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Financing instruments and challenges for innovation in the EU: Panel evidence from the SAFE survey

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Financing Instruments and Challenges for Innovation in the EU: Panel Evidence from the SAFE Survey.



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Erik CANTON



*Research and
Innovation*

Financing Instruments and Challenges for Innovation in the EU: Panel Evidence from the SAFE Survey

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Financing Instruments and Challenges for Innovation in the EU: Panel Evidence from the SAFE Survey



Working paper

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ABSTRACT

This paper studies the firm-level drivers of product, process, organisation and marketing innovation in the EU with panel data from 2009 to 2021. Employing conditional logit and linear probability models we investigate how firms' characteristics, firms' sources of financing, and firm perception of different challenges influence their likelihood to innovate. In line with the academic literature, we find that firms' size and profit level improve firms' innovation performance, while firms' age decreases it. We also observe that the effectiveness of different financing instruments varies considerably depending on whether the company is pursuing product, process, organisation or marketing innovation. Finally, innovative firms more frequently report access to finance and regulations as important challenges for their future, while the relevance of other challenges (e.g. the availability of skilled staff or finding customers) varies depending on what type of innovation activities companies are engaged in.

1 Introduction¹

Innovation is one of the key drivers of economic growth. Fostering innovation and creating a fertile innovation landscape for firms to grow and thrive have become even more imperative in the aftermath of the COVID-19 pandemic. Innovative enterprises showed better adaptation capacities to the shock than other enterprises, confirming the role of innovation as a key factor for economic resilience. From a policy perspective, we need to understand what the determinants of innovation activity by firms are. Accelerating the development and diffusion of innovative ideas and inventions is at the heart of the EU's strategy to boost productivity growth, competitiveness and socio-economic outcomes.

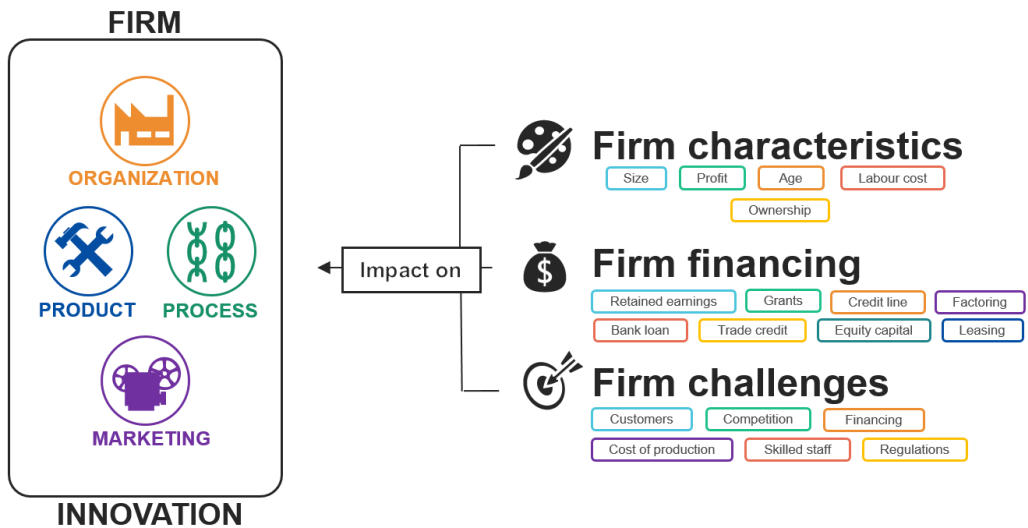
When analyzing firms' innovation activities, it is important to distinguish between technological (product and process innovations) and non-technological innovations (marketing and organisational innovations). The two categories are complementary to improve firms' innovative capabilities, but may be driven by different factors and require different skills, knowledge, and resources to be developed and implemented (Schmidt and Rammer, 2007). Additionally, different forms of innovation are associated with different costs and risk. As such, some financing instruments may be more suitable than others in supporting particular forms of innovation. Consequently, the effectiveness of different financing instruments varies depending on the type of innovation firms undertake, which is important for policymakers to keep in mind in the design of research and innovation policies.

The main aim of the paper is to investigate the drivers of firm-level innovation behavior by employing panel data techniques to account for unobserved heterogeneity. Specifically, the paper explores the effect of various firm-level characteristics, financing

¹ We wish to thank Alexandr Hobza, Julien Ravet, Océane Peiffer-Smadja, Athina Karvounaraki, Tiago Pereira, Jürgen Wengel and Romina Guri for providing very constructive comments and suggestions.

instruments and challenges perceived by innovative firms on their choice to innovate. Figure 1 depicts the conceptual map around which the paper is structured.

Figure 1. Conceptual plan of the paper



We use a rich survey dataset to investigate the impact of financing conditions on a variety of innovation activities, namely product, process, organisation and marketing innovations. Specifically, we consider different financing instruments such as retained earnings, grants and subsidies, bank loans, equity capital, credit lines etc. Most of the related academic research has focused on assessing the effectiveness of the different financing instruments separately (which would not allow to assess the effectiveness across instruments), and without differentiating by types of innovation. As an example, the work of Santos et al. (2019) has a very similar scope, as they employ a similar dataset to investigate the effect of different financing instruments on firms' innovation. However, differently from our analysis, they do not differentiate between the types of innovation enacted by the enterprises, and rely only on information over a two-year span, while we use data over thirteen years.

Secondly, we look into the different challenges that firms face based on the type of innovation that they pursue, and how the perception of such challenges impacts on their innovation activities.² More in detail, we focus on perceived difficulties related to six different factors (i.e., customers, competition, financing, production costs, skilled staff, and regulations) that play a role for firm performance. Finally, and as usual in the literature, we control in the analysis for firm-specific factors (firm size, age, profit, labour costs and ownership type), possibly affecting firms' likelihood of being engaged in innovative activities.

² Santos and Cincera (2022) employ a similar dataset to investigate the extent to which being an innovative firm increases the probability of being financially constrained.

We rely on firm-level data from the Survey on Access to Finance of Enterprises (SAFE) for 27 EU Member States, run by the European Central Bank and the European Commission. As the survey contains a firm identifier, we construct an unbalanced panel dataset³, covering the period 2009-2021, through which we can monitor the same firms across different waves. Thanks to the abundant number of observations in our sample, we can account for unobserved heterogeneity by controlling for firm fixed effects, year fixed effects and country \times year fixed effects.

Using a conditional (fixed-effect) logit model, and checking the robustness of our results employing linear probability regressions, we find that all sources of finance (except debt securities and trade credits) increase a firm's likelihood to innovate. Yet, we find broad heterogeneity as regards the relevance of the different financing instruments considered, depending on the type of innovation pursued by the company. For example, firms indicating grants as relevant source of finance are more likely to perform product, process, organisation or marketing innovation. Firms relying on venture capital as relevant source of finance are more likely to engage in product, process or organisation innovation, but not marketing innovation. While firms that have bank loans as important source of finance are more likely to do only process innovation.

Innovative firms are usually more concerned about the potential challenges posed by customers, financing, availability of skilled staff and regulations. Looking at the heterogeneity of the effect by innovation types, we find that firms engaged in organisation or marketing innovation are mostly concerned about finding customers, while companies engaging in product or process innovation are not. Financing is seen as an important challenge by all innovative firms, regardless of the type of innovation. Cost of production is a concern for firms doing organisational innovation, but not for firms doing product, process or marketing innovation. The availability of skilled staff is a concern for firms engaged in process or organisation innovation, but not in product or marketing innovation. Finally, all types of innovative firms are concerned about regulation. Finally, as regards the role of other factors, size and profits tend to improve firms' innovation performance, while firms' age decreases it. Product innovation is the type of innovation most sensitive to firms' size, profits and labour cost. Firms under individual ownership are the less likely to perform any type of innovations.

The rest of the paper is structured as follows: Section 2 presents an overview of the theoretical framework and relevant academic literature underpinning the study. Section 3 illustrates the methodology adopted to carry out the econometric analysis, and describes the dataset used, Section 4 presents and discusses the empirical results of the study, while section 5 presents the results from the robustness analysis. At last, Section 6 concludes the paper.

³ In average, across all considered waves, the same firm appear in 2.2 waves.

2 Literature review

There is a wide consensus about innovation being a key driver of productivity gains and long-term economic prosperity, and a vast economic literature has looked into factors behind firms' propensity to innovate. When investigating the drivers of firms' innovative behavior, the literature provides a wide range of empirical contributions that distinguish between factors related to the specificities of the environment in which innovative firms operate and factors related to firms' internal characteristics.

Sternberg and Arndt (2001) use data from the European Regional Innovation Survey for 11 European regions and find that firm-specific factors matter more than regional/external conditions for increasing firms' innovation output. Vega-Jurado et al. (2008) carry out a similar analysis, also finding that firm-level drivers weigh more than regional ones, and that technological competencies derived from firms' in-house R&D activities are a main driver of the firms' innovation performance.

Among these internal characteristics, firms' size, age, economic performances, technological competences, human resources and organisational capabilities have been identified by several authors as the main factors likely to increase firms' innovation performance (e.g., Sternberg and Arndt, 2001; Bhattacharya and Bloch, 2004; Beugelsdijk, 2007; Vega-Jurado et al., 2008). Kleinknecht (1989) uses data from an innovation survey in the Netherlands and finds that larger firms are more R&D intensive. This happens because the innovation process requires financial, managerial and human capital resources, and involves risk large businesses can better cope with (Caputo et al. 2002, Asheim et al., 2003). Hansen (1992) also finds that firm size positively relates to innovation, while there exists a negative relationship between firms' propensity to innovate and firms' age. Yet, Coad (2016) highlights how this is likely due to the fact that younger firms engage in more risky (win- or lose-it-all) activities than larger ones. Piening and Salge (2015) use German data to find a positive relationship between innovation and firm profits. Gupta et al. (2016) reach similar conclusions with data from India.

Notwithstanding the key role played by firms' internal factors, attention has also been put on the regional and national context in which firms operate. Institutional quality, market concentration, rule of law, regulatory framework, and better access to finance are widely recognized as main characteristics external to the firm positively affecting innovation (North, 1981; Olson, 2000; Sternberg and Arndt, 2001; Robinson and Acemoglu, 2012; Fitjar and Rodríguez-Pose, 2015). Beugelsdijk (2007) looks at the determinants of firms' innovation performance in 12 Dutch regions, assessing the importance of regional factors, such as regional R&D intensity, the number of R&D workers, and the presence of a research institute. López-Bazo and Motellón (2018) also provide an interesting analysis on Spanish firms, and find that their level of innovativeness varies considerably across different regions, depending also on the local framework conditions which must be taken into consideration. Such a result is in line with other empirical analyses also pointing at the important role played by local institutional quality in determining firms' innovation behavior, as well as at the regional educational level (e.g., Fitjar and Rodríguez-Pose, 2015; Robinson and Acemoglu, 2012).

Given these firm-specific and framework context-specific interlinkages that exist in innovation processes, it is important to account for them in our model specification. We do so by not only including in our regression models firm and year fixed effects, but also the interaction between country and year fixed effects (see Appendix).

Financing innovation is a particularly challenging task, due to the specific characteristics embedded in innovation outputs (e.g., non-rivalry and limited excludability, higher risk and uncertainty). It follows that innovative firms typically encounter more difficulties in accessing financing resources than their non-innovative counterparts (Aghion et al., 2004). Financial constraints are defined as a situation in which a firm's internal funds are not sufficient and it is necessary to recourse to the capital market to finance the firm's activities (Hall and Lerner, 2010). Many authors have investigated the presence of financing constraints as a determinant of R&D underinvestment (e.g. Hall, 1992; Himmelberg and Petersen, 1994; Bougheas et al., 2001; Silva and Carreira, 2012; Cincera et al., 2016; Santos and Cincera, 2022).

Nevertheless, measuring financial constraints and providing robust estimates of their impact on innovation is not a straightforward task. The literature has employed different strategies to empirically measure the presence of financial constraints.⁴ Among these, we distinguish two in particular: investment-equation studies and studies using survey data. The first consists in estimating R&D investment equations, and testing for the presence of excess sensitivity to internal resources (Fazzari et al., 1988). The second method relies on survey data, providing a more direct, yet subjective, measure of firms' difficulties in accessing finance (among others, see Sauvignac, 2009; Silva and Carreira, 2012; Coad et al., 2016; Santos and Cincera, 2022). In our study, we also rely on the latter method. When looking at the type of financing instruments typically employed by companies seeking financing resources, bank loans, grants, subsidies, tax incentives, equity investors, business angels and venture capital, are among the most common sources of financing (OECD, 2012; Cincera and Santos, 2015).

Access to finance is not the only challenge typically faced by innovative firms. Other examples include production costs, skill shortages and concerns related to the regulatory framework. As regards production costs, one may expect that companies focusing on efficiency improvements will step up innovation efforts. Yet, these innovation activities may increase production costs in the experimentation phase, before leading to lower costs when productivity gains kick in (Jaumandreu and Mairesse 2017).

Secondly, the ability of hiring staff with the appropriate technical skills is often reported as a major challenge by firms with high growth and innovative potential (EIB, 2020). Companies not concerned with the search of highly skilled employees are found to be typically less engaged in innovation activities (Tether, 2005). Indeed, there are strong complementarities between employees' skills and firms' innovation performance. Using data from Finland, Leiponen (2005) shows how high technical skills are enabling factors for product and process innovation. At the same time, Vinding (2006) finds for Denmark that the share of highly educated employees is not necessarily positively related to

⁴ See Hall (2010) for an overview.

firms' ability to innovate, although Schneider et al. (2010) argue that such discrepancies are due to sectoral specificities and different types of innovation. McGuirk (2015) highlights how employees' skills are more relevant for small firms compared to large firms, while Protogerou (2017) provides evidence on how access to skilled staff is crucial for young firms' innovation output.

Finally, regulations are also important factors influencing the innovation activities of companies, industries and whole economies (Blind, 2016). Rapidly changing innovative markets (such as in the digital and health sector) need agile regulatory systems able to keep up with the pace of innovation. When looking at the EU, factors preventing regulation to fully act as a driver for innovation include the excessive length of the legislative process, market fragmentation if the same innovation is treated differently across Member States, and problems in national implementation of EU regulation (European Commission, 2022). Being able to rely on an innovation-friendly regulatory system becomes, thus, essential to foster firms' innovation performance. Aghion (2021) estimates that a more regulated economy may have less innovation, but when firms do innovate they tend to "swing for the fence" with more radical (and labor saving) breakthroughs. Hence, it is reasonable to argue that firms engaged in innovative activities will be more concerned with the upcoming regulatory evolutions.

3 Data and methodology

We use firm-level data from the Survey on Access to Finance of Enterprises (SAFE) for 27 EU Member States, covering the period 2009-2021. SAFE⁵ is a firm-level survey conducted on behalf of the European Commission (DG Internal Market, Industry, Entrepreneurship and SMEs) and the European Central Bank (ECB). The survey runs every 6 months⁶, however the questions related to firm innovation activities occur every 12 months⁷. For this reason, in the regression analysis, our sample is restricted to the so called "common rounds" in which firms are interrogated about their innovation performances. The firms in the sample are selected randomly from the Dun & Bradstreet business register, and the sample is stratified⁸ by country, enterprise size class and economic activity. Some sectors (such as agriculture, forestry, fishing, finance, defence, social work and related) are excluded from the survey.

Our study employs a panel dataset constructed using a unique firm identifier, allowing to monitor the same firms across the different common rounds' waves: wave 1 (2009), wave 5 (2011), wave 9 (2013), wave 11 (2014), wave 13 (2015), wave 15 (2016), wave 17 (2017), wave 19 (2018), wave 21 (2019), wave 23 (2020) and wave 25 (2021). The final dataset consists of 98,757 unique firms operating in the EU 27. In the first waves of the survey unique firms rarely appear in subsequent waves, but in more recent waves

⁵ For more information see [here](#).

⁶ The so called "ECB rounds" with fewer questions covering a limited number of euro area countries.

⁷ The so called "Common rounds" with more comprehensive questions covering all European Union Member States.

⁸ The number of firms in each of these strata was adjusted to increase the accuracy of the survey across activities and size classes. The sample sizes in the different countries were selected on the basis of a compromise between the costs of the survey at the euro area level and representativeness at the country level.

the panel dimension increases in number⁹. Figure A1 (in Appendix) shows in how many different waves the same firms are interviewed in our sample. We keep all available firms, except for firms owned by venture capitalists¹⁰, regardless of how many times they appear longitudinally.

Our outcome variable of interest is defined as a dummy variable taking value 1 if firms' engage in innovation activities, and 0 otherwise. Given that we are interested in investigating how firms' choices to undertake innovation activities vary depending on a set of firms' internal factors, features of specific financing instruments, and challenges faced (regardless of other unobserved firms' characteristics), we opt for a conditional logit model as baseline specification.¹¹ Thanks to the abundant number of observations in our sample, we can account for unobserved heterogeneity by controlling for firm fixed effects, year fixed effects and country \times year fixed effects.¹² Specifically, we adopt the following model specification:

$$Firm\ innovation_{i,w} = \alpha + \beta X_{i,w} + \mu_i + \mu_w + \mu_i \times \mu_w + \varepsilon$$

Our outcome variable (*firm innovation*) indicates if a firm has performed any form of innovation in the past 12 months, with i denoting the firm, and w being the survey wave. Elements in vector β represent the change in the probability that a firm innovates for a one-unit change of the independent variable of interest, holding everything else constant. $X_{i,w}$ represents the set of the independent variables of interest, namely the aforementioned firm-level characteristics, financing instruments and perceived challenges. μ_i and μ_w represent, respectively, firm and wave fixed effects, while $\mu_c \times \mu_w$ denotes the interaction of country and wave fixed effects, introduced to control for any unobserved characteristic specific of a country in a defined time period.

In our set-up, firms' different types of innovation are captured by separate dummy variables indicating *product innovation*¹³, *process innovation*¹⁴, *organisation innovation*¹⁵ and *marketing innovation*¹⁶, taking value 1 if a firm declared to have introduced a certain type of innovation in the last 12 months, and 0 otherwise. Furthermore, we construct the variable *any innovation*, taking value 1 if the firm has introduced at least one of the four innovation types considered, and 0 otherwise. The definitions of the four types of

⁹ By defining a firm to be panel if it participated in the survey at least twice, our sample has 26% panel firms in wave 5, 47% in wave 9, 57% in wave 11, 56% in wave 13, 67% in wave 15, 64% in wave 17, 66% in wave 19, 55% in wave 21, 63% in wave 23, and 71% in wave 25.

¹⁰ In the EU, companies owned by VC account for only 0.7% of the firms.

¹¹ Underlying assumption of logit models is that observations are independent and identically distributed. As such, simple logit models cannot account for unobserved differences across firms that are constant over time. By contrast, a conditional logit model allows to account for unobserved heterogeneity across firms, thereby providing more accurate estimates of the model parameters.

¹² Country \times Year fixed effects are included in Appendix as robustness check.

¹³ SAFE variable called q1_a. Asked to the firm: "During the past 12 months have you introduced a new or significantly improved product or service to the market?"

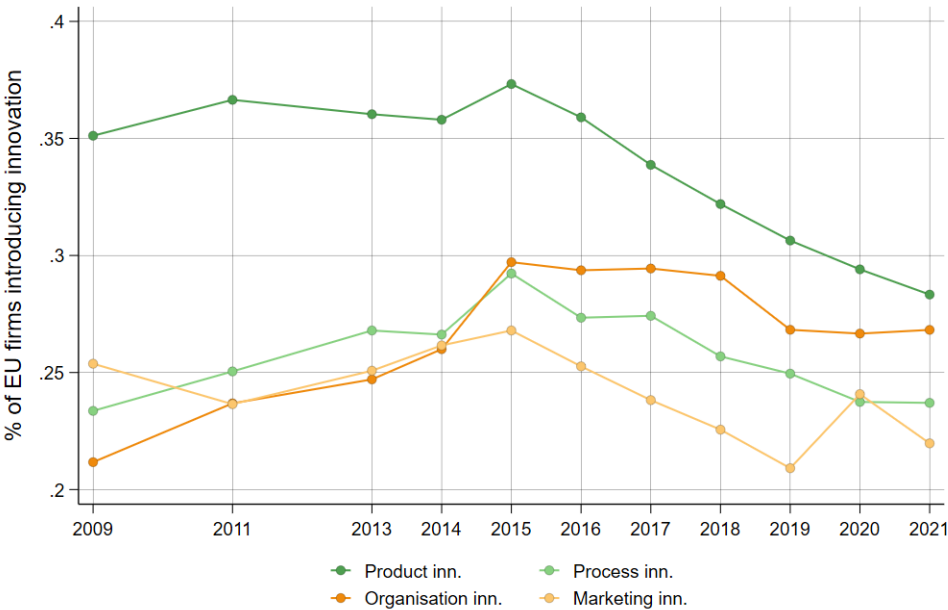
¹⁴ SAFE variable called q1_b. Asked to the firm: "During the past 12 months have you introduced a new or significantly improved production process or method?"

¹⁵ SAFE variable called q1_c. Asked to the firm: "During the past 12 months have you introduced a new organisation of management?"

¹⁶ SAFE variable called q1_d. Asked to the firm: "During the past 12 months have you introduced a new way of selling your goods or services?"

innovations follow the old edition of the “Oslo Manual” by OECD and Eurostat¹⁷. Figure 2 shows the innovation trends in the EU by innovation type from 2009 to 2021. We can observe how product and process innovation have increased from 2009 to 2015, and then drastically decreased from 2016 to 2021. Marketing innovation has fluctuated with an overall small diminishing trend. Organisation innovation has increased from 2009 to 2021.¹⁸

Figure 2. EU firm innovation trends by type



As regards firms’ characteristics, the regressors include variables capturing information on *firms’ size*¹⁹, *firms’ age*²⁰, *firms’ labour cost*²¹, *firms’ profits*²² and *firms’ ownership*²³. To distinguish across the different sources of finance, we define one variable for each

¹⁷ Exception for the fact that the SAFE survey does not distinguish between product innovation new to the firm and new to the market.

¹⁸ This could be due to several factors, such as the increasing diffusion of advanced technologies (e.g., AI, data analytics and cloud computing) that have enabled companies to adopt new tools and processes to improve their operations; globalisation forces (as companies expand to new markets, the need to adapt and innovate their organisational structure increases); the shift to teleworking (accelerated during the COVID-19 outbreak) that has led many firms to develop new organisational structures and management practices.

¹⁹ SAFE variable called d1_rec. Asked to the firm: “How many people does your enterprise currently employ either full or part-time at all its locations in your country?”

²⁰ SAFE variable called d5_rec. Asked to the firm: “In which year was your enterprise first registered?”

²¹ SAFE variable called q2_b. Asked to the firm: “Have the company labour costs (including social contributions) decreased, remained unchanged or increased over the past six months?”

²² SAFE variable called q2_e. “Have the company profit decreased, remained unchanged or increased over the past six months?”

²³ SAFE variable called d6. Asked to the firm: “Who owns the largest stake in your enterprise?”

financing instrument measuring whether the instrument is relevant for the firm or not.²⁴ The independent variables referring to the challenges perceived by firms are instead categorical variables, with firms indicating how important a challenge has been for the enterprise in the past 6 months.²⁵ The descriptive statistics for all the variables used are presented in Table 1. Figure A2 and A3 in Appendix shows the distribution of innovative firms by age and size, while Figure A4 and A5 in appendix shows the EU trends in financing instruments and challenges faced by innovative firms.

²⁴ SAFE variables called q4_a q4_b q4_c q4_d q4_e q4_f q4_h q4_j q4_m q4_r. Asked to the firm: “Is <this> source relevant to your enterprise?”

²⁵ SAFE variables called q0b_1 q0b_2 q0b_3 q0b_4 q0b_5 q0b_6. Asked to the firm: “How important the problem of <challenge> have been for your enterprise in the past six months?”

Table 1. Descriptive statistics

VARIABLES	(1) N.	(2) Mean	(3) SD	(4) Min	(5) Max
Firm innovation					
Any innovation	149,573	0.583	0.493	0	1
Product innovation	151,517	0.336	0.472	0	1
Process innovation	145,138	0.260	0.438	0	1
Organisation innovation	152,506	0.271	0.445	0	1
Marketing innovation	152,286	0.241	0.428	0	1
Firm characteristics					
1-9 employees	157,298	0.360	0.480	0	1
10-49 employees	157,298	0.289	0.453	0	1
50-249 employees	157,298	0.260	0.438	0	1
250 or more employees	157,298	0.0912	0.288	0	1
Less than 2 years old	155,879	0.0135	0.116	0	1
2-5 years old	155,879	0.0486	0.215	0	1
5-10 years old	155,879	0.118	0.322	0	1
10 or more years old	155,879	0.820	0.384	0	1
Firm labour costs	156,058	2.419	0.642	1	3
Firm profits	152,958	1.938	0.814	1	3
Firm ownership					
Own by an individual	139,980	0.366	0.482	0	1
Own by a family	139,980	0.433	0.495	0	1
Own by the public	139,980	0.0415	0.199	0	1
Own by the business	139,980	0.160	0.366	0	1
Relevant source of financing					
Retained earnings or sale of assets	152,017	0.358	0.479	0	1
Grants or subsidised bank loans	152,806	0.398	0.489	0	1
Credit line, bank/credit card overdraft	154,541	0.584	0.493	0	1
Bank loan	154,076	0.569	0.495	0	1
Trade credit	153,355	0.406	0.491	0	1
Other loan	152,935	0.278	0.448	0	1
Debt securities issued	151,448	0.0952	0.294	0	1
Equity capital	151,554	0.201	0.401	0	1
Leasing or hire-purchase	120,779	0.498	0.500	0	1
Factoring	118,512	0.127	0.333	0	1
Challenges for the firm					
Finding customers	134,926	6.256	2.996	1	10
Competition	134,857	6.032	2.608	1	10
Financing	131,693	4.630	3.116	1	10
Costs of production	134,472	6.323	2.542	1	10
Availability of skilled staff	134,255	6.316	2.889	1	10
Regulations	132,647	5.698	2.813	1	10
Reasons for not using bank loans					
Interest rate too high	53,818	0.0910	0.288	0	1
Not enough collateral	53,818	0.0443	0.206	0	1
Loss of control of the firm	53,818	0.0111	0.105	0	1
Too much paperwork	53,818	0.0354	0.185	0	1
No loan available	53,818	0.0366	0.188	0	1
No need of loan	53,818	0.782	0.413	0	1

Note: Descriptive of all “common round” waves. The mean VIF of an OLS regression with “Any innovation” as outcome variable and all independent variables of interest is 1.78, limiting potential concerns of multicollinearity.

4 Results

This section presents the results from the econometric analysis. Since looking at the impact of firms' financing instruments and firms' challenges on innovation in the same regression would lead to a loss of around 30% observations compared to doing it separately, and that the adjusted R^2 changes by only 0.002 units, we perform the analysis with separate regressions. Table 2 shows the results from estimating our baseline specification (conditional logit model) on the impact of firms' characteristics and ownership on different type of innovations. Firms with 1-9 employees and firms with 10-49 employees are less likely to innovate than firms with 50-249 employees. At the same time, firms with more than 250 employees are more likely to innovate than firms with 50-249 employees. Very young firms, less than 2 years old, are more likely to innovate than firms 5-10 years old. These results are in line with most of the empirical evidence on start-ups²⁶ performance, which acknowledges the highly innovative potential of this type of enterprises (European Commission, 2022).²⁷ Additionally, both profit and labour cost are found to increase the likelihood of firms to introduce innovations, while firms owned by an individual are less likely to innovate compared to family businesses.

Table 2. Impact of firm characteristics and ownership on firm innovation

	(1)	(2)	(3)	(4)	(5)
	Any inn.	Product inn.	Process inn.	Organisation inn.	Marketing inn.
VARIABLES	(margins)	(margins)	(margins)	(margins)	(margins)
1-9 employees	-0.133*** (0.0301)	-0.146*** (0.0241)	-0.112*** (0.0268)	-0.0636** (0.0268)	-0.0354 (0.0263)
10-49 employees	-0.0622*** (0.0224)	-0.0800*** (0.0186)	-0.0508*** (0.0195)	-0.00309 (0.0199)	-0.00946 (0.0183)
250 or more employees	0.0964*** (0.0297)	0.0776** (0.0337)	0.0162 (0.0246)	0.0772*** (0.0266)	0.0882*** (0.0339)
Less than 2 years old	0.101*** (0.0284)	0.0415 (0.0284)	0.0673* (0.0346)	0.144*** (0.0332)	0.0857** (0.0393)
2-5 years old	0.0245 (0.0191)	0.0491*** (0.0150)	0.0235 (0.0222)	-0.0325* (0.0170)	0.0129 (0.0225)
10 or more years old	0.00721 (0.00988)	-0.00236 (0.0128)	-0.00969 (0.0147)	0.00942 (0.0143)	-0.0186 (0.0136)
Profit	0.00975** (0.00412)	0.0184*** (0.00328)	0.0151*** (0.00346)	0.00166 (0.00297)	-0.00378 (0.00370)

²⁶ Although a generally accepted definition of start-ups does not exist, the young age is a characteristic common to all start-up definitions present in the literature.

²⁷ Although start-ups are typically small-sized companies, their innovative performance is typically ascribed to their young age, disruptive nature and fast-growth capabilities, rather than size.

Labour cost	0.0234*** (0.00507)	0.0293*** (0.00337)	0.0283*** (0.00635)	0.0142*** (0.00548)	0.0119** (0.00521)
Own by business	0.00267 (0.0133)	-0.0173 (0.0139)	0.00725 (0.0150)	0.0109 (0.0128)	0.000590 (0.0138)
Own by public	-0.00617 (0.0223)	0.0275 (0.0251)	-0.000673 (0.0192)	0.0246 (0.0237)	0.0179 (0.0266)
Own by individual	-0.0241* (0.0130)	-0.0174* (0.0102)	-0.0274** (0.0118)	-0.00445 (0.0131)	-0.0230* (0.0130)
Firm FE	YES	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES	YES
Observations	34,159	31,669	27,755	32,839	29,085

Note: Robust standard errors using bootstrap in parentheses *** p<0.01, ** p<0.05, * p<0.1. Coefficients are showed as average marginal effects. Firm constrained fixed effect and wave unconstrained fixed effect. "50-249 employees", "5-10 years old" and "Own by family" are used as reference variables. The number of observations varies because of the slightly different data availability of the dependent variables considered for the estimation.

Table 3 reports the results from estimating the conditional logit model (1), including different financing instruments as main independent variables of interest. When looking at innovation in general (column (1) in the table, "any innovation"), firms' relying on retained earnings are more likely to engage in innovation activities. Indeed, given the financing constraints faced by innovation projects (which typically are capital-intensive, risky, and difficult for external financiers to assess (Arrow, 1962), firms' internal cash flows represent a crucial source of R&D spending (Brown et al., 2009, Hall, 2002). At the same time, leasing, hire-purchase, grants and subsidised bank loans seem to be the external sources of finance that increase the most the likelihood of firms to innovate. For example, grants appear to increase the probability of a firm to innovate by 0.03. On the contrary, the use of trade credits and debt securities show up with insignificant coefficients.²⁸

If we differentiate by innovation type (column (2), (3), (4) and (5) in the table), we find that reliance on retained earnings is positively related with the likelihood of performing all types of innovation except marketing innovation. This is possibly explained by the less capital intensive character of marketing innovation vis-à-vis the other types of innovation. Grants and leasing are the only financing instruments that increase the likelihood of performing all types of innovation (product, process, organisation and marketing). Credit lines raise the likelihood of performing organisation and marketing innovation, but not of product and process innovation. Equity capital increases product and organisation innovation, but not process and marketing innovation. Factoring shows up with a positive and statistically significant coefficient for product and marketing innovation, but not for process and organisation innovation. Bank loans are effective only for process innovation, while for trade credits the table only reports a positive effect on

²⁸ Note that here we are referring to the results of columns (1) "any innovation" in the table. As explained in the section 3 "Data and Methodology" the dummy variable "any innovation" is equal to 1 if at least one of the innovation types is produced.

organisation innovation.²⁹ The coefficients of debt securities are insignificant for all innovations types.

The heterogeneity of the estimated coefficients across different financing instruments is not driven by firm-specific characteristics (such as size, age, and other unobserved firm-level time-invariant features which are controlled for in the panel specification). The preference of innovative firms for a particular financing instrument could depend on the specific contractual features of the instrument, as well as on the heterogeneous financing needs in term of flexibility, timing, etc. of the four innovation types.

As an example, factoring helps companies to meet their short-term cash needs by selling their receivables in return for an injection of cash from the factoring company. Such a form of financing may, thus, be convenient for marketing innovation, whose innovation lifecycle typically is elapsed on shorter time spans, but results to be relevant also for product innovators. Leasing is a contractual agreement in which one party agrees to rent an asset, typically machineries, owned by another party. Such a form of financing may be well employed by companies engaging in innovation activities that involve the purchase of new machineries such as industrial equipment for process and product innovations, or computers and software for organisation and marketing innovations.

Debt securities are fixed-income instruments that generate a defined stream of income from their interest payments. Since, unlike equity capital, the return earned by the investor is not dependent on the market performance of the issuer of the security, and require the investment capital to be fully repaid back along with the interests, it is reasonable to conclude that innovative firms do not favour such financing tool, thereby justifying the non-significance of our estimated coefficients. On the contrary, equity financing is usually best placed to support innovative companies as it raises capital by selling ownership shares, thereby allowing investors to share the profit of the firms and reducing the financial distress risk.

Yet, trade credit is a business-to-business agreement in which a customer can purchase goods without paying cash up front, and paying the supplier at a later scheduled date. The theoretical and empirical economic literature, suggest the existence of positive relationship between trade credit and innovation, as bank credit-constrained, such as innovative firms, are more likely to resort to this type of financing instruments to meet their short-term monetary needs (Bonte and Nielen, 2011). Although we do not find evidence of such a relationship in our general specification, our results suggest that the use of trade credit is more likely to increase the probability of a firm to engage in organisation innovation. As regards credit lines/overdrafts, they represent flexible loans from a bank or financial institution, establishing a pre-defined borrowing limit that can be tapped into at any time. As such, it may be difficult for firms associated to a high credit risk to access to benefit from this type of instruments, explaining why we find significant results only for organisation innovation. Nevertheless, the high flexibility of such type of instruments (credit lines' borrowers can are not obliged to use the entire amount at their disposal, and owe interest rates only on the amount actually used)

²⁹ This positive effect does not hold in the regression with "any innovation" as the outcome variable.

makes it suitable to finance type of innovations characterised by long innovation cycles, such as organisation innovation (Boer and During, 2001). Finally, grants are essentially a type of funding that does not have to be paid back. This makes them very flexible and best suited to support innovation activities of any type.

Table 2: Impact of the relevance of a financing instrument on firm innovation

	(1)	(2)	(3)	(4)	(5)
	Any inn.	Product inn.	Process inn.	Organisation inn.	Marketing inn.
VARIABLES	(margins)	(margins)	(margins)	(margins)	(margins)
Retained earnings or sale of assets	0.0378*** (0.00716)	0.0204*** (0.00715)	0.0272*** (0.00906)	0.0225*** (0.00776)	0.00644 (0.00824)
Grants or subsidised bank loans	0.0297*** (0.00629)	0.0291*** (0.00668)	0.0215*** (0.00799)	0.0197*** (0.00667)	0.0418*** (0.00890)
Credit line, bank/credit card overdraft	0.0132** (0.00651)	-0.00803 (0.00822)	0.00733 (0.00825)	0.0300*** (0.00638)	0.0231*** (0.00775)
Bank loan	0.0156** (0.00701)	0.00790 (0.00939)	0.0210*** (0.00706)	0.0117 (0.00827)	-0.00210 (0.00842)
Trade credit	0.0131 (0.00817)	0.00387 (0.00914)	0.00608 (0.00740)	0.0234*** (0.00681)	0.00953 (0.00792)
Other loan	0.0265*** (0.00818)	0.00312 (0.00788)	0.0135 (0.00930)	0.0267*** (0.00794)	0.0293*** (0.00709)
Debt securities issued	0.00338 (0.0168)	0.0215 (0.0184)	0.0225 (0.0183)	0.00313 (0.0160)	0.0296 (0.0187)
Equity capital	0.0196** (0.00959)	0.0361*** (0.00799)	0.0148 (0.00969)	0.0220*** (0.00793)	0.0138 (0.00894)
Leasing or hire-purchase	0.0350*** (0.00693)	0.0190** (0.00822)	0.0266*** (0.00714)	0.0306*** (0.00791)	0.0393*** (0.00807)
Factoring	0.0230** (0.0112)	0.0186* (0.0102)	0.00793 (0.0115)	0.00539 (0.0124)	0.0360*** (0.0134)
Firm FE	YES	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES
Observations	28,896	26,381	23,180	27,530	23,793

Note: Robust standard errors using bootstrap in parentheses *** p<0.01, ** p<0.05, * p<0.1. Coefficients are showed as average marginal effects. Firm constrained fixed effect and wave unconstrained fixed effect. Firms controls includes: firm size, firm profits, firm labour costs, firm age. The number of observations varies because of the slightly different data availability of the dependent variables considered for the estimation.

Given that bank financing is still the predominant source of financing for EU firms (European Commission, 2022), we also investigate what are the factors that may hinder firms' access to bank loans. Specifically, in Table 4 we dig deeper on the reasons why

firms may declare that bank loans are not a relevant source of financing for them. Our results suggest high interest rates, the lack of enough collaterals and the excessive paperwork required to be the main reasons discouraging innovative firms to rely on this type of financing sources. Indeed, asymmetries of information between the bank and the innovative firms requesting the loan, bundled with the inherent higher risk embedded in innovative projects, typically make innovative firms face higher interest rates, which may not be able to afford. Innovative firms may also not have enough collateral, as the spending in the form of salaries and wages for scientists and researchers (often representing a large fraction of innovation-related activities, and helping build human capital) cannot be collateralized (Agénor and Canuto, 2017). Bureaucracy and paperwork are also an important barrier to obtaining external finance, as they represent transaction costs for both borrower and lender (Demirgüç-Kunt and Levine, 2005). When looking more in details at the different type of innovations considered in the analysis, we find the issue of high interest rates to be more relevant for firms engaging in process and organisation innovation, while the lack of collateral is particularly important for firms performing product innovation. High interest rates are, instead found to be more relevant for firms engaging in process and organisation innovation, whereas the issue of too much paperwork particularly affects companies performing process, organisation and marketing innovation.

Table 3: Firms reasons for not having bank loans as a relevant source of financing and firm innovativeness

	(1)	(2)	(3)	(4)	(5)
	Any inn.	Product inn.	Process inn.	Organisation inn.	Marketing inn.
VARIABLES	(margins)	(margins)	(margins)	(margins)	(margins)
Interest rate too high	0.0526** (0.0211)	0.0213 (0.0236)	0.0489* (0.0277)	0.0583** (0.0270)	0.0276 (0.0238)
Not enough collateral	0.0613* (0.0316)	0.0623* (0.0327)	0.0488 (0.0349)	0.0182 (0.0373)	0.0397 (0.0305)
Loss of firm control	0.0371 (0.0589)	0.00709 (0.0407)	0.0587 (0.0572)	0.0229 (0.0562)	0.0378 (0.0556)
Too much paperwork	0.0782** (0.0358)	-0.00764 (0.0374)	0.0914** (0.0401)	0.107*** (0.0312)	0.0668* (0.0403)
No loan available	0.0556 (0.0455)	0.0759* (0.0407)	0.121*** (0.0451)	0.0586 (0.0392)	0.0862* (0.0440)
Firm FE	YES	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES
Observations	9,636	8,493	6,856	8,375	7,265

Note: Robust standard errors using bootstrap in parentheses *** p<0.01, ** p<0.05, * p<0.1. Coefficients are showed as average marginal effects. Firm constrained fixed effect and wave unconstrained fixed effect. Firms controls includes: firm size, firm profits, firm labour costs, firm age. "No need of a loan" is used as reference variable. The number of observations varies because of the slightly different data availability of the dependent variables considered for the estimation.

Table 5 reports the results from exploring the relationship between firms' perception on the main challenges they face and firms' innovativeness. It can be observed that companies that are more concerned about finding customers, financing, availability of skilled staff and complying with regulatory conditions are also those that are more likely to introduce innovations. Looking at the various innovation types, companies particularly concerned about finding customers are more often engaged in organisation and marketing innovation. This might be the case because organisation and marketing innovation are often motivated by quality demands put upon the company by the marketplace or even just one customer (Boer and During, 2001; Chen, 2006). Firms concerned with the availability of skilled staff are more likely to be doing process and organisation innovation. Indeed, process and organisation innovation are often linked to human capital requalification to accompany the purchase of new machineries and software set to replace technically obsolete ones (Boer and During, 2001). Finally, access to finance and regulation are of relevance for all types of innovations. Regulatory changes are capable to (either intentionally or unintentionally) disturb the economic environment shifting innovation decisions and modifying the values of the innovative options (Firth and Mellor, 1999; Aghion, Bergeaud and Van Reenen, 2021).

Table 4: Impact of challenges faced by firms on innovation

	(1)	(2)	(3)	(4)	(5)
	Any inn.	Product inn.	Process inn.	Organisation inn.	Marketing inn.
VARIABLES	(margins)	(margins)	(margins)	(margins)	(margins)
Finding customers	0.00247** (0.00111)	0.00134 (0.00117)	0.000983 (0.00148)	0.00383*** (0.000933)	0.00875*** (0.00145)
Competition	0.00119 (0.00125)	0.00101 (0.00153)	-0.00110 (0.00180)	-0.00115 (0.00155)	0.00316* (0.00179)
Financing	0.00235** (0.00107)	0.00259* (0.00134)	0.00306** (0.00150)	0.00292** (0.00136)	0.00317*** (0.00119)
Cost of production	0.000560 (0.00128)	0.000436 (0.00144)	-0.000632 (0.00170)	0.00273** (0.00138)	-0.00209 (0.00166)
Availability of skilled staff	0.00319*** (0.000988)	0.000568 (0.00119)	0.00328** (0.00129)	0.00523*** (0.00128)	0.000331 (0.00157)
Regulation	0.00388*** (0.00118)	0.00296*** (0.00113)	0.00555*** (0.00127)	0.00309*** (0.00111)	0.00252* (0.00131)
Firm FE	YES	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES
Observations	33,041	30,435	27,132	32,239	27,889

Note: Robust standard errors using bootstrap in parentheses *** p<0.01, ** p<0.05, * p<0.1. Coefficients are showed as average marginal effects. Firm constrained fixed effect and wave unconstrained fixed effect. Firms controls includes: firm size, firm profits, firm labour costs, firm age. The number of observations varies because of the slightly different data availability of the dependent variables considered for the estimation.

5 Robustness analysis

To validate the results presented in the previous section, we carried out a series of robustness checks. First, we replicated our analysis employing linear probability regression models with the inclusion of additional controls, such as the country \times year fixed effects. The relevance of comparing the results from the logit and the linear probability model (LPM) derives from the fact that when the dependent variable is a binary variable, but does not present extreme probabilities, LPM models may perform better than logit ones (Hellevik, 2009). The corresponding estimated coefficients can be found in Table A1-A4 in Appendix. It is reassuring to observe that the estimation results are broadly in line with those presented using the conditional logit model.

Additionally, since our original sample includes information about all the available firms in the database, regardless of the number of times they appear longitudinally, we check our results also against a sample in which only firms appearing in at least three waves are retained. The resulting estimated coefficients are reported in table A5-A7 in Appendix, and are broadly comparable to those obtained when employing the full sample.

Finally, since to maximize the amount of independent information that goes into our parameter estimates we performed the regression for financial instruments and challenges separately, we replicated the results including all the independent variables of interest in the same regression (see table A8), with results mostly unchanged.³⁰

6 Conclusions and implications for policy

This paper investigates the drivers of firm-level innovation in the EU, differentiating across different types of innovations. We derive comparable coefficients on a wide set of firm-level innovation drivers, while employing a panel dataset that allows to account for a large amount of unobserved heterogeneity, including at the firm level. In particular, we investigate how firms' characteristics, firms' sources of financing, and firm perception of different challenges influence their likelihood to innovate. The findings are relevant for the design of research and innovation policy, providing insights into which type of financing instrument is more adequate to promote a particular type of innovation, as well as the role of challenges the firm is encountering for its innovative endeavours.

We find that grants are among the financing instruments exerting the largest positive effect on firms' likelihood to innovate, regardless of the innovation type considered. This

³⁰ The main difference with our baseline results is the loss of significance for the coefficient associated to the challenge "financing". However we find such a change to be driven by the high heterogeneity in the response rate of our sample. Firms in the dataset do not always provide all the information requested under every question. As such, the inclusion of all the dependent variables of interest in our specification leads to a significant loss of observations (around 30%), which explains the change observed in the robustness analysis. As a matter of fact, the coefficient associated to "financing" loses significance also in the case we first exclude all observations for which the information related to the additional independent variables are missing, and then perform the regression separately as in Table 5.

result recapitulates the importance of grant schemes for innovation performance, with a particular role for the European Commission's Framework Programme for R&I, which employs grants as primary financing instruments to promote and foster innovation within the Union.

However, retained earnings show the highest estimated coefficients, confirming that EU innovative firms still largely rely on internal resources to finance their innovation activities, due to their difficulties in accessing external financing resources. This is related with the well-known limitations of the EU financial market, which is still largely bank driven. Indeed, bank loans remain the predominant financing instrument in the EU (European Commission, 2022). At the same time, we find that several factors undermine EU firms' ability to receive support from banks. Our results suggest that high interest rates and administrative hurdles represent the main reasons for innovative firms to renounce to bank loans, pointing to the need for simplifying and harmonising the EU's banking system, as well as for promoting financial innovation, which can provide financial intermediaries with better technology to screen information, thereby reducing financial risk deriving from information asymmetries (Yuan et al., 2021).

Additionally, our results confirm the critical role played by non-bank financing in enhancing innovation. Despite the limited use of equity capital financing, we find a positive impact on the firms' propensity to innovate, especially for product innovation, confirming that enhancing access to equity remains key to creating growth opportunities in the EU. From a policy perspective, our results thus strengthen the case for progressing and completing the EU Capital Markets Union (CMU). Solid market-based funding sources remain key to reduce innovative firms' financing gap. A successful transition to a green and digital economy in the EU requires significant investments (European Commission, 2020). To this purpose, the role of the CMU remains key to provide additional and alternative funding opportunities within the Union, thereby reducing the reliance on bank funding and increasing private risk sharing.

Finally, the analysis indicates that innovative firms are more likely to be concerned about finding customers, access to finance, availability of skilled staff, and regulations. These observations underline the importance of easing access to finance, reducing labour shortages, with a mix of reskilling and lifelong learning policies, as well as experimentation for fast deployment of novel innovation-friendly regulations.

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8 **Appendix**

Figure A1. Descriptive on the panel dimension of SAFE “common rounds”

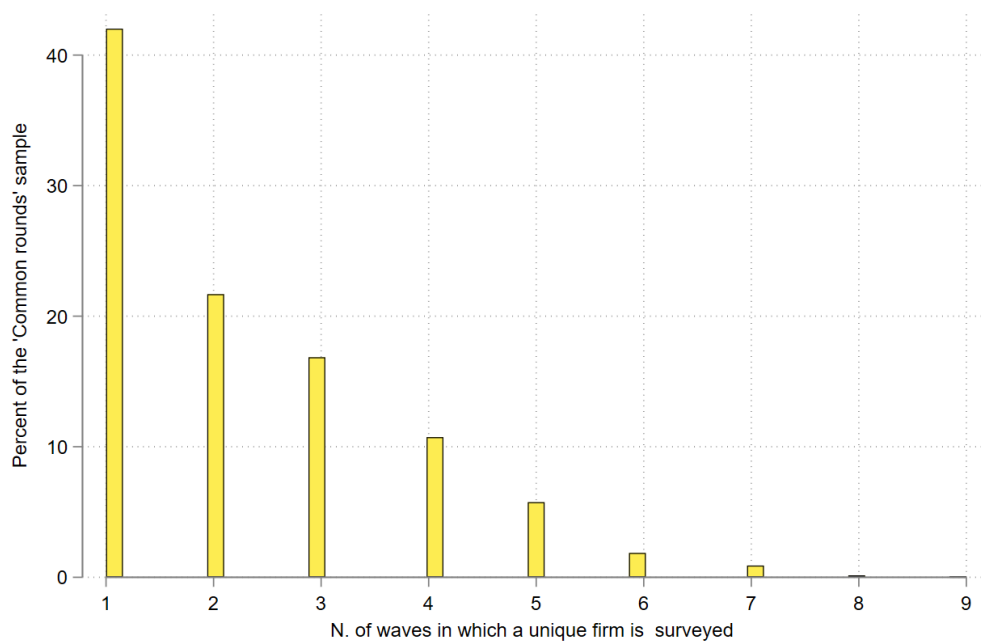


Figure A2. EU firm innovation by size (2009-2021)

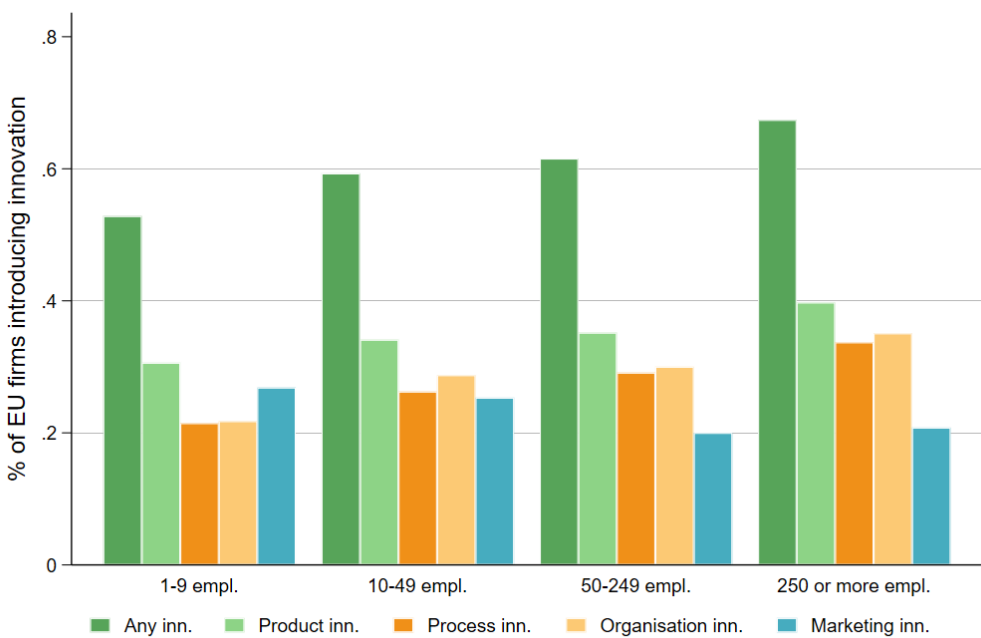


Figure A3. EU firm innovation by age (2009-2021)

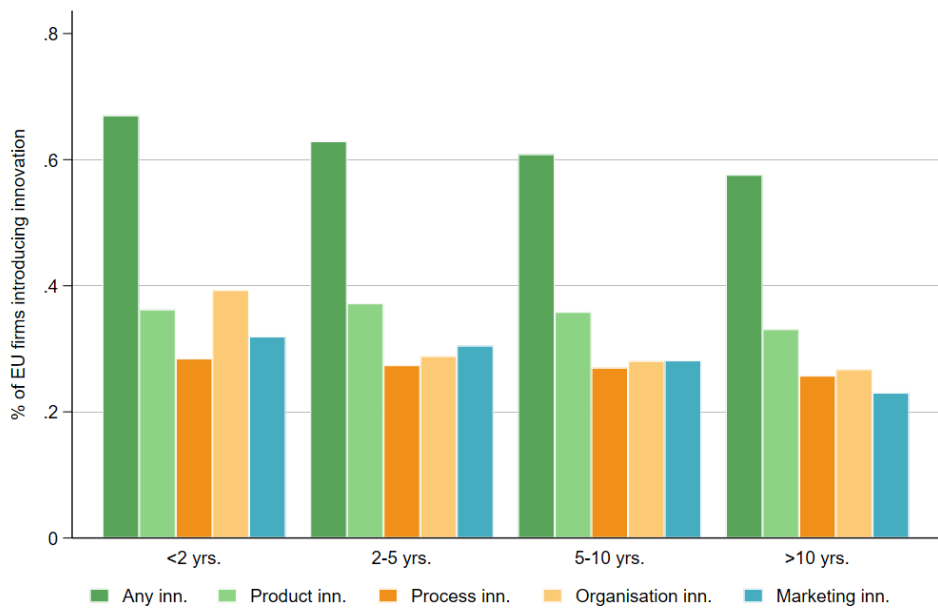


Figure A4. EU innovative firms financing trends

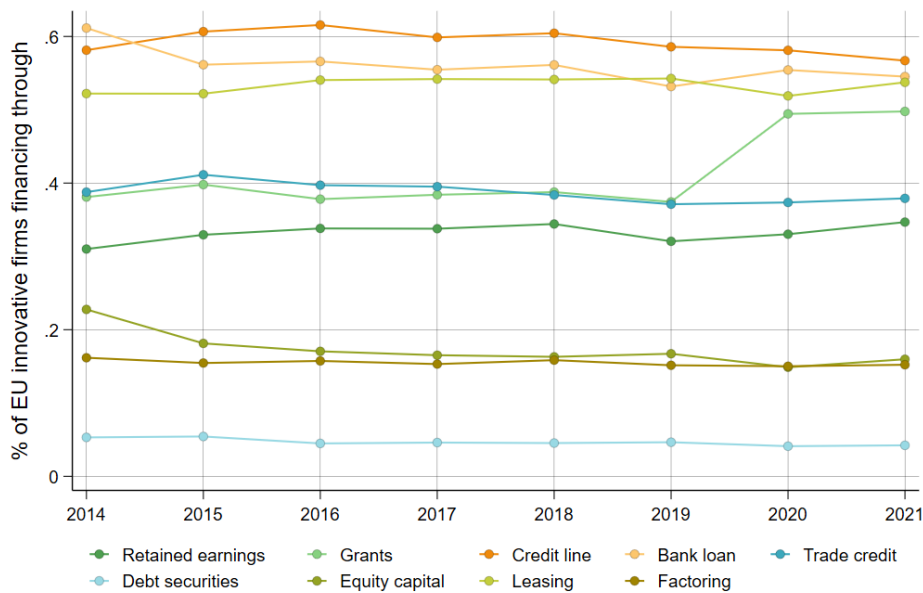


Figure A5. EU innovative firms challenges trends

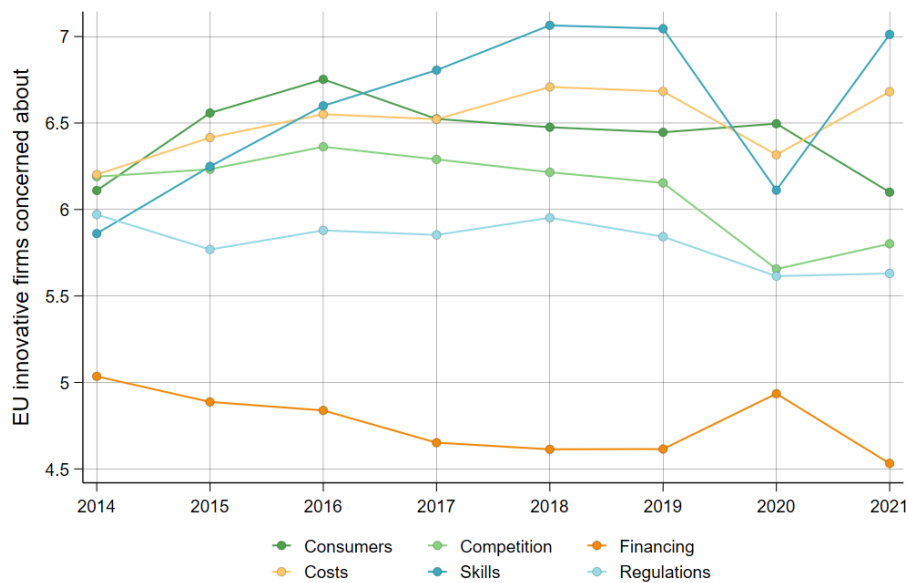


Table A1: Robustness test. Firm characteristics and ownership on innovativeness (LPM)

VARIABLES	(1) Any inn.	(2) Product inn.	(3) Process inn.	(4) Organisation inn.	(5) Marketing inn.
1-9 employees	-0.0915*** (0.0155)	-0.0878*** (0.0146)	-0.0631*** (0.0146)	-0.0435*** (0.0151)	-0.0177 (0.0140)
10-49 employees	-0.0420*** (0.0125)	-0.0495*** (0.0119)	-0.0291** (0.0118)	-0.00406 (0.0123)	-0.00416 (0.0110)
250 or more employees	0.0675*** (0.0188)	0.0500*** (0.0177)	0.00930 (0.0187)	0.0600*** (0.0195)	0.0437*** (0.0162)
Less than 2 years old	0.0691*** (0.0232)	0.0274 (0.0218)	0.0490** (0.0226)	0.105*** (0.0232)	0.0557** (0.0220)
2-5 years old	0.0154 (0.0126)	0.0323*** (0.0123)	0.0148 (0.0124)	-0.0232* (0.0125)	0.00977 (0.0123)
10 or more years old	0.00322 (0.00922)	-0.000548 (0.00876)	-0.00422 (0.00901)	0.00487 (0.00885)	-0.0124 (0.00849)
Profit	0.00557** (0.00254)	0.0122*** (0.00244)	0.00823*** (0.00245)	0.000224 (0.00248)	-0.00180 (0.00230)
Labour cost	0.0176*** (0.00340)	0.0189*** (0.00319)	0.0186*** (0.00325)	0.0101*** (0.00332)	0.00717** (0.00310)
Own by business	-3.69e-05 (0.00901)	-0.0138 (0.00861)	0.00315 (0.00869)	0.00639 (0.00859)	0.00108 (0.00786)
Own by public	0.000850 (0.0157)	0.0176 (0.0153)	-0.00154 (0.0153)	0.0203 (0.0156)	0.00963 (0.0140)
Own by individual	-0.0163** (0.00741)	-0.0114 (0.00712)	-0.0147** (0.00716)	-0.000706 (0.00718)	-0.0128* (0.00682)
Observations	77,241	78,792	73,560	79,504	79,381
R-squared	0.602	0.609	0.575	0.549	0.557
Firm FE	YES	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES	YES
Country × Wave FE	YES	YES	YES	YES	YES

Note: Robust standard error in parentheses. *** p<0.01, ** p<0.05, * p<0.1. "50-249 employees", "5-10 years old" and "Own by family" are used as reference variables.

Table A2: Robustness test. Firm source of finance and innovativeness (LPM)

VARIABLES	(1) Any inn.	(2) Product inn.	(3) Process inn.	(4) Organisatio n inn.	(5) Marketing inn.
Retained earnings or sale of assets	0.0292*** (0.00537)	0.0131** (0.00511)	0.0180*** (0.00523)	0.0163*** (0.00524)	0.00310 (0.00476)
Grants or subsidised bank loans	0.0232*** (0.00531)	0.0199*** (0.00505)	0.0135*** (0.00511)	0.0142*** (0.00516)	0.0232*** (0.00477)
Credit line, bank/credit card overdraft	0.0117** (0.00576)	-0.00693 (0.00539)	0.00647 (0.00544)	0.0203*** (0.00543)	0.0141*** (0.00514)
Bank loan	0.0130** (0.00552)	0.00461 (0.00510)	0.0126** (0.00518)	0.00875* (0.00524)	- (0.00491)
Trade credit	0.0117** (0.00557)	0.00321 (0.00536)	0.00365 (0.00552)	0.0167*** (0.00549)	0.00552 (0.00513)
Other loan	0.0210*** (0.00610)	0.00290 (0.00578)	0.00866 (0.00593)	0.0213*** (0.00606)	0.0170*** (0.00555)
Debt securities issued	0.000801 (0.0123)	0.0176 (0.0123)	0.0176 (0.0129)	0.00812 (0.0131)	0.0212* (0.0121)
Equity capital	0.0181*** (0.00702)	0.0270*** (0.00680)	0.0129* (0.00701)	0.0154** (0.00700)	0.00859 (0.00640)
Leasing or hire-purchase	0.0292*** (0.00566)	0.0131** (0.00529)	0.0187*** (0.00542)	0.0223*** (0.00543)	0.0224*** (0.00508)
Factoring	0.0152* (0.00868)	0.0114 (0.00855)	0.00393 (0.00894)	0.00474 (0.00890)	0.0249*** (0.00810)
Observations	67,632	69,136	64,624	69,760	69,656
R-squared	0.615	0.622	0.588	0.562	0.572
Firm FE	YES	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES	YES
Country × Wave FE	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES

Note: Robust standard error in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Firms controls includes: firm size, firm profits, firm labour costs, firm age.

Table A3: Robustness test. Firms reasons for not having bank loans as a relevant source of financing and firm innovativeness (LPM)

VARIABLES	(1) Any inn.	(2) Product inn.	(3) Process inn.	(4) Organisation inn.	(5) Marketing inn.
Interest rate to high	0.0383** (0.0154)	0.0117 (0.0145)	0.0233 (0.0143)	0.0311** (0.0140)	0.0162 (0.0140)
Not enough collateral	0.0431** (0.0216)	0.0415** (0.0195)	0.0268 (0.0199)	0.0100 (0.0190)	0.0159 (0.0176)
No firm control	0.0247 (0.0365)	0.000931 (0.0333)	0.0309 (0.0333)	0.0156 (0.0336)	0.0261 (0.0314)
Too much paperwork	0.0600*** (0.0222)	0.00221 (0.0198)	0.0489** (0.0207)	0.0590*** (0.0194)	0.0314* (0.0188)
No loan available	0.0443* (0.0251)	0.0503** (0.0239)	0.0655*** (0.0239)	0.0367 (0.0254)	0.0471** (0.0226)
Observations	24,797	25,636	23,536	25,868	25,875
R-squared	0.652	0.652	0.613	0.577	0.596
Firm FE	YES	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES	YES
Country × Wave FE	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES

Note: Robust standard error in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Firms controls includes: firm size, firm profits, firm labour costs, firm age. "No need of a loan" is used as reference variable.

Table A4: Robustness test. Impact of challenges faced by firms on innovation (LPM)

VARIABLES	(1) Any inn.	(2) Product inn.	(3) Process inn.	(4) Organisation inn.	(5) Marketing inn.
Finding customers	0.00259*** (0.000964)	0.000970 (0.000906)	0.000957 (0.000918)	0.00317*** (0.000922)	0.00514*** (0.000861)
Competition	0.000868 (0.00112)	0.000752 (0.00107)	-0.000815 (0.00110)	-0.00114 (0.00109)	0.00161 (0.00100)
Financing	0.00193** (0.000882)	0.00203** (0.000831)	0.00223*** (0.000846)	0.00210** (0.000848)	0.00165** (0.000798)
Costs of production	0.00123 (0.00110)	0.000725 (0.00102)	-4.66e-05 (0.00101)	0.00218** (0.00102)	-0.00136 (0.000981)
Availability of skilled staff	0.00274*** (0.000927)	0.000624 (0.000870)	0.00243*** (0.000881)	0.00403*** (0.000870)	0.000642 (0.000838)
Regulations	0.00341*** (0.000900)	0.00234*** (0.000843)	0.00357*** (0.000856)	0.00234*** (0.000857)	0.00157* (0.000813)
Observations	75,187	76,574	71,785	77,214	77,105
R-squared	0.604	0.613	0.576	0.550	0.560
Firm FE	YES	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES	YES
Country × Wave FE	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES

Note: Robust standard error in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Firms controls includes: firm size, firm profits, firm labour costs, firm age.

Table A5. Robustness test. Firm characteristics and ownership on innovativeness (LPM - Only firms that appears at least three times in the panel)

VARIABLES	(1) Any inn.	(2) Product inn.	(3) Process inn.	(4) Organisation inn.	(5) Marketing inn.
1-9 employees	-0.0916*** (0.0188)	-0.0914*** (0.0175)	-0.0564*** (0.0173)	-0.0523*** (0.0184)	-0.0320* (0.0167)
10-49 employees	-0.0496*** (0.0150)	-0.0524*** (0.0141)	-0.0274** (0.0137)	-0.0103 (0.0146)	-0.0179 (0.0130)
250 or more employees	0.0612*** (0.0219)	0.0620*** (0.0209)	0.00765 (0.0215)	0.0535** (0.0222)	0.0447** (0.0181)
Less than 2 years old	0.0706** (0.0298)	0.00731 (0.0275)	0.00706 (0.0281)	0.121*** (0.0296)	0.0461* (0.0274)
2-5 years old	0.0244 (0.0159)	0.0337** (0.0154)	0.0275* (0.0154)	-0.0113 (0.0157)	0.0204 (0.0155)
10 or more years old	-0.00119 (0.0114)	-0.0306*** (0.0108)	-0.0173 (0.0110)	0.0184* (0.0110)	-0.0177* (0.0105)
Profit	0.00572* (0.00298)	0.0106*** (0.00286)	0.00850*** (0.00285)	0.00187 (0.00293)	-0.000642 (0.00270)
Labour cost	0.0154*** (0.00401)	0.0177*** (0.00375)	0.0207*** (0.00380)	0.0111*** (0.00394)	0.00641* (0.00366)
Own by business	0.00669 (0.0114)	-0.00561 (0.0110)	0.00947 (0.0110)	0.00931 (0.0111)	0.0116 (0.0101)
Own by public	0.0245 (0.0216)	0.0274 (0.0207)	0.000738 (0.0207)	0.0196 (0.0210)	0.0221 (0.0192)
Own by individual	-0.0170* (0.00949)	-0.0102 (0.00922)	-0.0152* (0.00918)	-0.00186 (0.00940)	-0.00849 (0.00885)
Observations	51,992	52,669	49,929	53,085	52,945
R-squared	0.570	0.582	0.548	0.515	0.525
Firm FE	YES	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES	YES
Country × Wave	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Firms controls includes: firm size, firm profits, firm labour costs, firm age. "50-249 employees", "5-10 years old" and "Own by family" are used as reference variables.

Table A6. Robustness test. Firm source of finance and innovativeness (LPM - Only firms that appears at least three times in the panel)

VARIABLES	(1) Any inn.	(2) Product inn.	(3) Process inn.	(4) Organisation inn.	(5) Marketing inn.
Retained earnings or sale of assets	0.0250*** (0.00640)	0.0145** (0.00609)	0.0149** (0.00622)	0.0198*** (0.00629)	-0.000370 (0.00567)
Grants or subsidised bank loans	0.0251*** (0.00629)	0.0182*** (0.00595)	0.0132** (0.00603)	0.0123** (0.00617)	0.0211*** (0.00565)
Credit line, bank/credit card overdraft	0.00451 (0.00684)	-0.0133** (0.00640)	0.00359 (0.00645)	0.0154** (0.00653)	0.0152** (0.00614)
Bank loan	0.0104 (0.00660)	0.00657 (0.00610)	0.0182*** (0.00615)	0.00140 (0.00629)	2.66e-05 (0.00588)
Trade credit	0.0130** (0.00657)	-0.00136 (0.00634)	0.000391 (0.00651)	0.0192*** (0.00655)	0.00944 (0.00608)
Other loan	0.0194*** (0.00730)	-0.00163 (0.00688)	0.00859 (0.00704)	0.0268*** (0.00733)	0.0115* (0.00666)
Debt securities issued	0.0165 (0.0144)	0.0257* (0.0145)	0.0156 (0.0154)	0.0204 (0.0156)	0.0199 (0.0143)
Equity capital	0.0176** (0.00840)	0.0252*** (0.00812)	0.0111 (0.00841)	0.0209** (0.00838)	0.00429 (0.00764)
Leasing or hire-purchase	0.0333*** (0.00674)	0.0118* (0.00632)	0.0216*** (0.00645)	0.0226*** (0.00651)	0.0279*** (0.00612)
Factoring	0.0183* (0.0104)	0.0121 (0.0101)	0.00534 (0.0105)	-0.00338 (0.0107)	0.0213** (0.00968)
Observations	45,274	45,888	43,557	46,284	46,181
R-squared	0.589	0.599	0.565	0.535	0.545
Firm FE	YES	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES	YES
Country × Wave FE	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Firms controls includes: firm size, firm profits, firm labour costs, firm age.

Table A7. Robustness test. Firm challenges on innovativeness (LPM - Only firms that appears at least three times in the panel)

VARIABLES	(1) Any inn.	(2) Product inn.	(3) Process inn.	(4) Organisation inn.	(5) Marketing inn.
Finding customers	0.00199* (0.00117)	0.00125 (0.00109)	0.000631 (0.00111)	0.00280** (0.00113)	0.00459*** (0.00104)
Competition	0.000859 (0.00136)	0.000536 (0.00130)	-0.00153 (0.00133)	-0.00192 (0.00132)	0.00135 (0.00122)
Financing	0.00239** (0.00106)	0.00105 (0.000998)	0.00203** (0.00102)	0.00236** (0.00104)	0.00189* (0.000963)
Costs of production	0.000810 (0.00134)	0.000228 (0.00124)	-0.000835 (0.00123)	0.00272** (0.00126)	-0.00107 (0.00120)
Availability of skilled staff	0.00288** (0.00112)	0.000872 (0.00105)	0.00327*** (0.00105)	0.00512*** (0.00106)	0.000269 (0.00102)
Regulations	0.00372*** (0.00109)	0.00328*** (0.00102)	0.00462*** (0.00103)	0.00212** (0.00104)	0.00260*** (0.000987)
Observations	51,016	51,626	49,047	52,013	51,903
R-squared	0.576	0.588	0.551	0.518	0.529
Firm FE	YES	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES	YES
Country * Wave FE	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Firms controls includes: firm size, firm profits, firm labour costs, firm age.

Table A8. Robustness test. Financial instruments and Firm challenges on innovativeness (Logit)

VARIABLES	(1) Any inn. (margins)	(2) Product inn. (margins)	(3) Process inn. (margins)	(4) Organisation inn. (margins)	(5) Marketing inn. (margins)
Firm characteristics					
1-9 employees	-0.114*** (0.0239)	-0.120*** (0.0288)	-0.0962*** (0.0287)	-0.0626** (0.0261)	-0.0133 (0.0207)
10-49 employees	-0.0477** (0.0187)	-0.0538*** (0.0201)	-0.0407* (0.0224)	-0.0186 (0.0175)	0.0103 (0.0193)
250 or more employees	0.0782*** (0.0287)	0.105*** (0.0264)	0.0361 (0.0280)	0.0481** (0.0233)	0.0351 (0.0332)
Less than 2 years old	0.0830*** (0.0311)	0.0137 (0.0319)	0.0488 (0.0384)	0.111*** (0.0343)	0.0702** (0.0337)
2-5 years old	0.00448 (0.0166)	0.0420* (0.0241)	0.0170 (0.0188)	-0.0259 (0.0188)	0.00335 (0.0185)
10 or more years old	-0.00255 (0.0128)	-0.00178 (0.0137)	-0.00940 (0.0159)	0.00483 (0.0131)	-0.0162 (0.0141)
Profit	0.00688** (0.00332)	0.0155*** (0.00392)	0.0115*** (0.00366)	0.00275 (0.00378)	0.00402 (0.00389)
Labour cost	0.0190*** (0.00338)	0.0218*** (0.00505)	0.0239*** (0.00548)	0.0103** (0.00462)	0.00847* (0.00511)
Own by business	0.00653 (0.0118)	-0.00768 (0.0154)	0.00567 (0.0150)	0.00357 (0.0119)	0.00532 (0.0202)
Own by public	-0.00445 (0.0252)	0.0114 (0.0191)	-0.0220 (0.0219)	0.0310 (0.0223)	0.0331 (0.0309)
Own by individual	-0.00664 (0.0103)	0.000364 (0.0143)	-0.0106 (0.0146)	0.00349 (0.0116)	-0.0287* (0.0153)
Financing instruments					
Retained earnings or sale of assets	0.0340*** (0.00722)	0.0182*** (0.00689)	0.0248*** (0.00793)	0.0192** (0.00792)	0.0112 (0.00782)
Grants or subsidised bank loans	0.0253*** (0.00621)	0.0253*** (0.00783)	0.0213** (0.00852)	0.0128* (0.00680)	0.0298*** (0.00854)
Credit line, bank/credit card overdraft	0.00821 (0.00611)	-0.0119 (0.00784)	-5.78e-05 (0.00765)	0.0257*** (0.00673)	0.0233*** (0.00734)
Bank loan	0.0122* (0.00691)	0.00667 (0.00740)	0.0171** (0.00768)	0.00931 (0.00673)	-0.00604 (0.00781)
Trade credit	0.00903 (0.00758)	0.00718 (0.00765)	0.00169 (0.00833)	0.0131* (0.00753)	0.00671 (0.00729)
Other loan	0.0238*** (0.00868)	0.000503 (0.00799)	0.00778 (0.00819)	0.0275*** (0.00749)	0.0275** (0.0116)
Debt securities issued	0.00139 (0.0194)	0.0266 (0.0170)	0.0247 (0.0186)	0.00312 (0.0167)	0.0205 (0.0174)
Equity capital	0.0228***	0.0357***	0.0174	0.0209**	0.00678

	(0.00812)	(0.00912)	(0.0114)	(0.00895)	(0.00886)
Leasing or hire-purchase	0.0281***	0.0171**	0.0217**	0.0281***	0.0365***
	(0.00762)	(0.00796)	(0.00926)	(0.00772)	(0.00788)
Factoring	0.0239***	0.0177	0.0134	0.00467	0.0300***
	(0.00909)	(0.0110)	(0.0123)	(0.0107)	(0.0106)

Firm challenges

Finding customers	0.00191	0.000412	0.000306	0.00235**	0.00859***
	(0.00117)	(0.00125)	(0.00168)	(0.00109)	(0.00167)
Competition	0.000425	0.000486	-0.00136	-0.00127	0.00259
	(0.00134)	(0.00167)	(0.00207)	(0.00139)	(0.00171)
Financing	0.000496	0.00165	0.000634	0.000641	0.000847
	(0.00112)	(0.00120)	(0.00109)	(0.00106)	(0.00140)
Cost of production	0.00134	0.000887	0.000608	0.00331**	-0.000957
	(0.00154)	(0.00164)	(0.00166)	(0.00153)	(0.00159)
Availability of skilled staff	0.00218*	0.000760	0.00324**	0.00436***	0.000768
	(0.00131)	(0.00155)	(0.00158)	(0.00134)	(0.00125)
Regulation	0.00327***	0.00326***	0.00493***	0.00209*	0.00193
	(0.00124)	(0.00112)	(0.00167)	(0.00117)	(0.00146)

Observations	24,294	22,396	19,846	23,304	20,329
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Note: Robust standard errors using bootstrap in parentheses *** p<0.01, ** p<0.05, * p<0.1. Coefficients are showed as average marginal effects. Firm constrained fixed effect and wave unconstrained fixed effect.

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This paper studies the firm-level drivers of product, process, organisation and marketing innovation in the EU with panel data from 2009 to 2021. Employing conditional logit and linear probability models we investigate how firms' characteristics, firms' sources of financing, and firm perception of different challenges influence their likelihood to innovate. In line with the academic literature, we find that firms' size and profit level improve firms' innovation performance, while firms' age decreases it. We also observe that the effectiveness of different financing instruments varies considerably depending on whether the company is pursuing product, process, organisation or marketing innovation. Finally, innovative firms more frequently report access to finance and regulations as important challenges for their future, while the relevance of other challenges (e.g. the availability of skilled staff or finding customers) varies depending on what type of innovation activities companies are engaged in.

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