36	1.00			
External			1.00		
Internal			0.43	1.00	

Notes: Authors' calculations on SAFE data. Cluster robust standard errors in parentheses. Cluster level: country. T-values and p-values in square brackets. ***p<0.01, **p<0.05, *p<0.1. The dependent variables are, technical (col.1), non-technical (col.2), external (col.3), internal (col.4), innovation dummies and innovation complexity (col.5). The set of firms' controls includes size, turnover, age, legal status, ownership types, and past growth. Each column includes firms' controls and time, country, sector FE

Table 8 Frequency of innovation

	Freq.	*Percent*
No innovation (0/3)	1,305	19.96
Low frequency (1/3)	1,331	20.36
Medium frequency (2/3)	1,620	24.78
High frequency (3/3)	2,281	34.89

Notes: Authors' calculations on SAFE data

Figure 7 provides preliminary evidence about the relationship between the frequency of innovation and the average perceived level of competition. As it emerges, the frequency initially increases with competition and then it slightly declines. We specify the new regression as follows:

$$\begin{aligned} Innov\_freq_{i,c,s,t} = \alpha &+ \beta_1 Comp\_mean_{i,c,s,t} \\ &+\beta_2 Comp\_mean^2_{i,c,s,t} \\ &+\beta_j X_{i,c,s,t} + \eta_c + \theta_s \\ &+\epsilon_{i,c,s,t}, \end{aligned} \quad (3)$$

where $X_{i,c,s,t}$ is the usual firms' controls vector, including the same variable of regressions (1) and (2). To account for unobserved heterogeneity, not only do we include country and sector fixed effects, we also cluster the standard errors at country level. Given the average dimension of the dependent and the main independent variable of interest, we only consider the end-period year and, thus, we do not include time dummies. We estimate regression (3) for the full sample (col.1) and for micro firms only (col.2) using OLS. Table 9 shows that, considering the full sample, for low starting level of competition, an increase in the perceived level of competition is positively associated with the frequency of innovation, while negatively when the starting level is high.[21] This specification is robust to the Lind and Mehlum test. Looking at the coefficients for micro firms, although they have the same signs as column 1, they are not statistically significant. This might be due by the limited number of observations and it suggests that the results for the full sample are mainly driven by larger firms.[22] Thus, at least for the overall sample of MSMEs, the estimates show that, together with innovation status and complexity, a non-monotone relationship in the form of an inverted-U curve occurs also between competition and frequency of innovation.

7 Conclusion

Micro businesses are often considered to be marginal players in innovation. Due to the greater interest in large companies and the scarcity of comprehensive data, several aspects of their innovative behavior are still unexplored. This fact is surprising, as micro enterprises represent the largest share of firms in the non-financial business sector.

With this paper, we contribute to filling this gap by examining whether and how these companies innovate and by empirically investigating how competition affects their innovative activity. Exploring a large sample of small businesses across 28 European Union member states, we find that a non-negligible share of innovative firms have fewer than 10 employees. We also find evidence of an inverted-U-shaped relationship between innovation and competition, whereby when the latter increases, the former goes along if the initial level of competition is low, while it slightly declines if the initial level is high. The results hold for all firms regardless of their size, while some differences in the size of the effects emerge when we consider different typologies of innovation. Indeed, competition has a stronger relationship with technical and external innovation. In this regard, we contribute to reducing the knowledge gap between large and very small companies in terms of innovation by providing a first empirical exploration of the innovation-competition nexus for microbusinesses. By including them, we provide elements to the understanding of innovative patterns and activities in firms of all size.

We also know that the self-reported nature of the dataset we rely on, despite being unique in terms of micro firms coverage, raises some measurement concerns and that some important characteristics of

[21] As for innovation complexity, we replicate the estimation using both fractional and Poisson regressions. For the latter, the count dependent variable is used. The findings reported in Table 9 are confirmed. Results are available in Table OA3 in the Online Appendix.

[22] We check this hypothesis by doing regressions considering small and medium firms only. Statistically significant quadratic estimates emerge indeed for medium firms only. Results are available in Table OA4 in the Online Appendix.

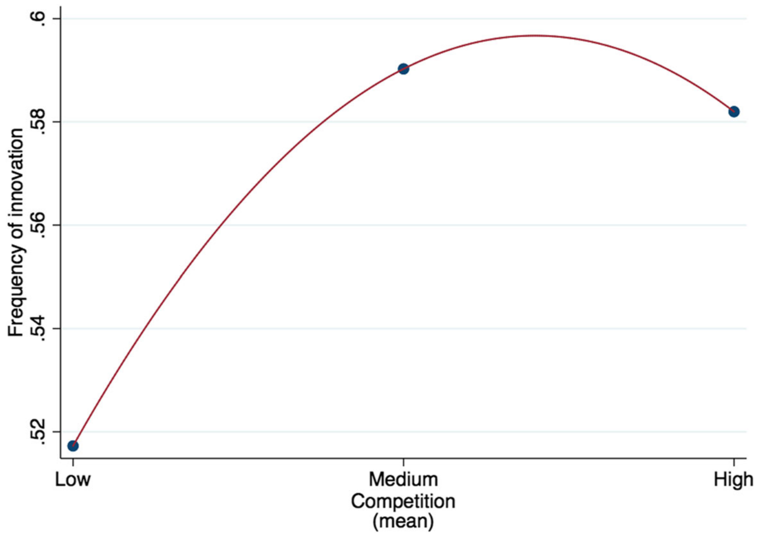


Fig. 7 Competition and frequency of innovation. Notes: Authors' calculations on SAFE data. The figure plots the frequency of innovation over competition. The statistics refer to the five Common round waves from 2014 to 2018

innovation and competition are not considered. For instance, the survey does not allow for distinguishing between radical and incremental innovation or between *ex ante*/*ex post* and product/credit market competition, which would be interesting to include in future research. Moreover, the small panel component

Table 9 Frequency of innovation

	(1) Full sample	(2) Micro firms
Competition (mean)	0.043***	0.014
	(0.010)	(0.019)
Competition (mean)^2	−0.003***	−0.001
	(0.001)	(0.002)
Firms controls	Yes	Yes
Country, sector FE	Yes	Yes
Observations	6,376	2160
Adj. R^2	0.08	0.08
F test — H0: all coefficients = 0	0.0000	0.0000
Lind-Mehlum test		
Extreme point	6,95	9.57
Lower bound slope	0.04	0.01
	[4.33; 0.000]	[0.82; 0.21]
Upper bound slope	−0.02	−0.00
	[−2.69; 0.006]	[−0.03; 0.48]
Overall test	[2.69; 0.006]	[0.03; 0.48]
90% Fieller CI	[5.89; 8.36]	[−inf; +inf]

Notes: Authors' calculations on SAFE data. Cluster robust standard errors in parentheses. Cluster level: country. T-values and p-values in square brackets. ***$p<0.01$, **$p<0.05$, *$p<0.1$. The table reports the OLS estimates using sampling weights. The dependent variable is *frequency of innovation.*. The set of firms' controls includes size, turnover, age, legal status, ownership types, and past growth. Country and sector FE are included of the survey prevents us from developing a rigorous longitudinal analysis that establishes causation. A larger and strongly balanced panel would have also allowed to explore the effect of different lags of competition on current innovation. However, we are not aware of other dataset including such a large number of micro firms with explicit questions on firm-level innovation and perceived competition. Thus, although more details about innovation and competition for micro firms would be helpful to develop further analyses, we consider this paper to be a starting point for exploiting the available information. Indeed, our findings suggest that firms with fewer than 10 employees should be considered as relevant players in innovation and, therefore, included in innovation research. They could also provide interesting policy implications. As long as competition fosters innovation by small businesses, but excessive competition can hamper it, promoting well-balanced competitive markets appear crucial for enabling smaller firms to exploit their full innovation potential. Another implication is that small firms seeking the protection of a market niche to avoid competition and to have better chance of survival could see their innovative activity reduced. A strong protection from competition, when its starting level is not excessively high, can increase MSMEs lifetime, but also limit their innovation potential. This implies that a right balance between survival needs and innovation growth should be pursued by small businesses' entrepreneurs and promoted by policy makers. Moreover, our findings imply that policies aimed at supporting microbusinesses' innovation should take into account that the intensity of the effect of competition is not unique, but it varies according to the different types of innovation. Deepening how the competition-innovation relationship varies with innovation types might represent a further stimulating goal for future research. Finally, our analysis is limited to the EU economy. It could be explored whether similar or different findings emerge for other regions or countries.

Appendix. Additional figures and tables

Correlation between innovation indicators In Table 11, we correlate the SAFE country percentages of innovative firms with three alternative measures

Table 10 Observations by country — Full sample

Country	*Freq.*	*Percent*	*Micro*	*Small*	*Medium*
Austria	2,282	3.02	770	823	689
Belgium	2,239	2.96	983	692	594
Bulgaria	2,280	3.01	746	746	788
Croatia	1,291	1.71	463	388	440
Cyprus	476	0.63	176	147	153
Czech Rep.	1,990	2.63	715	593	682
Denmark	2,174	2,87	595	811	768
Estonia	473	0.63	151	150	172
Finland	2,248	2.97	824	753	671
France	6,509	8.60	2,586	2,061	1,859
Germany	6,375	8.42	1,701	2,337	2,337
Greece	2,384	3.15	1,489	549	346
Hungary	2,214	2.93	927	643	644
Ireland	2,296	3.03	797	775	724
Italy	6,994	9.24	3,719	1,983	1,292
Latvia	900	1.19	266	315	319
Lithuania	1,363	1.80	371	474	518
Luxembourg	447	0.59	123	150	174
Malta	472	0.62	173	148	151
Netherlands	3,618	4.78	1,388	1,111	1,119

Table 10 (continued)

Country	*Freq.*	*Percent*	*Micro*	*Small*	*Medium*
Poland	5,827	7.70	2,817	1,180	1,830
Portugal	2,355	3.11	1,161	669	525
Romania	2,167	2.86	639	714	814
Slovakia	1,983	2.62	849	573	561
Slovenia	890	1.18	323	245	322
Spain	5,959	7.87	2,834	1,807	1,318
Sweden	2,096	2.77	676	720	700
UK	5,374	7.10	1,692	1,961	1,721
Total	75,673	100.00	29,954	23,518	22,201
			(39%)	(31%)	(30%)

Notes: The table reports the number of observations for each of the 28 EU countries considered in the sample over the 2014–2018 period

derived from the Community Innovation Survey (CIS), covering all the EU27 countries (excluding the UK). From the CIS 2018, as reported in Eurostat, we select results for the country percentages during 2016 and 2018 of (i) firms with innovation activities; (ii) firms with research and development (R&D) activities; and (iii) firm turnover from new or significantly improved products. Columns (1) to (3) in panel (a) show positive and statistically significant correlations between our measure of innovation and the CIS measures. In panel (b) we do the same exercise, but excluding Romania (where the SAFE over-estimation of innovative firms is higher); we find that the correlations look stronger with higher significance levels. Overall, despite overestimating firms' innovative activity in some countries, our measure moves in the same direction as the considered alternative indicators.

Table 11 Innovation measures correlations

	(1) Firms with innovation activities (CIS)	(2) Firms with R&D (CIS)	(3) Turnover from new products (CIS)
Panel (a)			
Innovative (SAFE)	0.3353*	0.3264*	0.3827*
10–249 employees	(0.0873)	(0.0966)	(0.0537)
Countries	27	27	26
Panel (b): excluding Romania			
Innovative (SAFE)	0.4515**	0.3931**	0.4153**
10–249 employees	(0.0206)	(0.0470)	(0.0390)
Countries	26	26	25

Notes: The table reports the correlation between the SAFE country percentages of innovative firms and the CIS 2018 country percentages of (1) firms with innovation activities; (2) firms with R&D activities; and (3) firms turnover from new or significantly improved products. $^{***}p<0.01$, $^{**}p<0.05$, $^{*}p<0.1$. *p*-values in parentheses

Table 12 Descriptive statistics

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Innovative (*innov*)	75,673	0.57	0.49	0	1
Product innovation	74,552	0.34	0.47	0	1
Process innovation	70,507	0.26	0.44	0	1
Organization innovation	75,029	0.28	0.45	0	1
Marketing innovation	75,025	0.25	0.43	0	1
Competition (*comp*)	75,673	6.11	2.57	1	10
Firms size					
Micro (1–9 empl.)	75,673	0.39	0.49	0	1
Small (10–49 empl.)	75,673	0.31	0.46	0	1
Medium (50–249 empl.)	75,673	0.30	0.45	0	1
Sector					
Industry	75,673	0.23	0.42	0	1
Construction	75,673	0.12	0.32	0	1
Trade	75,673	0.26	0.44	0	1
Services	75,673	0.39	0.49	0	1
Age					
Years < 2	75,578	0.01	0.11	0	1
2 <= years < 5	75,578	0.05	0.22	0	1
5 <= years < 10	75,578	0.13	0.34	0	1
Years >= 10	75,578	0.81	0.39	0	1
Turnover (t)					
Up to 500th	73,424	0.29	0.45	0	1
500th < t <= 1mln	73,424	0.14	0.34	0	1
1mln < t <= 2mln	73,424	0.13	0.33	0	1
2mln < t <= 10mln	73,424	0.25	0.43	0	1
10mln < t <= 50mln	73,424	0.16	0.33	0	1
t > 50mln	73,424	0.03	0.18	0	1
Ownership type					
Public shareholders	75,475	0.03	0.33	0	1
Family or entrepreneurs	75,475	0.41	0.49	0	1
Other firms or business associate	75,475	0.13	0.33	0	1
Venture capital or business angel	75,475	0.01	0.09	0	1
Single owner	75,475	0.39	0.49	0	1
Others	75,475	0.04	0.19	0	1
Legal form					
Autonomous	75,673	0.86	0.35	0	1
Turnover past growth					
Over 20%	73,696	0.16	0.36	0	1
Less than 20%	73,696	0.46	0.50	0	1
No growth	73,696	0.21	0.41	0	1
Got smaller	73,696	0.16	0.37	0	1

Notes: This table reports the unweighted descriptive statistics for the variables used in the empirical tests. It covers the five Common round waves over the 2014–2018 period

Table 13 Main variables definitions

Variable	*Definition*
Innovative (*innov*)	Dummy equal to 1 if the firm introduced in the last 12 months at least one of the following: (a) a new or significantly improved product or service to the market; (b) a new or significantly improved production process or method; (c) a new organization of management; (d) a new way of selling goods or services.
Product innovation	Dummy equal to 1 if the firm introduced (a)
Process innovation	Dummy equal to 1 if the firm introduced (b)
Organization innovation	Dummy equal to 1 if the firm introduced (c)
Marketing innovation	Dummy equal to 1 if the firm introduced (d)
Technical innovation	Dummy equal to 1 if the firm introduced (a) or (b)
Non-technical innovation	Dummy equal to 1 if the firm introduced (c) or (d)
External innovation	Dummy equal to 1 if the firm introduced (a) or (d)
Internal innovation	Dummy equal to 1 if the firm introduced (b) or (c)
Competition (*comp*)	Continuous variable with values from 1 to 10. Firms are asked how important have been the competition problem in the past six months from 1 (not at all) to 10 (extremely important).
Micro (1–9 empl.)	Dummy equal to 1 if the firms declared to have from 1 to 9 employees.
Small (10–49 empl.)	Dummy equal to 1 if the firms declared to have from 10 to 49 employees.
Medium (50–249 empl.)	Dummy equal to 1 if the firms declared to have from 50 to 249 employees.
Innovation complexity	Continuous (normalized) variable indicating the number of types of innovation introduced by the firm. It is equal to 0 if the firm introduces 0 types, 0,25 if 1, 0,50 if 2, 0,75 if 3, and 1 if 4.
Frequency of innovation	Continuous (normalized) variable indicating the number of years in which the firm introduced at least one type of innovation. It is derived from a 3 year weakly balanced panel. It can take values 0 (never innovative over the three years), 0.33 (innovative in one of the three years, 0.66 (innovative in two of the three years), and 1 (innovative in all the three years).

Notes: The table provides detailed definitions of the dependent and main independent variables used in the empirical analysis

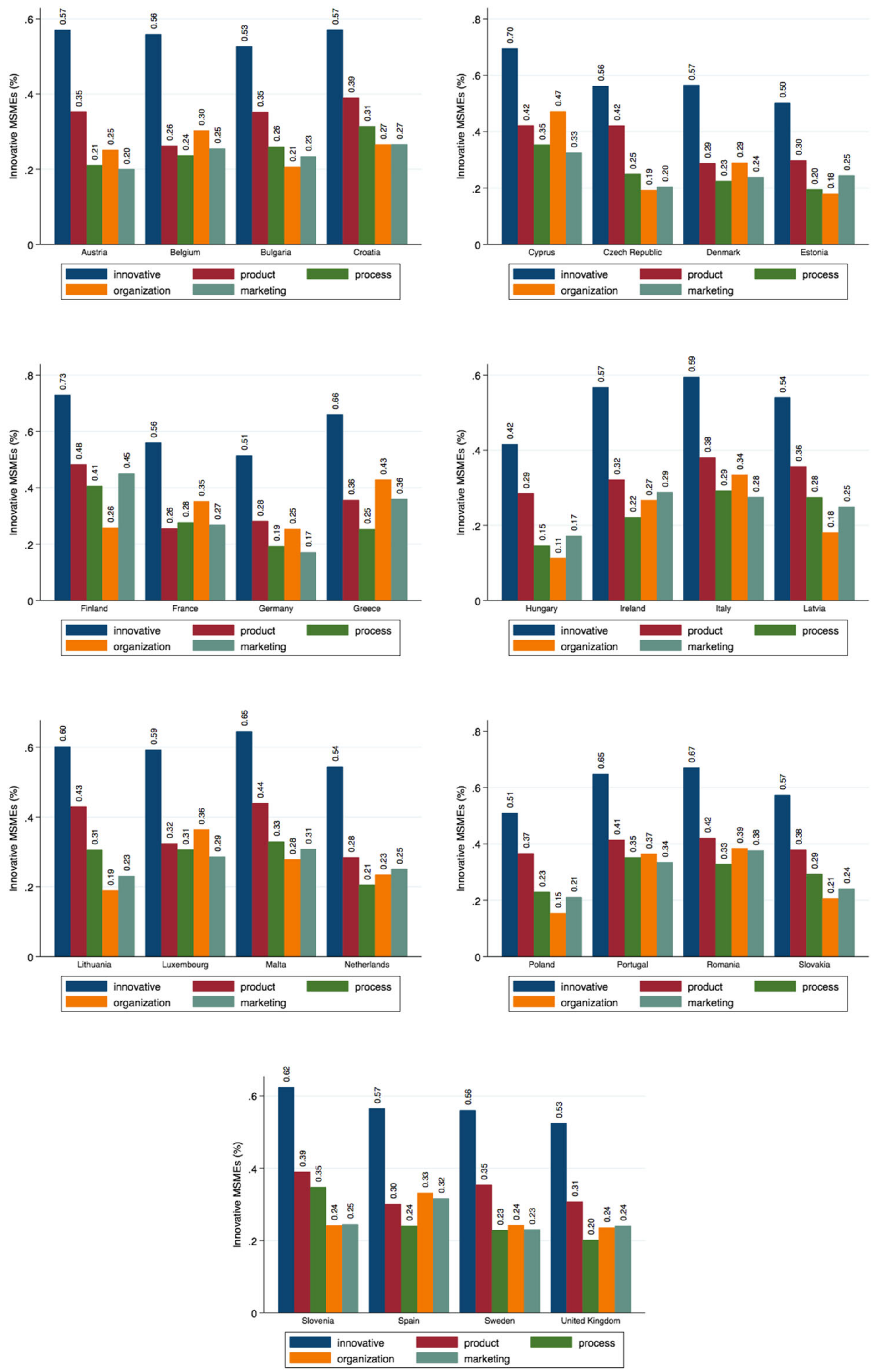


Fig. 8 Innovative firms by country. Notes: Authors' calculations on SAFE data. The figure reports the weighted percentage of firms that introduced at least one types of innovation (innovative) and product, process, organization, marketing innovation in each country. The statistics refer to the five Common round waves from 2014 to 2018

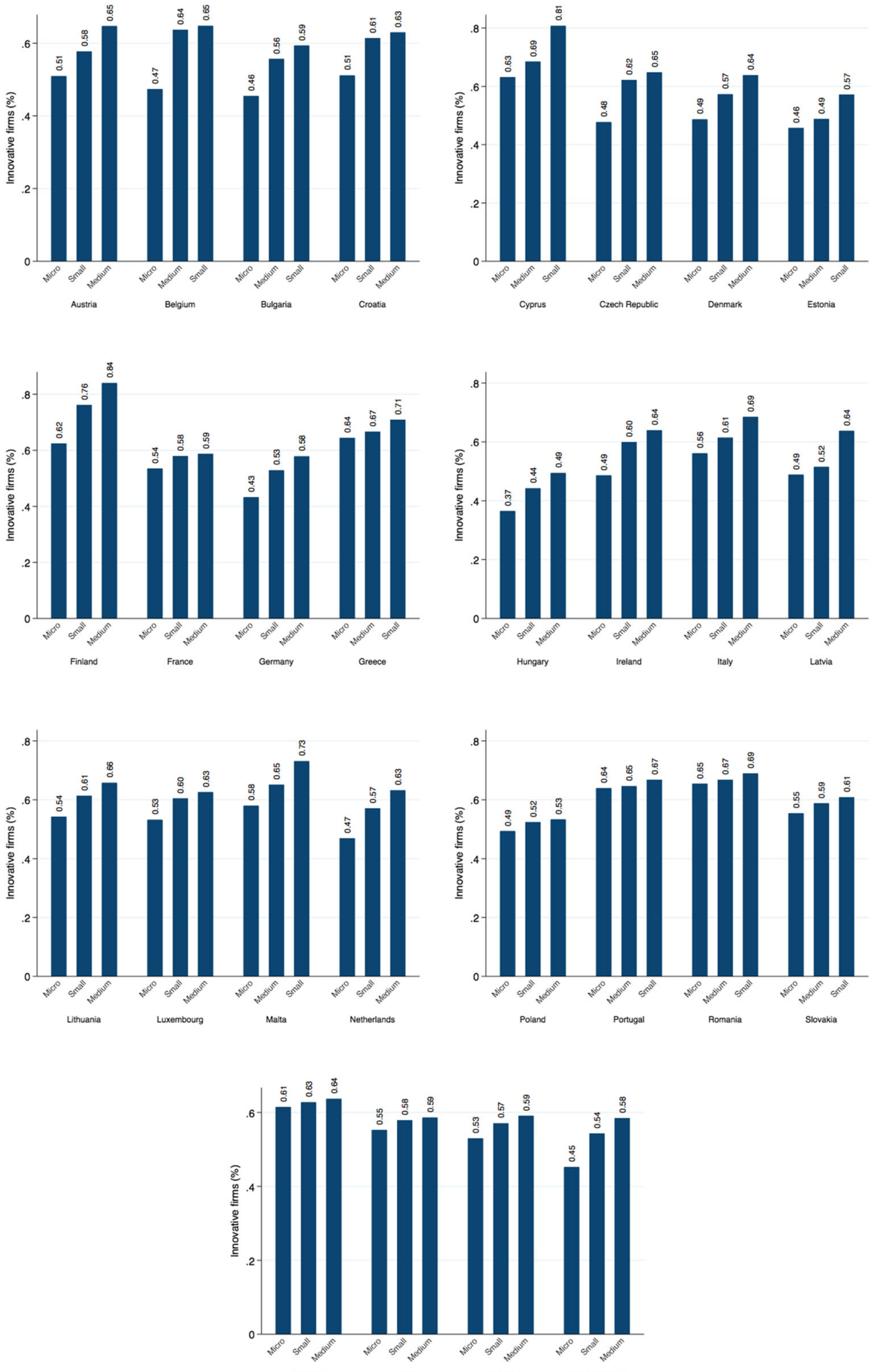


Fig. 9 Innovative firms by country and size. Notes: Authors' calculations on SAFE data. The figure reports the weighted percentage of innovative firms by size in each country. The statistics refer to the five Common round waves from 2014 to 2018

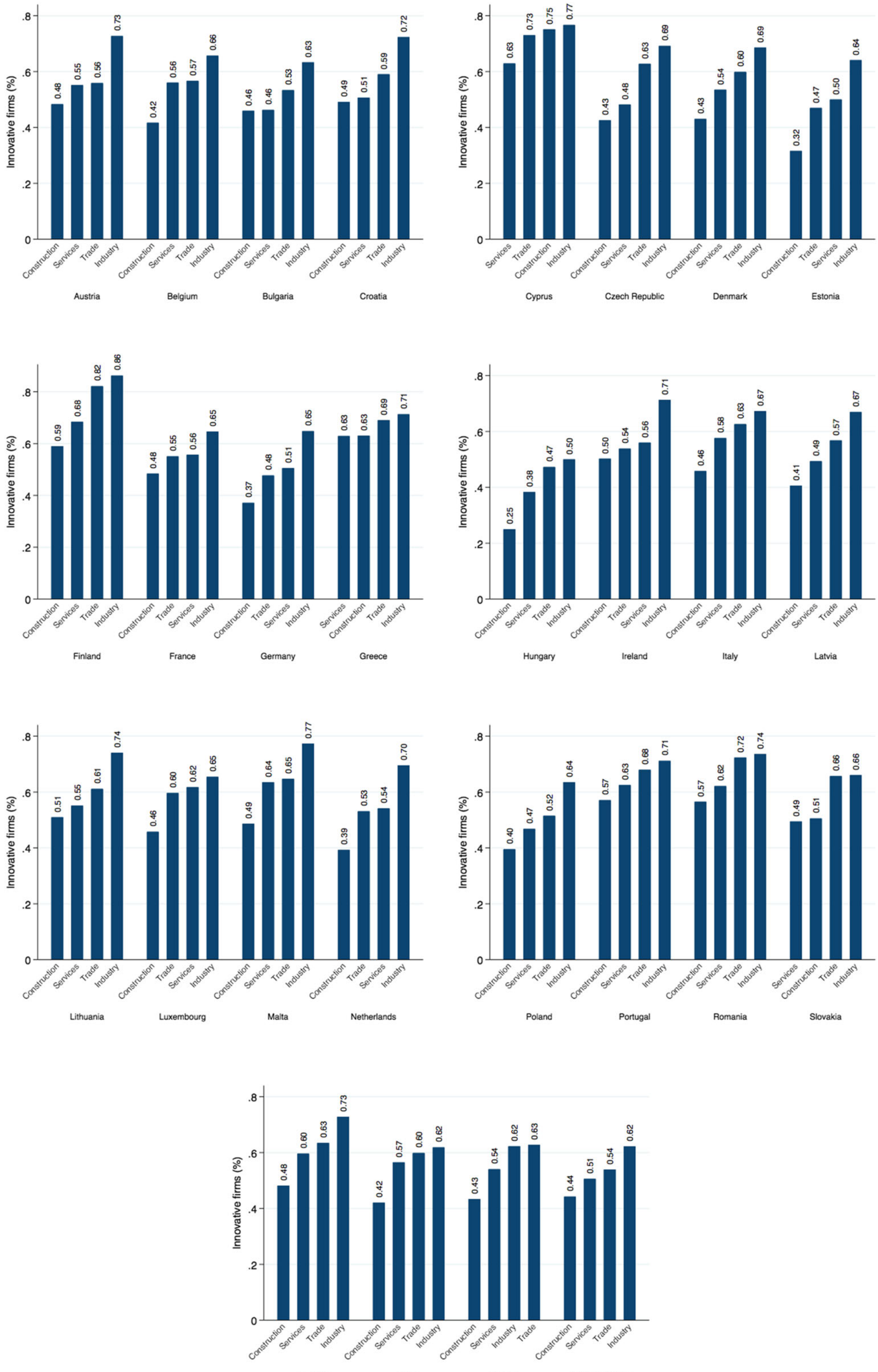


Fig. 10 Innovative firms by country and sector. Notes: Authors' calculations on SAFE data. The figure reports the weighted percentage of innovative firms by sector in each country. The statistics refer to the five Common round waves from 2014 to 2018

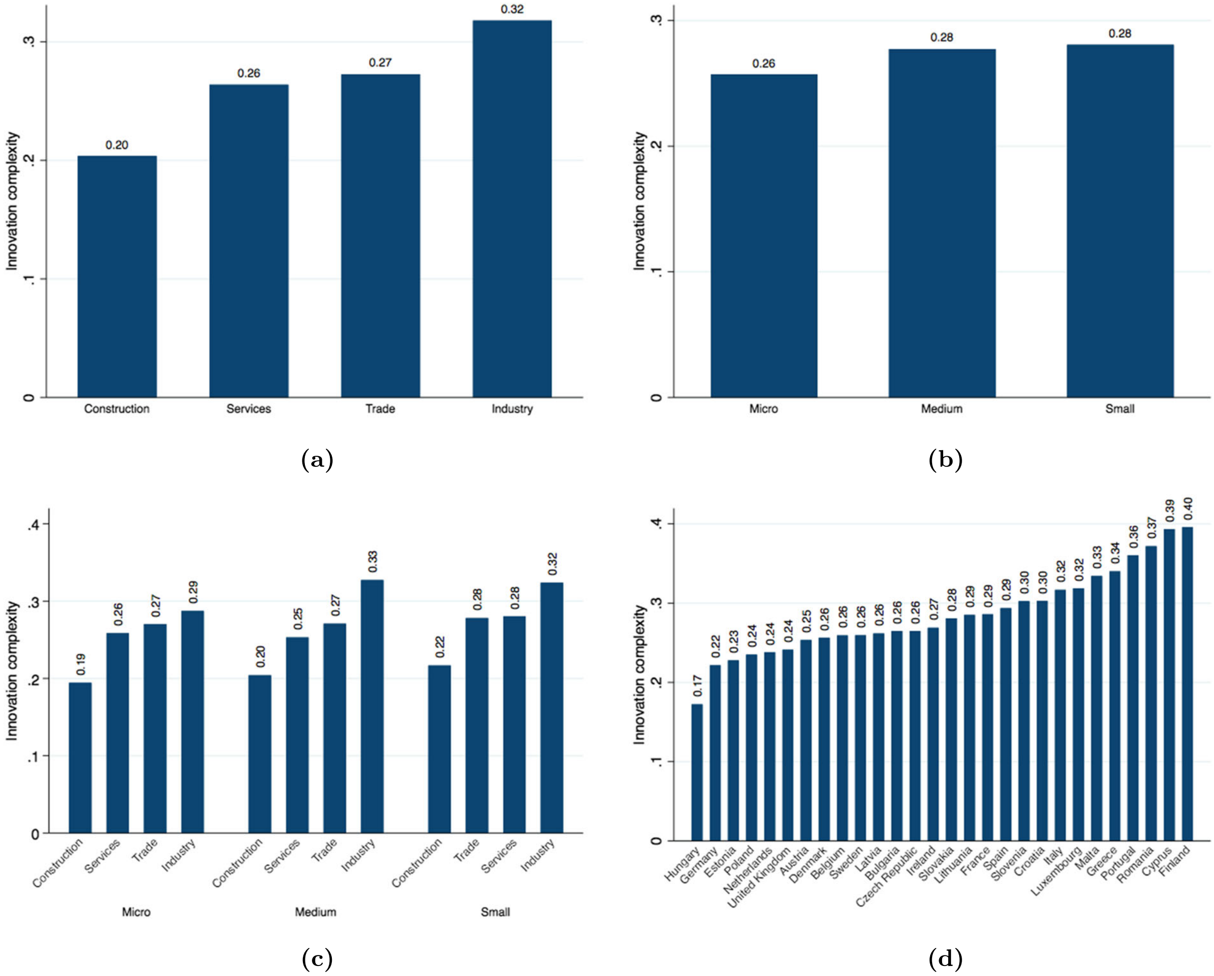
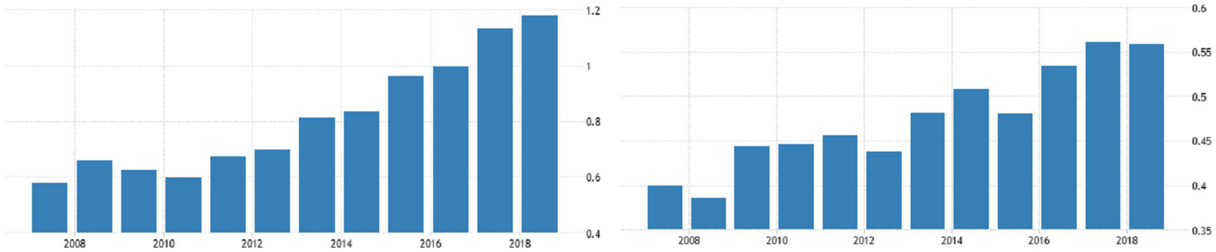


Fig. 11 Innovation complexity by firm size, sector, and country. Notes: Authors' calculations on SAFE data. The figure reports the weighted average level of innovation complexity by sector (a), size (b), sector and size, (c) and country (d). The statistics refer to the five Common round waves from 2014 to 2018

Table 14 Observations by country — Panel component

Country	*Freq.*	*Percent*	*Micro*	*Small*	*Medium*
Austria	1,287	2,95	382	492	413
Belgium	1,187	2.72	500	368	319
Bulgaria	1,232	2.82	387	376	469
Croatia	676	1.55	222	214	240
Cyprus	245	0.56	108	62	75
Czech Rep.	1,046	2.39	325	306	415
Denmark	1,394	3,19	367	524	504
Estonia	207	0.47	64	59	84
Finland	1,311	3.00	464	465	382
France	3,930	9.00	1,446	1,283	1,201
Germany	3,503	8.02	812	1,314	1,377
Greece	1,379	3.15	857	297	222
Hungary	1,287	2.95	546	367	374
Ireland	1,267	2.90	410	466	391
Italy	4,616	10.57	2,266	1,394	956
Latvia	442	1.01	118	148	176
Lithuania	754	1.73	191	259	304
Luxembourg	280	0.64	70	99	111
Malta	301	0.69	109	92	100
Netherlands	2,051	4.69	692	674	685
Poland	3,512	8.04	1,638	674	1,200
Portugal	1,303	2.98	594	392	317
Romania	1,201	2.75	347	282	472
Slovakia	1,016	2.33	383	309	324
Slovenia	496	1.14	185	129	182
Spain	3,763	8.61	1,675	1,244	844
Sweden	1,187	2.49	355	399	333
UK	2,918	6.68	914	1,070	934
Total	43,688	100.00			

Notes: This table reports the number of observations for each of the 28 EU countries when panel components only are included in the sample. It covers the five Common round waves over the 2014–2018 period



(a) Cyprus (b) Greece

Fig. 12 R&D expenditures (% of GDP). World Bank

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References

Acs, Z. J., & Audretsch, D. B. (1987). Innovation, market structure, and firm size. *The Review of Economics and Statistics*, *69*(4), 567–574.

Acs, Z. J., & Audretsch, D. B. (1988). Innovation in large and small firms: an empirical analysis. *American Economic Review*, *78*(4), 678–690.

Acs, Z. J., & Audretsch, D. B. (2005). Entrepreneurship, innovation, and technological change. *Foundations and Trends in Entrepreneurship*, *1*(4), 1–65.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P. (2005). Competition and innovation: An inverted-U relationship. *The Quarterly Journal of Economics*, *120*(2), 701–728.

Aghion, P., & Howitt, P. (1992). A model of growth through creative destruction. *Econometrica*, *60*(2), 323–351.

Anderson, C. R., & Paine, F. T. (1975). Managerial perceptions and strategic behavior. *Academy of Management Journal*, *18*(4), 811–823.

Angrist, J. D., & Pischke, J.-S. (2008). *Mostly harmless econometrics: An empiricist's companion*. Princeton University Press.

Arrow, K. J. (1962). Economic welfare and the allocation of resources for invention. In *Readings in Industrial Economics* (pp. 219–236). Springer.

Askenazy, P., Cahn, C., & Irac, D. (2013). Competition, R&D and the cost of innovation: evidence for France. *Oxford Economic Papers*, *65*(2), 293–311.

Audretsch, D. B., Kritikos, A. S., & Schiersch, A. (2020). Microfirms and innovation in the service sector. *Small Business Economics*, *55*(4), 997–1018.

Ayyagari, M., Demirgüċ-Kunt, A., & Maksimovic, V. (2011). Firm innovation in emerging markets: The role of finance, governance, and competition. *Journal of Financial and Quantitative Analysis*, *46*(6), 1545–1580.

Baumann, J., & Kritikos, A. S. (2016). The link between R&D innovation and productivity: Are micro firms different? *Research Policy*, *45*(6), 1263–1274.

Beyer, J. M., Chattopadhyay, P., George, E., Glick, W. H., Ogilvie, D., & Pugliese, D. (1997). The selective perception of managers revisited. *Academy of Management Journal*, *40*(3), 716–737.

Blundell, R., Griffith, R., & Van Reenen, J. (1999). Market share, market value and innovation in a panel of British manufacturing firms. *The Review of Economic Studies*, *66*(3), 529–554.

Cabagnols, A., & Le Bas, C. (2002). Differences in the determinants of product and process innovations: the French case. In *Innovation and firm performance* (pp. 112–149). Springer.

Castellacci, F. (2011). How does competition affect the relationship between innovation and productivity? Estimation of a CDM model for Norway. *Economics of Innovation and New Technology*, *20*(7), 637–658.

Cooper, A. C., Willard, G. E., & Woo, C. Y. (1986). Strategies of high performing new and small firms: a reexamination of the niche concept. *Journal of Business Venturing*, *1*(3), 247–260.

Cornett, M. M., Erhemjamts, O., & Tehranian, H. (2019). Competitive environment and innovation intensity. *Global Finance Journal*, *41*, 44–59.

Crowley, F., & Jordan, D. (2017). Does more competition increase business-level innovation? Evidence from domestically focused firms in emerging economies. *Economics of Innovation and New Technology*, *26*(5), 477–488.

Dasgupta, P., & Stiglitz, J. (1980). Industrial structure and the nature of innovative activity. *The Economic Journal*, *90*(358), 266–293.

Demircioglu, M. A., Audretsch, D. B., & Slaper, T. F. (2019). Sources of innovation and innovation type: firm-level evidence from the United States. *Industrial and Corporate Change*, *28*(6), 1365–1379.

European Commission (2019). *SME Annual Report 2018-2019*. EC.

Ferrando, A., Popov, A., & Udell, G. F. (2019). Do SMEs benefit from unconventional monetary policy and how? Microevidence from the Eurozone. Journal of Money. *Credit and Banking*, *51*(4), 895–928.

Ferrando, A., Rossi, S. P., Bonanno, G., & et al. (2020). Determinants of firms' efficiency: do innovations and finance constraints matter? The case of European SMEs. Working Paper Series No. 2419, European Central Bank.

Friesenbichler, K., & Peneder, M. (2016). Innovation, competition and productivity: Firm-level evidence for Eastern Europe and Central Asia. *Economics of Transition*, *24*(3), 535–580.

Galdon-Sanchez, J. E., & Schmitz, J. A. Jr. (2002). Competitive pressure and labor productivity: World iron-ore markets in the 1980's. *American Economic Review*, *92*(4), 1222–1235.

Geroski, P. A. (1990). Innovation, technological opportunity, and market structure. *Oxford Economic Papers*, *42*(3), 586–602.

Geroski, P. A., et al. (1995). MARKET STRUCTURE, CORPORATE PERFORMANCE, AND INNOVATIVE ACTIVITY. Oxford University Press.

Haans, R. F., Pieters, C., & He, Z. -L. (2016). Thinking about U: Theorizing and testing U-and inverted U-shaped relationships in strategy research. *Strategic Management Journal*, *37*(7), 1177–1195.

Hall, B. H., & Harhoff, D. (2012). Recent research on the economics of patents. *Annual Review of Economics*, *4*(1), 541–565.

Halpern, L., & Muraközy, B. (2015). The relationship between competition and R&D: Theoretical approaches and quantitative results. Hungarian Institute of Economics, Centre for Economic and Regional Studies.

Hashmi, A. R. (2013). Competition and innovation: The inverted-U relationship revisited. *Review of Economics and Statistics*, *95*(5), 1653–1668.

Henley, A., & Song, M. (2020). Innovation, internationalisation and the performance of microbusinesses. *International Small Business Journal*, *38*(4), 337–364.

Kamien, M. I., & Schwartz, N. L. (1976). On the degree of rivalry for maximum innovative activity. *The Quarterly Journal of Economics*, *90*(2), 245–260.

Karaman, F. N., & Lahiri, S. (2014). Competition and innovation in product quality: Theory and evidence from Eastern Europe and Central Asia. *The BE Journal of Economic Analysis & Policy*, *14*(3), 979–1014.

Kraft, K. (1989). Market structure, firm characteristics and innovative activity. *The Journal of Industrial Economics*, 329–336.

Lind, J. T., & Mehlum, H. (2010). With or without U? The appropriate test for a U-shaped relationship. *Oxford Bulletin of Economics and Statistics*, *72*(1), 109–118.

Mairesse, J., & Mohnen, P. (2010). Using innovation surveys for econometric analysis. In *Handbook of the Economics of Innovation*, (Vol. 2 pp. 1129–1155). Elsevier.

Martínez-Ros, E., & Labeaga, J. M. (2002). Modelling innovation activities using discrete choice panel data models. In *Innovation and Firm Performance* (pp. 150–171). Springer.

Miravete, E. J., & Pernias, J. C. (2006). Innovation complementarity and scale of production. *The Journal of Industrial Economics*, *54*(1), 1–29.

Moen, Ø., Tvedten, T., & Wold, A. (2018). Exploring the relationship between competition and innovation in Norwegian SMEs. *Cogent Business & Management, 5*(1), 1564167.

Mulkay, B. (2019). How does competition affect innovation behaviour in French firms? *Structural Change and Economic Dynamics*, *51*(C), 237–251.

Nickell, S. J. (1996). Competition and corporate performance. *Journal of Political Economy*, *104*(4), 724–746.

OECD (2005). *Oslo manual 2005: Guidelines for collecting and interpreting innovation data*. Organisation for Economic Co-operation and Development (OECD).

OECD (2018). Oslo Manual 2018: Guidelines for collecting, reporting and using data on innovation. Organisation for Economic Co-operation and Development (OECD).

OECD (2019). *SME and Entrepreneurship Outlook 2019*. Organisation for Economic Co-operation and Development (OECD).

OECD (2021). *Methodologies to Measure Market Competition*. Organisation for Economic Co-operation and Development (OECD).

Pavitt, K., Robson, M., & Townsend, J. (1987). The size distribution of innovating firms in the UK: 1945-1983. *The Journal of Industrial Economics*, *35*(3), 297–316.

Peneder, M., & Wörter, M. (2014). Competition, R&D and innovation: testing the inverted-U in a simultaneous system. *Journal of Evolutionary Economics*, *24*(3), 653–687.

Porter, M. E. (1990). The competitive advantage of nations. *Harvard Business Review*, *68*(2), 73–93.

Rammer, C., & Schubert, T. (2018). Concentration on the few: mechanisms behind a falling share of innovative firms in Germany. *Research Policy*, *47*(2), 379–389.

Reed, W. R. (2015). On the practice of lagging variables to avoid simultaneity. *Oxford Bulletin of Economics and Statistics*, *77*(6), 897–905.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, *98*(5, Part 2), S71–S102.

Roper, S., & Hewitt-Dundas, N. (2017). Investigating a neglected part of Schumpeter's creative army: what drives new-to-the-market innovation in micro-enterprises? *Small Business Economics*, *49*(3), 559–577.

Santos, A., & Cincera, M. (2021). Determinants of financing constraints. *Small Business Economics*, *3*(2), 1–13.

Scherer, F. M. (1967). Market structure and the employment of scientists and engineers. *The American Economic Review*, *57*(3), 524–531.

Schumpeter, J. (1942). *Capitalism, socialism and democracy*. New York.

Siepel, J., & Dejardin, M. (2020). How do we measure firm performance? A review of issues facing entrepreneurship researchers. In *Handbook of Quantitative Research Methods in Entrepreneurship* (pp. 4–20). Edward Elgar Publishing.

Spence, A. M. (1984). Industrial organization and competitive advantage in multinational industries. *American Economic Review*, *74*(2), 356–360.

Symeonidis, G. (1996). Innovation, firm size and market structure: Schumpeterian hypotheses and some new themes. *OECD*.

Tang, J. (2006). Competition and innovation behaviour. *Research Policy*, *35*(1), 68–82.

Tingvall, P., & Poldhal, A. (2006). Is there really an inverted U-shaped relation between competition and R&D? *Economics of Innovation and New Technology*, *15*(2), 101–118.

Tu, C., Hwang, S.-N., & Wong, J. -Y. (2014). How does cooperation affect innovation in micro-enterprises? *Management Decision*, *52*(8), 1390–1409.

Vives, X. (2008). Innovation and competitive pressure. *Journal of Industrial Economics*, *56*(3), 419–469.