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The impact of Covid-19 and of the earlier crisis on firms' innovation and growth: a comparative analysis

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Authors:
Marques Santos, A.
Haegeman, K.
Moncada-Paternò-Castello, P.

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Contact information
Name: Simone Salotti
Address: Edificio Expo, C/Inca Garcilaso 3, 41092 Sevilla (Spain)
Email: simone.salotti@ec.europa.eu
Tel.: +34 954488406

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The impact of Covid-19 and of the earlier crisis on firms' innovation and growth: a comparative analysis

Anabela M. Santos * (corresponding author)
Anabela.MARQUES-SANTOS@ec.europa.eu

Karel Haegeman *
Karel-Herman.HAEGEMAN@ec.europa.eu

Pietro Moncada-Paternò-Castello *
Pietro.MONCADA-PATERNO-CASTELLO@ec.europa.eu

* European Commission, JRC, unit B7, Seville, Spain

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Anabela M. Santos * (corresponding author)
Anabela.MARQUES-SANTOS@ec.europa.eu

Karel Haegeman *
Karel-Herman.HAEGEMAN@ec.europa.eu

Pietro Moncada-Paternò-Castello *
Pietro.MONCADA-PATERNO-CASTELLO@ec.europa.eu

* European Commission, JRC, unit B7, Seville, Spain

Disclaimer: The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

Abstract

Using the results of the Survey on the Access to Finance of Enterprises (2009 to 2020 editions), this paper aims to assess the effect of Covid-19 pandemic on the probabilities of firm to innovate and grow and to compare their likelihood with that of the previous downturn. To control for a possible endogeneity bias as part of innovation decisions a Recursive Bivariate Probit Model is used. Results show that the probabilities of firms to innovate and grow are lower in 2020 (Covid-19 crisis) than in 2009 (financial crisis). The economic performance of innovative firms was also affected by the pandemic, but considerably less than the performance of non-innovative ones. Changes in the innovation patterns are also observed. Possible implications for decision-makers are derived.

Keywords: Innovation; Growth; Covid-19; Europe.

JEL Classification: O31; O12; O52.

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Executive Summary

This working paper aims to contribute to better understanding the Covid-19 effect on the EU firms' decisions to innovate and on their growth performance, measured by the likelihood of turnover increases. To perform such analysis, data from the Survey on the Access to Finance of Enterprises (SAFE), covering the period between 2009 and 2020, is used.

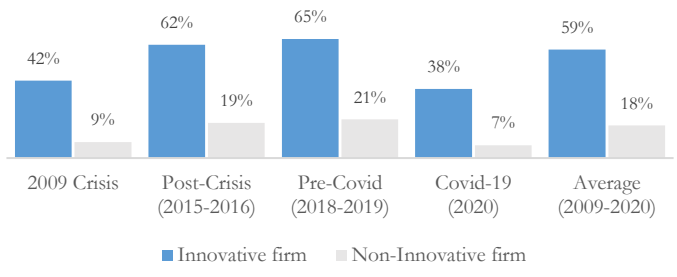
COVID-19 brought new obstacles to business activities

The Covid-19 health crisis appears as an unprecedented situation, different from the previous crisis that started in the financial sector (2008/2009 crisis). Given the nature of this crisis, firms are also faced with different and new obstacles related to their activities. For instance, access to finance, together with finding customers, were considered by EU firms to be the two main pressing problems to business activity during the economic crisis 2008/2009, whereas, **during the first year of Covid-19 crisis** (2020), **access to finance was considered a problem of secondary importance**. The **most pressing problem in 2020 was related to Covid-19 issues,** such as mobility/travel restrictions, lockdown, closure of borders, and disruption of the value chain (production and supply) together with bottlenecks in logistics. **Finding customers was the second most important problem** pointed out by EU firms in 2020.

Innovating in periods of downturn is more important than ever

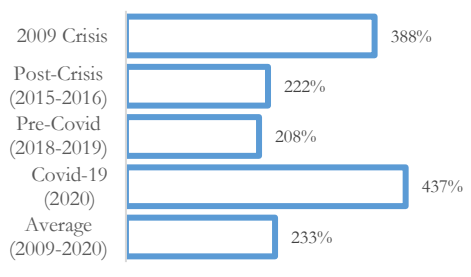
Growth likelihood of EU firms was more affected by the Covid-19 pandemic (2020) **than by the previous economic downturn** (2009). Although both **innovative and non-innovative firms** are affected by the Covid-19 crisis, innovative firms are **less affected than non-innovative ones** (Figure I). For instance, in 2020, the probability of an increase in turnover for innovative firms is around four times more than that of their counterparts, whereas in pre-Covid period this difference was only the double (Figure II). Furthermore, such difference in terms of performance in 2020 was also higher than in 2009. These findings suggest that innovation was more important than ever to mitigate the negative effect of the Covid-19 pandemic, especially as we also observe that the probability of firms' growth was more affected by the health crisis than by the 2009 downturn.

Figure I. Probability of turnover growth, by innovation behaviour and period (EU27)



Source: Own estimation based on Table 5.

Figure II. Relative difference in the probability of turnover growth: Innovative *versus* non-innovative firms (EU27)

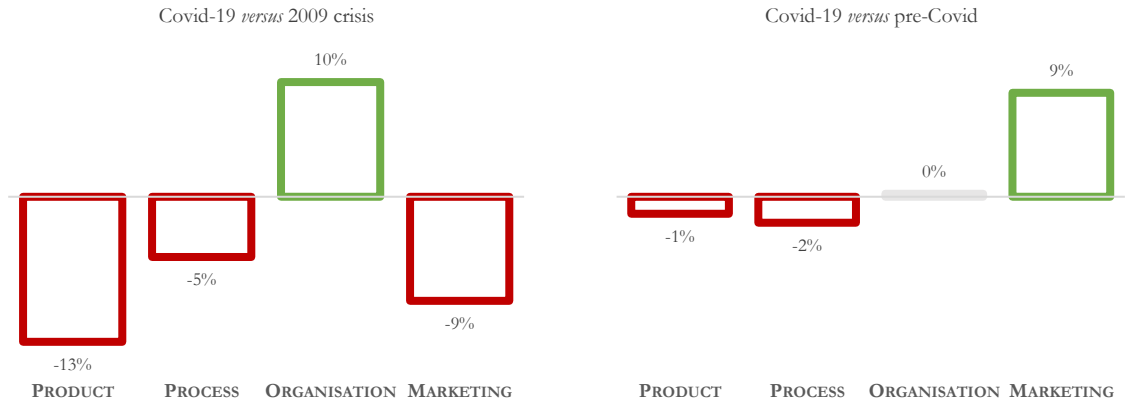


Source: Own estimation based on Figure I.

Changes in innovation behaviour

Changes can be observed in the innovation patterns in 2020 (Figure III), compared to the pre-Covid period, in particular with regard to a higher propensity to introduce a marketing innovation (e.g. a new way of selling goods or services). Furthermore, in comparison with the 2009 crisis, all types of innovation, except organisational innovation, report a lower innovation propensity in 2020. Organisational innovation appears to be the least affected by the Covid-19 crisis, by remaining at the same level as in the pre-Covid period. Such findings illustrate the differences between the Covid-19 health crisis and the earlier downturn, and provide evidences on how EU firms have reacted to overcome the negative effects of the first year of the Covid-19 crisis. They also support some trends observed in the course of 2020-2021 (e.g. changes in the business to consumer (B2C) and business to business (B2B) relationships, changes in consumer behaviour/preferences, and changes in the organisation) with quantitative evidence.

Figure III. Changes of innovation probability by innovation typology



Source: Own estimation based on Table 6.

Policy implications for recovery

Results of this work suggest that the EU should strengthen its own capacity and autonomy by facilitating open and dynamic markets that promote innovation and consumers' confidence.

Instruments tailored to mitigating the economic and social impact of the coronavirus disease such as the Next Generation EU, which includes the "Recovery and Resilience Facility", represent a cornerstone opportunity (also) for the private sector. These instruments, together with Horizon Europe, offer wide opportunities for firms to move out of the present crisis and boost their future competitiveness.

It is equally important to fully exploit and complete the (Digital) Single Market in order to stimulate short and long term demand for innovative goods/services and investments in intangibles, and ultimately, to create a pro-innovation, more transformative, environment in the EU.

1. Introduction

The year 2020 (and part of 2021) will probably be known as one of the most challenging ones since the Great Depression of the 1930s, due to the Covid-19 pandemic. Nevertheless, this health crisis has other characteristics than the previous economic crisis (2009). Its singularity lies in the causes of the economic contraction. To stop the spread of the virus, governments adopted drastic restrictive measures, which have been affecting both demand and supply sides of the value chain, leading to an economic contraction, job loss and income reduction.

To help firms to survive and maintain their employment level, governments have taken drastic measures. At national level, the legal framework for the temporary layoffs and related unemployment benefits were adjusted to help companies cope with the Covid-19 crisis. At EU level, the NextGenerationEU, and in particular its "Recovery and Resilience Facility" aims to both boost recovery and support the twin green and digital transition. On the other hand, in view of new market needs and in order to mitigate the negative effects of the pandemic (e.g. dramatic reduction in sales), some firms have changed their economic activities([1]), launched new products or services and/or adapted their ways of working. Investments in ICT and remote digital tools have increased significantly in 2020 (**Santos, 2020**). Virtual meetings replaced in-person meetings on a large scale and teleworking was adopted (**Santos, 2020**), whenever the activity allowed for it.

Previous research has demonstrated that organisational adaptive behaviour and/or changes in the business model are key factors for firms' survival (**Cucculelli and Peruzzi, 2020**) and performance (**Makkonen *et al.*, 2014**) during a crisis. Nevertheless, although innovations play an important role in raising firms' competitiveness and growth (**Hall *et al.*, 2016**) and, in particular, in overcoming the financial crisis (**Hausman and Wesley, 2014**), in period of economic contraction firms tend to reduce (**Archibugi *et al.*, 2013**) or to stop innovative projects (**Paunov, 2012**). Indeed, uncertainty about economic recovery and the return of investment tends to discourage firms to undertake innovation activities (**Archibugi *et al.*, 2013**), and the singularity of the Covid-19 pandemic makes investments even more risky. Indeed, firms are likely to invest only when there is a market for their products and services.

The Covid-19 outbreak can be a challenge for many companies (e.g. for those operating in brick and mortar retail or tourism industry), but, it represents an opportunity for other companies (e.g. pharmaceutical companies or firms in the ICT sector). Given the exceptionality of this pandemic disease and the related unprecedented socio-economic shocks, there is a clear need to collect and analyse data about its effects in order to help governments in providing the most adequate policy response.

([1]) For instance, the fashion manufacturing industry started producing surgical masks and surgical and isolation gowns; the wine and spirit manufacturing industry used its raw materials to produce disinfectant gel; restaurants re-inforced their take-away and home delivery capacity.

In view of contributing to addressing this information gap, this paper aims to better understand the Covid-19 effect on firms' decisions to innovate and on their growth performance in EU27. To perform this analysis, we use data from the Survey on the Access to Finance of Enterprises (SAFE). The data covers the period between 2009 and 2020. In order to control for a possible endogeneity in innovation behaviour, we use a Recursive Bivariate Probit Model, where the first equation corresponds to being an innovative firm and the second to being a growing firm. Firm growth is measured by increase of turnover in the last 6 months.

The paper is organised as follows. After the introduction, section 2 provides an overview of the related literature. Section 3 presents and describes the database used. Section 4 defines the methodological approach. Section 5 presents the results of the analysis and section 6 addresses policy implications and conclusions.

2. Literature review

The importance of innovation for firm growth has been highlighted by many scholars (see e.g. **Mansfield, 1962**; **Aghion and Howitt, 1988, 1992**; **Colombelli et al., 2011**; **Rosenbusch *et al.*, 2011**; **Santos *et al.*, 2019**) since the seminal contribution of **Schumpeter** (1934). According to the Schumpeterian theory, a successful innovation can provide a competitive advantage to a firm in the market, leading to its economic growth. However, internal and external factors to the firm (Figure 1) can affect the probability of success to transform innovation in growth, as well as the firm's incentive to innovate.

Figure 1. Main elements influencing business innovation and growth

Internal factors	External factors
• Firm's size and age • Management capacity • Workforce skills • Financing capacity • Ownership	• Macroeconomic conditions • Size of the market: customers, users and competition • Regulation • Government support: subsidies, tax system • Public infrastructure • Knowledge flows and networks

Source: Authors' own elaboration based on **Coad** (2007) and **OECD** (2018).

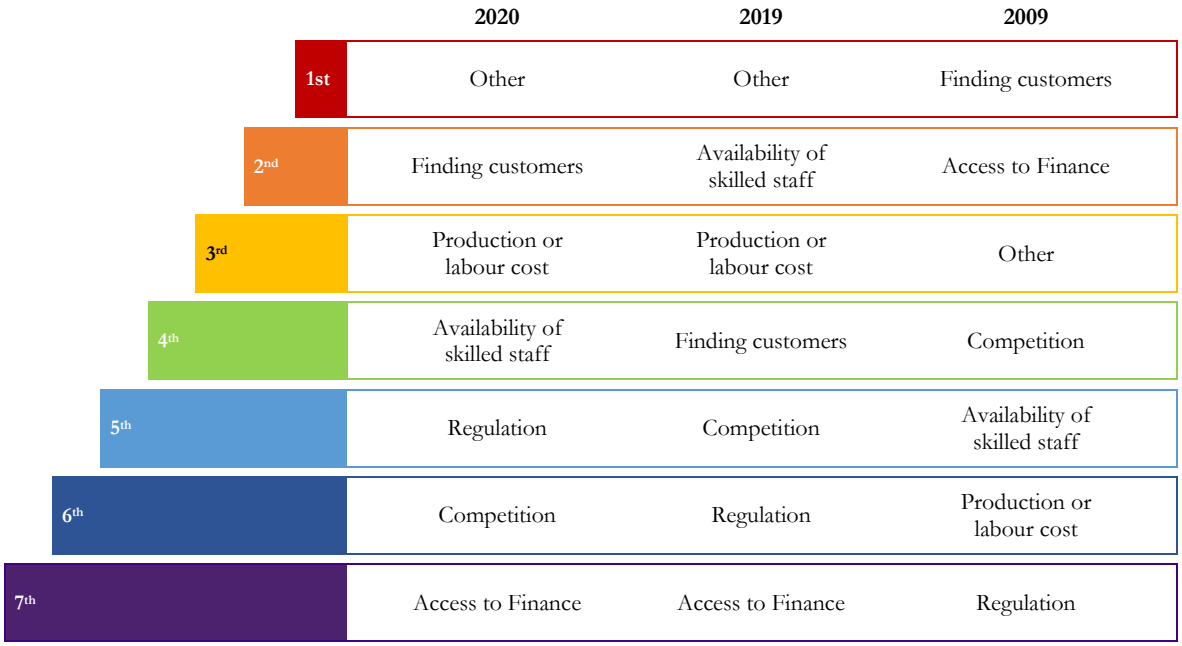
While firms can, to a certain extent, overcome internal weakness ([2]), they cannot easily mitigate the negative effects of external factors, such as macroeconomics conditions. Downturns or economic crises are

([2]) For instance, hiring more qualified worker(s) or up-skilling current labor force thanks to training, improving financing capacity by attracting new investors.

exogenous shocks essentially related to market contraction, unemployment, loss of confidence in investment, liquidity constraints, loss of income, uncertainty.

Existing literature about economic crises has mainly focused on financial aspects, such as the lack of funding in periods of downturn as a main obstacle to business operation (**Eggers, 2020**). Indeed, access to finance, together with finding customers, were considered by EU firms to be the two main pressing problem to business activity during the economic crisis of 2008/2009, whereas, in the pre-Covid crisis period (2019), access to finance was considered to be the least pressing problem (Figure 2). The Covid-19 crisis ([3]) appears to be different from the previous economic crisis that started in the financial sector. The origin of the current economic crisis stems from a health crisis *per se* (increase of health costs and expenditures to find a treatment), and the disease control practices (**Ebersberger and Kuckertz, 2021**) related to this health crisis. Given the particular nature of this crisis, firms are faced with different obstacles to their business activities (Figure 2).

Figure 2. Ranking of pressing problems to business activity, by period (EU27)



Source: Own estimation based on SAFE data. Note: For 2020, the category other includes essentially Covid-19 related issues, whereas, for 2019, it refers mainly to BREXIT.

For instance, EU firms highlighted in the SAFE that the most pressing problem in 2020, identified as "other" in Figure 2, was related to Covid-19 issues such as mobility/travel restrictions, lockdown, closure of borders, lack of personnel (absenteeism and sick leave), disruption of the value chain (production and supply), together with bottlenecks in logistics. Finding customers was the second most pressing problem pointed out by EU firms in 2020, similar to the previous downturn (2009), where it was the most hampering

([3]) Started essentially in March 2020 when the World Health Organization (WHO) declared the COVID-19 outbreak a pandemic and most of the EU citizens were lockdown.

obstacle. For 2020, access to finance appears as the least pressing problem to business activity, similar to the pre-Covid crisis period. Such findings confirm the differences between the Covid-19 crisis and the economic crisis of 2009. Considering these differences, it is expected that firms also reacted differently (**Pantano *et al.*, 2020**; **Ebersberger and Kuckertz, 2021**), and that their behaviour is also motivated by different factors, such as changes in consumer preferences and behaviour (**Marques Santos *et al.*, 2020**; **Santos, 2020**).

At country level (Figure 11 in Appendix) the perceived most pressing problems in pandemic times (April-September 2020) reveal some differences, even if the "other" category appears in a first position for all the EU Member states. For instance, Covid related issues are particularly hampering companies in Greece, Malta, Austria and Ireland. Bulgaria and Romania are among the top five countries that perceived pressing problems to business operation (4) with a greater intensity. Access to finance is a pressing problem especially for Greek companies, where it comes out in a third position of the ranking, whereas in other countries it is in last position, mostly (5).

Nevertheless, and despite the previous obstacles, the Covid-19 crisis also strongly stimulated research & development (R&D) and innovation (RDI), especially in the health sector (**Borunsky *et al.*, 2020**). Facing an unprecedented situation, firms and organisations reinvented themselves (**Pantano *et al.*, 2020**; **Ebersberger and Kuckertz, 2021**). However, even if there is strong theoretical and empirical evidence regarding the singularity of the Covid-19 crisis and of the importance of innovation in times of crisis, a clear understanding of the changes in innovation patterns and of the role of innovation to mitigate the effects of the Covid-19 crisis is still missing. The present study aims to overcome this gap.

3. Database and sample description

To perform our analysis, we use the anonymous Survey on the Access to Finance of Enterprises (SAFE). SAFE is conducted bi-annually together by the European Central Bank and the European Commission since 2009. The firms included in the survey are selected randomly from the Dun & Bradstreet business register (**ECB, 2020**). The sample is stratified by country, enterprise size class and economic activity to control for its representativeness at country level (**ECB, 2020**). Since SAFE is anonymous, it is not possible to cross information with other data sources.

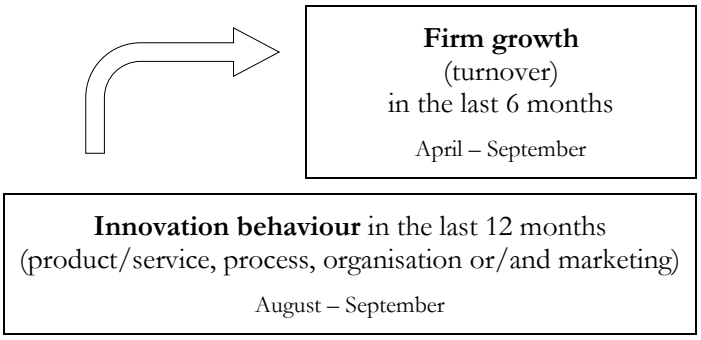
We used data from the 10 first year rounds of SAFE, which covers the period from 2009 and 2020, excluding 2010 and 2012 due to missing information about innovation behaviour in these years. We only use the first year round of SAFE because the question about innovation behaviour is not included in its second annual

(4) i.e. availability of skilled staff, labour or production cost, regulation, finding customers, competition and access to finance.

(5) 18 out of 27 reports access to finance the less pressing (7th position in the ranking) and 6 out of 27 position it the before the last (6th position in the ranking) - Figure 11 in Appendix.

round. The SAFE includes mainly questions about access to finance and performance performance indicators in the last 6 months. Each first round of SAFE also includes a question about innovation behaviour in the last 12 months. Then, innovation behaviour is observed before or simultaneously to the firms' performance as schematised in Figure 3.

Figure 3. Conceptual framework timeline



Source: Own elaboration.
Note: Timeline applicable to all the first waves of SAFE, except for 2009, where it refers to the period from January to June 2009 for firm growth and from July 2008 to June 2009 for innovation behaviour

The concept of innovation behaviour behind the SAFE, included in the Q1, is the same as what is used by the **OECD** (2018) in the Oslo Manual, and it refers to the introduction of:

- a new or significantly improved product or service to the market;
- a new or significantly improved production process or method (not applicable if the enterprise does not produce anything);
- a new organisation of the management (for example, a re-organisation of different parts of the enterprise or reporting hierarchy aimed at increasing efficiency or reducing costs);
- a new way of selling your goods or services (marketing innovation).

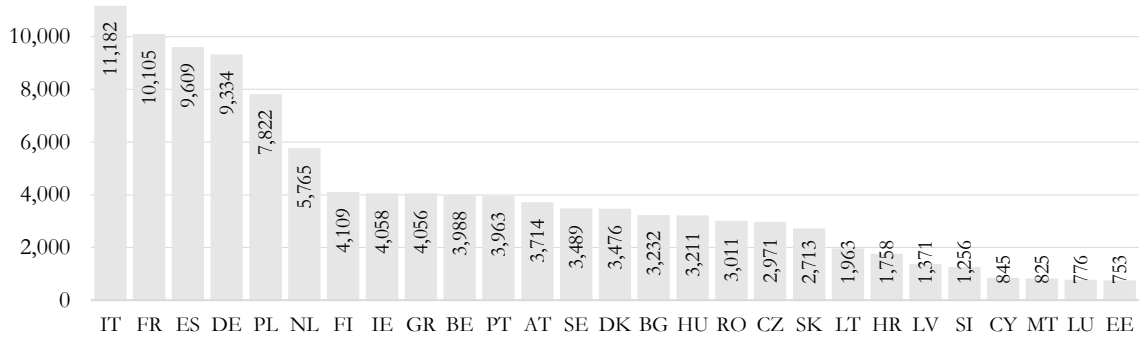
Firms' performance or growth is measured by increases in their turnover (Q2a in SAFE).

Not all firms that have answered to a wave reply also to the next one. Only few of them ([6]) answer to the survey repeatedly. Then, the database is constructed using repeated cross-sectional data. Even if the SAFE is conducted with firms in EU and non-EU countries ([7]), for the present study, we include only firms located in the 27 EU Member states (Figure 4). After selecting only firms with valid answers to all the selected

([6]) For instance, only around 28% of the companies that have answered to the fist survey of 2020 have also responded to the first of 2019; and less than 10% have been included in the first surveys of 2020, 2019 and 2018.
([7]) Non-EU countries include, depending on the waves, Albania, Iceland, Norway, United Kingdom, Turkey, Montenegro, Switzerland, The former Yugoslav Republic of Macedonia, Bosnia and Herzegovina, Serbia, Kosovo, Liechtenstein and Israel.

questions under analysis ([8]) in the first rounds of SAFE from 2009 to 2020, we obtained a sample with 109,355 firm-year observations.

Figure 4. Geographical distribution of the sample



Source: Own elaboration.

Except for the first 3 years, we have an average of 12,000 firms per year (Table 9 in Appendix). Those firms are operating in construction (12%), industry (24%), trade (26%) and services to businesses or persons (38%) ([9]). Our sample is composed of micro (38%), small (32%) and medium-sized (30%) enterprises. Young firms represent around 6% of the sample and old firms about 82% ([10]). Innovative firms account for 57.5% of the total, a value that is close to that of the Community Innovation Survey (50% of innovative firms in EU27 in 2016-2018). 34% have introduced a new or improved product or service, 27% a new management organisation, 26% a process and 25% a marketing innovation. Around 40% of the respondents report increases in their turnover.

Turnover growth and innovation behaviour are positively correlated to firm-size (Figure 5 and Figure 6) and negatively to firm-age (Figure 7 and Figure 8). Figure 9 shows that the number of firms reporting an increase in their turnover is substantially lower in 2009 (financial crisis) and 2020 (Covid-19 health crisis) in comparison with the other periods under analysis. Concerning the innovation decision (i.e. the decision of a firm to innovate) (Figure 10), the observed trends are slightly different. Although in the post-2009 crisis the number of firms reporting an innovation behaviour is higher than in 2009, we also observe that in the pre-Covid period the innovation decision is lower than the average, as well as lower than in 2009 and in the post-2009 crisis. Such trends are similar to those observed with the number of innovative firms in the Community Innovation Survey (CIS). Indeed, their representativeness in the CIS2018 (50%) is also lower than what was reported in the CIS2008 (52%) and in the CIS2010 (53%).

([8]) For more details about them see the next section.
([9]) Entities in agriculture, public administration, financial services are not included in the SAFE.
([10]) The threshold for each age level was defined according to the definition of **Criscuolo *et al.*** (2014). For more details see Table 8 in Appendix.

Figure 5. Turnover increase by firm size

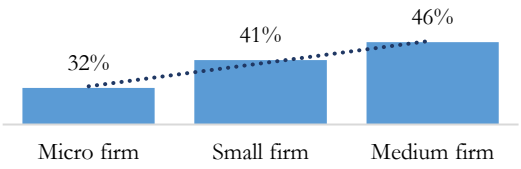


Figure 6. Innovation decision by firm size

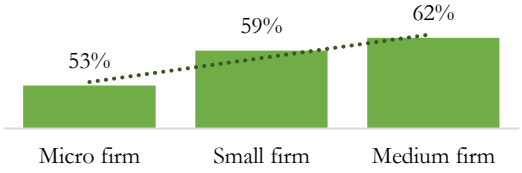


Figure 7. Turnover increase by firm age

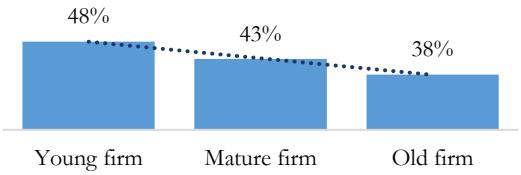


Figure 8. Innovation decision by firm age

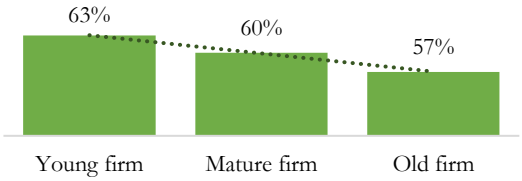


Figure 9. Turnover increase by year

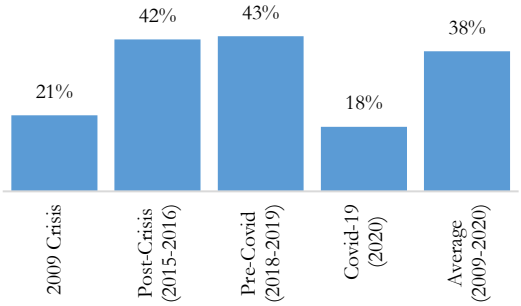
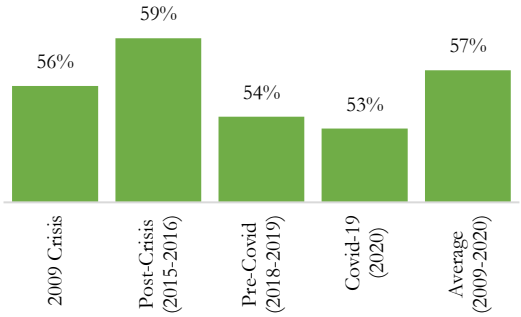


Figure 10. Innovation decision by year



Source: Own elaboration.
Note: Number of observations = 109,355. Figures refer to the frequency of the observations.

4. Methodological approach

Our main interest lies in determining the effect of Covid-19 on the probabilities to innovate and firm growth, and to assess how the persistence of innovation behaviour during periods of downturn has affected firms' performance. As our main variables of interest are dichotomous variables ([11]), a binary Probit model is used to perform the analysis. However, as innovation is included in the growth equation, and the decision to innovate is not random, to control for a potential endogenous bias, we use the simultaneous Recursive Bivariate Probit Model (RBPM) proposed by **Heckman** (1987) and **Maddala** (1983). The RBPM has the advantage of allowing to control for the presence of unobservable confounding and to provide better estimates (for using likelihood estimation methods) than with the two-stage instrumental variable procedure (**Wooldridge, 2002**; **Freedman and Sekhon, 2010**).

([11]) Indeed, almost all the answers in the SAFE are binary or categorical.

The RBPM (1) adopts a structural approach in which the second equation (y_{2i}^*) includes the dependent variable of the first equation (y_{1i}) as an endogenous variable and both variables of interest are binary variables. The RBPM assumes that the error terms (ε_i) are independent and follow a bivariate standard normalisation distribution (2). However, the joint estimation of both equations is only required if the correlation coefficient (ρ) of the two error terms is statistically different from zero.

$$\begin{cases} y_{1i}^* = x_{1i}\beta_1 + \varepsilon_{1i}, & y_{1i} = 1 \; if \; y_{1i}^* > 0; 0 \; otherwise, \\ y_{2i}^* = x_{2i}\beta_2 + \theta_1 y_{1i} + \varepsilon_{2i}, & y_{2i} = 1 \; if \; y_{2i}^* > 0; 0 \; otherwise \end{cases} \quad (1)$$

$$\begin{pmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{pmatrix} \rightarrow \Phi_2 \left[\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \right] \quad (2)$$

where Φ_2 refers to the bivariate standard normal-distribution function

In the present study, the first equation corresponds to being an innovative firm and the second to being a growing firm. Firm growth is measured by turnover improvement. We follow **Santos *et al.*** (2019) and **Santos and Cincera** (2021), who used the SAFE in their study, together with **Coad** (2007) to identify the explanatory variables to include in both equations, but with the additional limitation that only variables that are common to all waves since 2009 are included.

The selected common explanatory variables included in the first and second equations are: firm size (micro, small or medium), firm age (young, mature or old), economic activity (manufacturing, construction, trade or services), country and year of the survey. For more details about the variables used, see Table 8 (variable description) and Table 9 (descriptive statistics) in Appendix. Results of the multi-collinearity diagnostics (correlation matrix and the variance inflation factor - VIF) are reported in Table 10 in Appendix.

To explain innovation behaviour, we additionally consider competition level ([12]) in the previous period, measured by the number of companies in sector j in country i divided by the total number of companies in country i, where sector j, corresponds to manufacturing (NACE code C), construction (NACE code F), trade (NACE G) and services (NACE H-N). The time series was extracted from EUROSTAT and merged with the SAFE database. Competition is considered our exclusion restriction ([13]) following **Santos and Cincera** (2021). Furthermore, as there is a strong empirical evidence about the non-linear relationship between innovation and competition (see e.g. **Aghion *et al.*, 2005; Friesenbichler and Peneder, 2016**; **Crowley and Jordan, 2017**), our innovation equation also includes the square of the competition level.

([12]) Competition is only included in the innovation equation because it reveals to have no significant direct effect on growth (results available upon request).
([13]) Even if we know that according to **Wilde** (2000) and **Greene** (2008) no exclusion restrictions are needed if there is sufficient variation in the data. However, following **Chabé-Ferret et al.** (2018) we also decided to include an exclusion restriction in innovation decision for improving the variation in our model.

The second equation includes, in addition to the common explanatory variables and the endogenous innovation variable, firm's past performance regarding turnover (following **Santos et al., 2019**) and financing capacity (**Coad, 2007**). We are aware that access to finance is also important for the innovation decision (**Schumpeter, 1934**; **Levine, 2005**), however, in the SAFE firm-level information about financing refers to the firm's situation/perception in the last 6 months, whereas innovation behaviour mentions the firm status in the last 12 months. So, as highlighted by **Santos and Cincera** (2021), innovation is observed before or simultaneously to the firms' access to finance, whereby the relationship between financing and innovation cannot be precisely tested in this way. However, indirectly access to finance is captured by firm-size. Indeed, there is vast scientific literature (see e.g. **Beck *et al.*, 2006**; **Canepa and Stoneman, 2008**; **Coad *et al.*, 2016**) explaining that smaller firms are more financially constrained. Furthermore, sector dummies also capture the activity risk able to influence the level of financing constraints (**Canepa and Stoneman, 2002** and **2008**).

Regression estimation is weighted, in order to control for representativeness of firms' characteristics (size, industry sector and country) in their country and in the EU. We used the weight variable present in the SAFE database, where the weight of each enterprise is adjusted in each size class, economic sector, and country.

After estimating the RBPM, and following **Santos and Cincera** (2021) ([14]), we will be able to estimate the individual probability (of a firm to grow and innovate) for each firm-year observation. Then, thanks to those estimates we can map the intensity of this likelihood by year to assess differences (using a T-test for equality of means) to identify when growth and innovation likelihood were the most affected.

In order to identify benchmarks for 2020, we use Eurostat data regarding the evolution of the Gross Domestic Product (GDP). Figure 12 and Figure 13 in Appendix report two big falls in GDP in 2009 (financial crisis) and 2020 (Covid-19 health crisis). We also observe a drop in GDP in 2012-2013, still as a consequence of the 2009 Crisis, but affecting only some EU countries (Figure 13 in Appendix). We therefore exclude it as a benchmark. As post-2009 crisis we selected the years of 2015-2016, when almost all EU countries display a positive growth of their GDP and the size of this growth appears to be stable. The pre-Covid period includes the years of 2018-2019. In short, the estimated values for 2020 are compared with 2009 Crisis, 2015-2016 (post-2009 Crisis), 2018-2019 (pre-Covid) and the sample average (2009-2020).

5. Results and discussion

5.1. Assessing the innovation-growth relationship: baseline model

We start by estimating a univariate Probit model, where innovation behaviour is considered as an exogenous variable. Results, displayed in column (1) in Table 1, show that being an innovative firm has a significant

([14]) **Santos and Cincera** (2021), using a RBPM to assess the effect of innovation behaviour on financing constraints, estimated the probability of innovative firms to be financially constrained by country.

positive effect on the probability of turnover increase, improving its likelihood by 7.6% (column (1) in Table 2). Columns (2) and (3) in Table 1 report the results of the Recursive Bivariate Probit Model, where innovation is considered as an endogenous variable. The innovation coefficient is still significant and positive but the size of the effect is now higher - column (3) in Table 1. Findings are confirmed by the sign of the correlation coefficient (ρ) of the two error terms of both equations. Indeed, at the bottom of the Table 1, we observe a significant negative correlation between the error terms (ρ = -0.719); and the negative value of ρ means that the existing bias due to endogeneity lowers the effect of innovation behaviour on the firm's growth. Furthermore, as ρ is significant this also means that, to obtain consistent estimators, both Probit equations need to be estimated jointly, in order to control for the endogeneity bias of innovation behaviour.

Table 1. Results of the Probit and Recursive Bivariate Probit Model

Variables	Probit	Recursive Bivariate Probit	
	Y = Turnover increased (Y/N)	Y = Innovative firm (Y/N)	Y = Turnover increased (Y/N)
	(1)	(2)	(3)
Innovative firm (Y/N)	0.229***	-	1.174***
	(0.0102)	-	(0.142)
Market competition	-	0.779**	-
	-	(0.349)	-
Market competition - Squared	-	-0.738	-
	-	(0.469)	-
Past performance: sales (Y/N)	0.709***	-	0.621***
	(0.0137)	-	(0.0336)
Financial capacity (Y/N)	0.557***	-	0.487***
	(0.0116)	-	(0.0265)
Age: Mature firm (Y/N)	-0.116***	-0.0791***	-0.0699***
	(0.0244)	(0.0240)	(0.0254)
Age: Old firm (Y/N)	-0.214***	-0.248***	-0.0918***
	(0.0211)	(0.0208)	(0.0322)
Size: Small firm (Y/N)	0.223***	0.168***	0.131***
	(0.0121)	(0.0114)	(0.0236)
Size: Medium firm (Y/N)	0.358***	0.214***	0.231***
	(0.0129)	(0.0123)	(0.0319)
Activity and country dummy	Yes	Yes	Yes
Year (wave) dummy	Yes	Yes	Yes
Constant	-1.067***	0.431***	-1.608***
	(0.0452)	(0.0470)	(0.0733)
Log (pseudo)likelihood functions	-		-94,959.14
Pseudo R2	0.1145		-
Wald test - *H0: All coefficients = 0*	-		22,224.04 (0.000)
Coefficient correlation: rho	-		-0.719***
	-		(0.163)
Wald test - *H0: rho=0*	-		19.43 (0.000)
Number of observations (firms)	109,355		109,355

Source: Own elaboration based on SAFE database. Note: Robust standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1. Results refer to weighted regression estimation. Reference category for firm size is micro and for firm age is young. Results of Wald test include the p-value in parentheses.

Table 2. Marginal effects from the results in Table 1

Variables	Probit			Recursive Bivariate Probit Model					
	Y = Turnover increased			Y = Turnover increased			Y = Innovative firm		
	dy/dx	SE	P>z	dy/dx	SE	P>z	dy/dx	SE	P>z
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Innovative firm (Y/N)	0.076	0.003	0.000	0.356	0.036	0.000	-	-	-
Market competition	-	-	-	-	-	-	0.300	0.134	0.026
Market competition ²	-	-	-	-	-	-	-0.284	0.180	0.115
Past performance (Y/N)	0.236	0.004	0.000	0.188	0.014	0.000	-	-	-
Financial capacity (Y/N)	0.186	0.004	0.000	0.148	0.011	0.000	-	-	-
Age: Mature firm (Y/N)	-0.040	0.008	0.000	-0.021	0.008	0.008	-0.029	0.009	0.001
Age: Old firm (Y/N)	-0.073	0.007	0.000	-0.028	0.010	0.007	-0.094	0.008	0.000
Size: Small firm (Y/N)	0.074	0.004	0.000	0.040	0.008	0.000	0.065	0.004	0.000
Size: Medium firm (Y/N)	0.121	0.004	0.000	0.071	0.011	0.000	0.082	0.005	0.000
Year: 2011	0.182	0.010	0.000	0.151	0.013	0.000	-0.007	0.011	0.548
Year: 2013	0.109	0.010	0.000	0.089	0.011	0.000	0.009	0.012	0.449
Year: 2014	0.163	0.010	0.000	0.134	0.012	0.000	0.002	0.011	0.834
Year: 2015	0.172	0.010	0.000	0.136	0.013	0.000	0.017	0.011	0.127
Year: 2016	0.177	0.010	0.000	0.143	0.013	0.000	0.007	0.011	0.533
Year: 2017	0.220	0.010	0.000	0.178	0.015	0.000	0.003	0.011	0.809
Year: 2018	0.198	0.010	0.000	0.167	0.013	0.000	-0.018	0.011	0.097
Year: 2019	0.178	0.010	0.000	0.162	0.011	0.000	-0.049	0.011	0.000
Year: 2020	-0.047	0.009	0.000	-0.034	0.009	0.000	-0.032	0.011	0.005

Source: Own elaboration based on the SAFE database.

Note: SE = Standard Error. Reference category for firm size is micro, for firm age is young and for year is 2009.

An important finding from the results of the RBPM (Table 1**)** is that innovation has a positive effect on firm's growth, in line with the vast majority of previous studies (e.g. **Schumpeter, 1934**; **Mansfield, 1962**; **Aghion and Howitt, 1988, 1992**; **Colombelli *et al.*, 2011**; **Rosenbusch *et al.*, 2011**; **Santos *et al.*, 2019**). Results in Table 2 (referring to marginal effects) also report that, after controlling for firm's characteristics, the probability of firm's growth (column 4) and firms to innovate (column 7) is, respectively, 3.4% and 3.2% lower in 2020 in comparison with 2009, suggesting that the effect of the Covid-19 crisis could be higher than that of the previous economic crisis 2008/2009.

Table 1 also shows that the probability of firm's growth is negatively correlated with age, in line with previous findings (**Fizaine, 1968**; **Evans, 1987**; **Kangasharju, 2000**; **Coad, 2007**; **Navaretti *et al.*, 2014**). Its justification lies in the firm's motivation to grow to be higher for younger firms due to their recent entry in the market (**Kangasharju, 2000**; **Baum *et al.* 2001**; **Stenholm and Toivonen, 2009**) and also because of their tendency to be more innovative (**Pellegrino and Savona, 2013**).

Firm size reveals to be positively associated with the likelihood of firm growth ([15]), confirming the findings of **Santos *et al.*** (2019), and potentially explained by the higher market possibilities and networking of larger firms (**Bentzen *et al.*, 2012**), to be less financially constraint (**Beck *et al.*, 2006**; **Santos and Cincera, 2021**) and more innovative (**Pellegrino and Savona, 2013**).

Concerning the relationship between financial capacity and firm's growth likelihood, results in Table 1 are also in line with scientific literature (**Beck *et al*, 2005**; **Bottazzi et al. 2014**), revealing that improving firm's credit history is associated with firm growth. Past performance in terms of turnover also reveals to be positively correlated with firm growth as reported in other research (**Coad, 2007**; **Santos *et al.*, 2019**).

Regarding the results of the innovation equation (column 2 in Table 1), as expected, younger and larger firms disclose a higher likelihood to innovate (**Pellegrino and Savona, 2013**). Indeed, on the one hand younger firm have a higher incentive to innovate in order to enter into the market and to survive in the early stages of their activity. On the other hand, since larger firms have more financing possibilities, assets and resources, they have a higher capacity to innovate (**Santos, 2018**). With respect to the relationship between competition and innovation behaviour, we can only prove the inverted U-shape relationship of **Aghion *et al.*** (2005) at 12% significance level ([16]). Nevertheless, testing the non-linear relationship between competition and innovation is not the main purpose of this study, and the indicator to measure competition in this study is different from the one used by **Aghion *et al.*** (2005). We are using the number of companies by economic activity as proxy for competition level and **Aghion *et al.*** (2005) use the inverse of price-cost margin.

5.2. Covid-19 downturn and innovation behaviour

Based on the results of the RBPM we estimated the marginal success probability for innovation equation (Pr Innov = 1), to show by how much the innovation probability in 2020, estimated based on a set of firm characteristics, was affected by the Covid-19 crisis in comparison with the other benchmark periods. Results of the t-test for equality of means (Table 3) shows that the likelihood to innovate in 2020 is the same as in the pre-Covid period, but lower than in all the other benchmark periods (2009 crisis, post-2009 crisis and average). To potentially explain these findings, let's first remember that our data don't reflect the value of innovation or its intensity, our estimates only refer to the likelihood of innovation behaviour, which is associated with the number of firms introducing at least one typology of innovation. Secondly, we also know from the CIS that the percentage of innovative companies has decreased in recent years, their number being even lower in 2018 than in 2009 and following years, similar to the trend observed with the SAFE data.

([15]) Such findings are different from other researches (e.g. **Evans, 1987**; **Bentzen *et al.*, 2012**) that have tested the Gibrat's Law (**Gibrat, 1931**) and that are related to the effect of firm's size on the speed of the growth. Since we are working we a dichotomous variable, we are only testing how firm's size affects the likelihood of firm's growth and not how the firm' size affects the relative or absolute growth size.
([16]) We also replicated the same estimation without the squared of competition (results available upon request) but the model fits less well the data based on the value of the pseudo-likelihood.

Third, Eurostat data on the evolution of corporate R&D expenditure (Figure 14 in Appendix) display a real positive growth trend since 2010, even if we also observe a slowdown of its growth rate since 2018 (Figure 14 in Appendix). Lastly, the pre-Covid period is also associated with a great market uncertainty due to Brexit ([17]). So, based on what was listed, we can deduce that the pre-Covid period is characterised by a higher concentration of innovation decision and probability of innovation investment (because business R&D spending in the EU has increased, but the number of innovative companies has decreased). Furthermore, even if the likelihood to innovate was lower in 2020 in comparison with 2009, this doesn't mean that Covid-19 had a higher effect on innovation decision, because in the pre-Covid period the value observed is the same as in 2020. Lastly, 2020 refers to the first year of the health crisis and a certain delay in the effect of the pandemic may also be observed, which opens the door for new lines of research on this topic in the near future.

Table 3. Estimated probability of firm's innovation in EU27, by period

Benchmark Period	N° of observations		Means		Difference of means	Standard Error	P-value	Relative diff.
	Year: 2020	Benchmark	Year: 2020	Benchmark				
2009 crisis	11,845	3,893	0.545	0.576	-0.031	0.002	0.000	-5%
Post-crisis	11,845	24,343	0.545	0.597	-0.052	0.001	0.000	-9%
Pre-Covid	11,845	23,757	0.545	0.545	0.000	0.001	0.679	0%
Average	11,845	97,510	0.545	0.581	-0.036	0.001	0.000	-6%

Source: Own elaboration.

Note: results refer to a t-test for equality of means using the estimated marginal success probability for innovation equation based on the results from Table 1. Post-Crisis refers to the years of 2015-2016. Pre-Covid includes the years of 2018-2019.

5.3. Covid-19 and firm's growth

Based on the results of the RBPM, we also estimated the marginal success probability for growth equation (Pr growth = 1), to show how much Covid-19 affected growth likelihood and how the innovation behaviour affects outcomes in periods of downturn. Results in Table 4 and Table 5 refer to the estimated probability of firm's turnover growth based on a set of firm characteristics and obtained after controlling for the endogenous bias of innovation behaviour which affects growth.

Innovative firms have a higher probability to report an increase in their turnover than non-innovative ones during both upturns and downturns (Table 5). Even if innovative firms are also affected by Covid-19 crisis, they are less affected than non-innovative ones (Table 5). For instance, in 2020, the probability of turnover growth for innovative firms is around four times more than their counterparts, whereas in the pre-Covid crisis this difference was only the double (Table 5). A similar behaviour is also observed in all EU countries

([17]) Brexit refers to the withdrawal of the United Kingdom (UK) from the European Union. The calendar of events that are at the heart of the withdrawal started in 2015 with a referendum, passing through the beginning of the process in March 2017 (invocation of the article 50 of the Treaty on European Union), until the official exit of the UK on 31 January 2020.

(Table 11 in Appendix), even if more pronounced in some countries (e.g. Slovenia, Austria, Hungary and Germany) than in others (e.g. Romania, Portugal and Luxembourg).

Table 4. Estimated probability of firm's turnover growth in EU27, by period

Benchmark period	N° of observations		Means		Difference of means	Standard Error	P-value	Relative diff.
	Year: 2020	Benchmark	Year: 2020	Benchmark				
2009 Crisis	11,845	3,893	0.235	0.273	-0.038	0.004	0.000	-14%
Post-Crisis	11,845	24,343	0.235	0.444	-0.209	0.003	0.000	-47%
Pre-Covid	11,845	23,757	0.235	0.449	-0.214	0.003	0.000	-48%
Average	11,845	97,510	0.235	0.436	-0.201	0.003	0.000	-46%

Source: Own elaboration.

Note: results refer to a t-test for equality of means using the estimated marginal success probability for growth equation based on the results from Table 1. Post-Crisis refers to the years of 2015-2016. Pre-Covid includes the years of 2018-2019.

Table 5. Estimated probability of firm's turnover growth in EU27, by innovation behaviour and period

Period	N° of observations		Means		Difference of means	Standard Error	P-value	Relative diff.
	Innov	Non-Innov	Innov	Non-Innov				
2009 Crisis	2,175	1,718	0.420	0.086	0.334	0.004	0.000	388%
Post-Crisis	14,545	9,798	0.615	0.191	0.424	0.002	0.000	222%
Pre-Covid	12,983	10,774	0.647	0.210	0.437	0.002	0.000	208%
Covid-19	6,378	5,467	0.376	0.070	0.306	0.002	0.000	437%
Average	62,911	46,444	0.589	0.177	0.412	0.001	0.000	233%
Statistical differences between coefficients (Results Z-test)						|Z|	P-value	
Covid-19 *versus* 2009 Crisis					0.028	0.004	6.261	0.000
Covid-19 *versus* Pre-Covid					0.131	0.003	46.315	0.000

Source: Own elaboration.

Note: Results refer to a t-test for equality of means using the estimated marginal success probability for growth equation based on the results from Table 1. Post-Crisis refers to the years of 2015-2016. Pre-Covid includes the years of 2018-2019.

Furthermore, the difference between innovative and non-innovative firms in terms of their economic performance in 2020 was also higher than in 2009 (437% *versus* 388%) and this divergence between coefficients is also statistically significant at 1% level (Table 5). Such findings suggest that innovation was more important than ever to mitigate the negative effect of the Covid-19 pandemic, especially as we also observe that the probability of turnover growth was more affected by the health crisis than by the economic 2009 crisis as reported in Table 4.

5.4. Covid-19 and changes in innovation behaviour

As a complementarity analysis, and based on the review of the literature (section 2), we also analyse changes in innovation behaviour. To this purpose, we estimated a Probit regression model (equation 1) by type of innovations, where the reference category corresponds to non-innovate. Results are reported in Table 13 in

Appendix. The estimated probabilities by innovation typology by year are summarised in Table 6, where the values for 2020 are compared to those of others periods.

Table 6. Estimated probability of firm's innovate in EU27, by innovation typology and period

	Benchmark period	N° of observations		Means		Difference of means	Standard Error	P-value	Relative diff.
		Year: 2020	Benchmark	Year: 2020	Benchmark				
Product	2009 crisis	11,845	3,893	0.399	0.457	-0.058	0.002	0.000	-13%
	Post-crisis	11,845	24,343	0.399	0.474	-0.075	0.002	0.000	-16%
	Pre-Covid	11,845	23,757	0.399	0.405	-0.006	0.002	0.000	-1%
	Average	11,845	97,510	0.399	0.452	-0.053	0.001	0.000	-12%
Process	2009 crisis	11,845	3,893	0.342	0.361	-0.019	0.002	0.000	-5%
	Post-crisis	11,845	24,343	0.342	0.406	-0.064	0.002	0.000	-16%
	Pre-Covid	11,845	23,757	0.342	0.350	-0.008	0.002	0.000	-2%
	Average	11,845	97,510	0.342	0.383	-0.041	0.001	0.000	-11%
Organisation	2009 crisis	11,845	3,893	0.384	0.349	0.035	0.002	0.000	10%
	Post-crisis	11,845	24,343	0.384	0.426	-0.042	0.001	0.000	-10%
	Pre-Covid	11,845	23,757	0.384	0.383	0.001	0.001	0.178	0%
	Average	11,845	97,510	0.384	0.393	-0.009	0.001	0.000	-2%
Marketing	2009 crisis	11,845	3,893	0.360	0.396	-0.036	0.002	0.000	-9%
	Post-crisis	11,845	24,343	0.360	0.401	-0.041	0.001	0.000	-10%
	Pre-Covid	11,845	23,757	0.360	0.330	0.030	0.001	0.000	9%
	Average	11,845	97,510	0.360	0.377	-0.017	0.001	0.000	-5%

Source: Own elaboration. Note: results refer to a t-test for equality of means using the estimated marginal success probability for innovation equation based on the results from Table 13. Post-Crisis refers to the years of 2015-2016. Pre-Covid includes the years of 2018-2019.

Results in Table 6 indicate that not all types of innovations were negatively affected by the pandemic. For instance, in comparison with the Pre-Covid period, only product and process innovation report a decrease in their likelihood. Furthermore, changes in the innovation patterns in 2020 are also observed. Marketing innovation (i.e. new ways of selling goods or services) registered a higher value in comparison with the Pre-Covid period. Organisation innovation (e.g. related to an increase of efficiency or reducing of costs) appears to be not affected by the pandemic and register even a higher value than in the 2009 crisis.

Such findings show the differences between the Covid-19 health crisis and other downturns, and report evidences on how EU firms have reacted to overcome the negative effects of the first year of the Covid-19 crisis. Furthermore, they also provide quantitative proof of the observed trends in the 2020 ([18]), namely:

- **Changes in the business to consumer** (B2C) **or business to business** (B2B) **relationship**, due to lockdown, mobility/travel restrictions and changes in consumer behaviour/preferences. Therefore, to survive, firms have improved their online presence and introduced new ways of selling products or services.

([18]) See for example **Marques Santos *et al.*** (2020) and **Santos** (2020).

- **Changes in the organisation methods** due to teleworking and replacement of physical meetings for on-line ones.

6. Conclusions and implications for policy

The present study aims to assess how Covid-19 affected innovation behaviour and the likelihood of EU firm growth in comparison with previous downturns. Furthermore, it provides also empirical evidence on how the persistence of innovation in periods of economic downturns helps firms to mitigate the negative effects of the crisis.

Using a Recursive Bivariate Probit Model and survey (SAFE) data, results show that the economic performance of innovative firms in 2020 was less affected by the coronavirus disease than non-innovative ones. This result emphasises that research and innovation remains at the heart of competitiveness, resilience and recover of the economy, especially when facing the effects of the present pandemic crisis.

The analysis also points out that organisation and marketing innovation were the patterns primarily pursued by the firms. This firms' strategy is likely deployed because both types of innovation could better tackle the revealed main business activity problem of finding customers (shortness in demand), as suggested by literature ([19]). Furthermore, such strategy could also be chosen by firms because the mentioned innovations are normally less expensive and achievable in a shorter-time than R&I investments in the production chain of goods and services – being the production or labour cost the second most important business activity problem found by this analysis.

The Covid-19 pandemic also brought new obstacles to business activities (mobility/travel restrictions, lockdown, disruption of the value chain, closure of borders,…). Finding customers, problems with cost of production and labour, and availability of skilled staff are other problems raised more frequently by firms. Interesting, the availability of skilled staff emerges from this analysis as a relevant business activity problem also during the pandemic crisis. In fact, the shortness in skilled workforce is an endemic limitation of the EU labour market, especially in important knowledge-intensive sectors ([20]).

It derives that the EU should strengthen its own capacity and autonomy ([21]), especially in strategic areas, building on the opportunities of a fully functioning Single Market ([22]), competition policy, Industrial Policy ([23]) and Trade Policy ([24]), facilitating open and dynamic markets that promote innovation and consumers'

([19]) See for instance **Grewal and Tansuhaj** (2001), **Kanagal** (2015) **and Ramirez *et al.*** (2018).
([20]) The reductions of investments in higher education and research and innovation due to short-term perspectives are curtailing the long-term EU growth and welfare potential (**Moncada-Paternò-Castello *et al.*, 2018**).
([21]) See also **European Parliamentary Research Service** (2020) .
([22]) Potential gains of completing the (classic and digital) Single Market are estimated to result in gains of around € 890 billion (**European Parliamentary Research Service, 2019**)
([23]) **European Commission** (2021a)
([24]) **European Commission** (2021b)

confidence. Taking full advantage of new technologies such as Artificial Intelligence can also contribute substantially to cost reduction and efficiency gains ([25]).

Instruments tailored to mitigating the economic and social impact of the coronavirus disease such as the Next Generation EU, which includes the "Recovery and Resilience Facility", represent a cornerstone opportunity (also) for the private sector.

Accompanying policy responses are also necessary and should include special lay-off schemes, fiscal incentives, and special business credit lines, among others. Furthermore, targeted research and innovation efforts (including through "Horizon Europe") are also key in addressing the EU's RDI gap in high-tech ecosystems in comparison with its global competitors, for finding a way out of the present crisis and for equipping the EU for the next competition race. Table 7 provides a synopsis of the policy options described in this section.

Table 7. Policy options – a synopsis

Dimension	Short term	Medium term	Long term
Create an innovative & more transformative environment in firms	- Support in-the-firm innovation (organisation, marketing, product,…) for short term survival (national, regional) through grants of fiscal incentives - Increase innovation literacy (through associations, clusters,…) - Increase digitalisation of firms - SME Instrument of EIC, Erasmus for Young Entrepreneurs, Enterprise Europe Network,…	- Maximise benefits for firms of the investments of Recovery and Resilience Facility (Pillar 1 of the EC Recovery Plan), Strategic Investment Facility, Upgraded InvestEU, Just Transition Fund, EIB, and upgraded Cohesion policy programmes, R&I Missions - Support diversified participation in Horizon Europe, EIC, EIT - National, regional, local support programmes and fiscal policy	- Make the twin transition a reality in firms, drawing on all public and private investment opportunities
Finding customers and markets	- Support market research - Stimulate short-term demand e.g. through fiscal measures, vouchers,…	- Monitor changing consumer preferences/invest in behavioural economics - Update Smart Specialisation Strategies and take advantage of economies of scope - Reinforce governance of European value chains around core systems central to the twin transition[26]	- Optimise the functioning of the Single Market - Draw on competition policy to facilitate open and dynamic markets promoting innovation and consumers' confidence

Continued in the next page …

([25]) See the White Paper on AI. The World Economic Forum estimates that 'developing and diffusing AI in its current assets and digital position could add up to an estimated €2.7 trillion to European economic output by 2030' (**World Economic Forum, 2019**; **McKinsey, 2019**).

([26]) Typically 5 key systems are recognised as being central to this transition towards sustainability: the housing system, the agri-food system, the manufacturing system, the mobility system, and the energy system (**McCann and Soete, 2020**).

Table 7. Policy options – a synopsis (Continuation)

Dimension	Short term	Medium term	Long term
Production and labour cost	- Special lay-off schemes - Temporary flexibility and exemptions for social security contributions[27] - Maximise the use of SURE[28] and EASE[29] instruments - Special business credit lines	- Draw on public and private financing for increasing energy efficiency e.g. through RRF, EIB, Cohesion fund, etc.	- Increase benefits and reduce costs in potential areas of strategic autonomy, through Trade Policy Industrial Policy etc. - Take full advantage of new technologies, e.g. through AI (see footnote 26)
Availability of skilled staff	- Draw on the Youth Guarantee and apprenticeships - EC support for the Centres of Vocational Excellence (COVEs)	- Communication on a European Skills Agenda for sustainable competitiveness, social fairness and resilience - Council Recommendation on vocational education and training (VET) - Develop EU Talent Partnerships and reform EU Blue Card Directive, Directive on long-term residents, and of Single Permit Directive	- Take full advantage of the European Education Area - Leverage international recruitment into the Single Market

Source: Own elaboration based on sources cited in this section.

The specific innovation policy objectives that can be derived from the main results of the analysis should aim to create a pro-innovation, more transformative, environment. It also appears of utmost importance to guarantee the provision of adequate human capital to fulfil the present shortness of skilled staff and the future knowledge needs.

This work has also shown that young firms are more able to generate turnover growth and to undertake innovative activities. Therefore, investments in and incentives for firms–notably innovative start-ups ([30]) and young innovative SMEs- are essential to create the capacity to maintain their economic activity and invest in RDI during the crisis ([31]) to build system-wide resilience and recovery.

([27]) For an overview, see: ISSA
([28]) European instrument for temporary Support to mitigate Unemployment Risks in an Emergency.
([29]) Effective Active Support to Employment.
([30]) Start-ups are key dynamic players and drivers of innovation, e.g. young firms account for about 20% of employment but create nearly half of new jobs across OECD countries (**OECD, 2016**), and innovation by young firms contributes significantly to aggregate productivity growth, accounting for half of it in the US (**Klenow and Li, 2020**).
([31]) An interesting "EU start-up calculator" elaborated by the European Commission allows to compute an estimate of the medium-run impact that Covid-19 may have on aggregate employment due to the disruption of start-ups and young firms (**Benedetti Fasil *et al.*, 2020**).

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Appendix

Figure 11. Perceived intensity of different pressing problems by country in April – September 2020 (pandemic time)

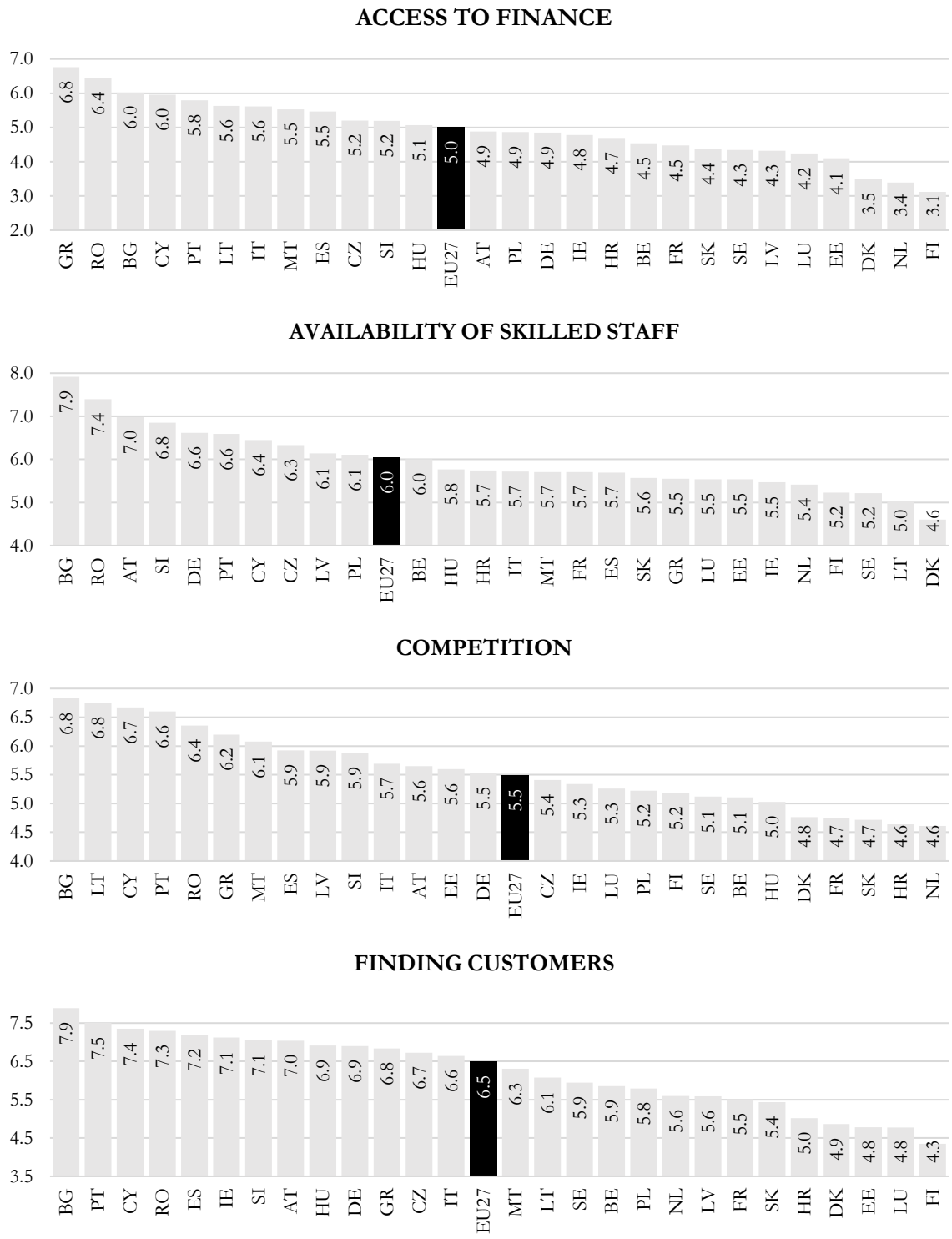

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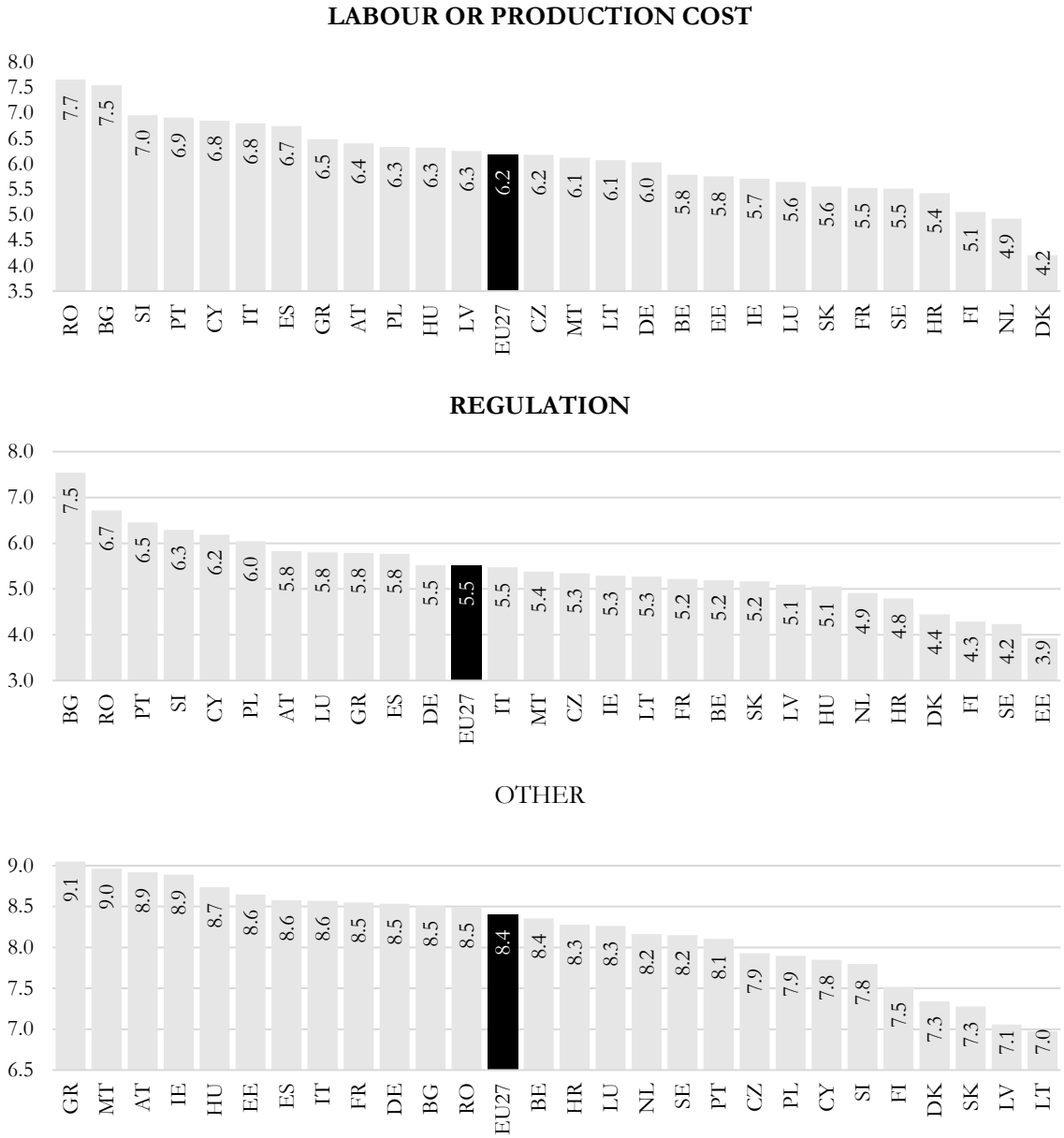
Figure 11. Perceived intensity of different pressing problems by country in April – September 2020 (pandemic time) (Continuation)



Source: Own elaboration.
Note: Results refer to weighted average.

Table 8. Variable name and description

Variable name	Variable description
Dependent variable – Equation 1	
Innovative firm	= 1 if firm has introduced, during the past 12 months, one of the following types of innovative activities: a) new or improved product or service; b) new or improved production process or method; c) new organisation of management; d) new way of selling goods or services (marketing); 0 otherwise.
Dependent variable – Equation 2	
Firm growth	= 1 if firm has increased its turnover in the past 6 months; 0 otherwise (= remained unchanged or decreased).
Independent variables	
Firm size	
Firm size considering the criteria: n° of employees, as reported in the Commission Recommendation 2003/361.	
Size: Micro	= 1 if micro firm; 0 otherwise.
Size: Small	= 1 if small firm; 0 otherwise.
Size: Medium	= 1 if medium-sized firm; 0 otherwise.
Firm age	
Firm age was divided in three categories considering the criteria of **Criscuolo *et al.*** (2014).	
Age: Young firm	= 1 if it is a young firm less than 5 years old; 0 otherwise.
Age: Mature firm	= 1 if it is a mature firm between 5 and 10 years old; 0 otherwise
Age: Old firm	= 1 if it is an old firm more than 10 years old; 0 otherwise
Economic activity	
Industry	= 1 if main activity is included in manufacturing, mining and electricity, gas and water supply
Construction	= 1 if main activity is construction
Trade	= 1 if main activity is included in wholesale or retail trade
Services	= 1 if main activity in included in services to businesses or persons (e.g. hotels, restaurants, IT services)
Other variables	
Market diversification	Percentage of firms (n°) by economic activity (activity-country-year data from EUROSTAT)
Firm's past performance	= 1 if over the past three years the company grow in terms of turnover on average over 20% per year; 0 otherwise (= less than 20% per year, no growth or got smaller)
Financial capacity	= 1 if firm's improved credit history over the past six months; 0 otherwise (= remained unchanged or deteriorated)

Source: Authors' own elaboration.

Table 9. Mean, Standard deviation, minimum and maximum

Variable	Obs	Mean	Std. Dev.	Min	Max
Turnover increased (Y/N)	109,355	0.390	0.488	0	1
Past performance (Y/N)	109,355	0.160	0.366	0	1
Financial capacity (Y/N)	109,355	0.244	0.430	0	1
Innovative firm (Y/N)	109,355	0.575	0.494	0	1
Market competition (%)	109,355	0.300	0.173	0.02	0.63
Size: Micro firm (Y/N)	109,355	0.379	0.485	0	1
Size: Small firm (Y/N)	109,355	0.324	0.468	0	1
Size: Medium firm (Y/N)	109,355	0.297	0.457	0	1
Age: Young firm (Y/N)	109,355	0.058	0.234	0	1
Age: Mature firm (Y/N)	109,355	0.126	0.332	0	1
Age: Old firm (Y/N)	109,355	0.816	0.387	0	1
Activity: Manufacturing	109,355	0.241	0.428	0	1
Activity: Construction	109,355	0.119	0.324	0	1
Activity: Trade	109,355	0.263	0.440	0	1
Activity: Services	109,355	0.376	0.484	0	1
Year: 2009	109,355	0.036	0.185	0	1
Year: 2011	109,355	0.095	0.293	0	1
Year: 2013	109,355	0.095	0.293	0	1
Year: 2014	109,355	0.118	0.323	0	1
Year: 2015	109,355	0.111	0.314	0	1
Year: 2016	109,355	0.111	0.315	0	1
Year: 2017	109,355	0.108	0.311	0	1
Year: 2018	109,355	0.109	0.312	0	1
Year: 2019	109,355	0.108	0.310	0	1
Year: 2020	109,355	0.108	0.311	0	1

Source: Own elaboration.

Table 10. Correlation matrix and VIF

#	Variables	VIF	Correlation matrix						
			1	2	3	4	5	6	7
1	Innovative firm (Y/N)	1.02	1						
2	Past performance: sales (Y/N)	1.04	0.098	1					
3	Financial performance (Y/N)	1.03	0.098	0.107	1				
4	Age: Mature firm (Y/N)	2.77	0.021	0.102	0.017	1			
5	Age: Old firm (Y/N)	2.84	-0.036	-0.153	-0.018	-0.799	1		
6	Size: Small firm (Y/N)	1.27	0.024	0.028	0.025	-0.014	0.028	1	
7	Size: Medium firm (Y/N)	1.30	0.054	-0.022	0.061	-0.093	0.125	-0.450	1
	Mean VIF	1.61							

Source: Own elaboration.

Figure 12. GDP evolution, real change (%) compared to the previous year, EU27

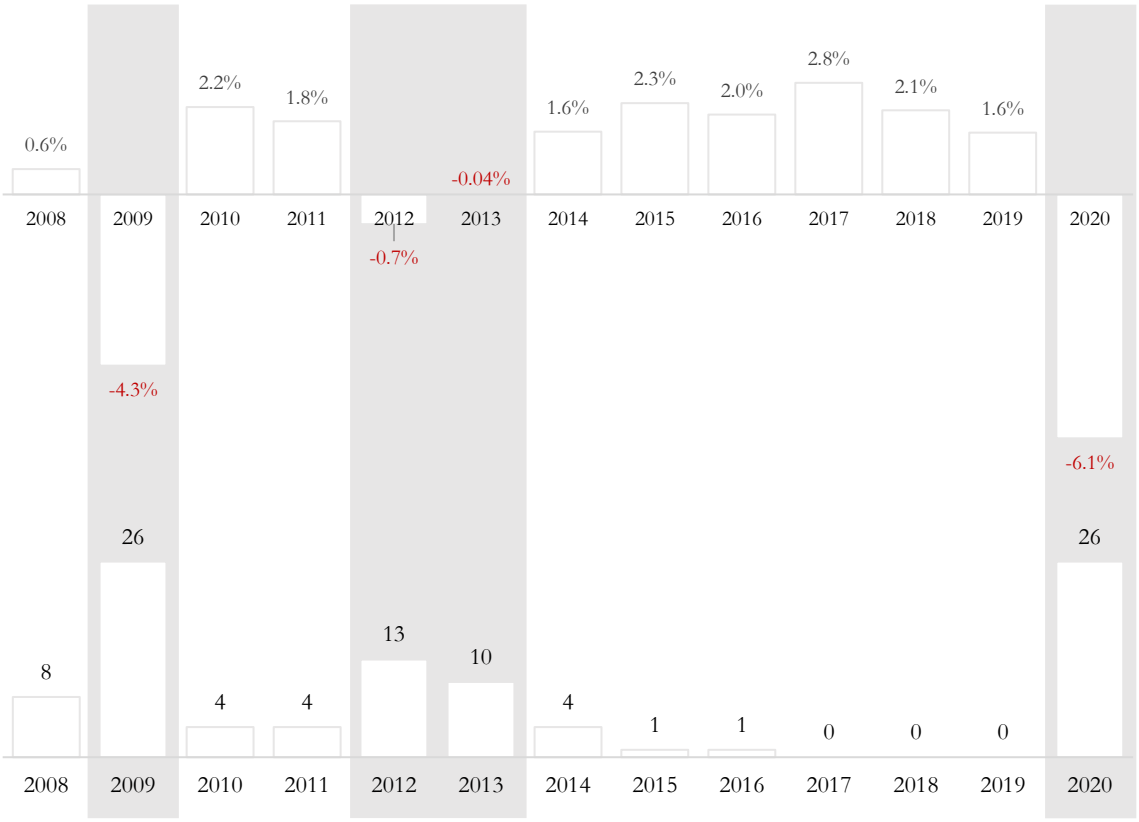
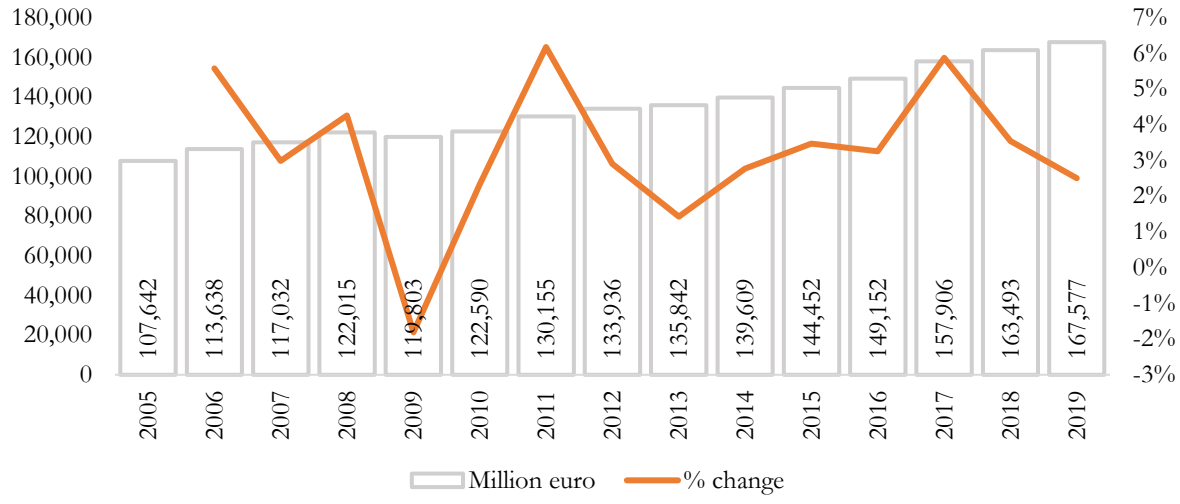


Figure 13. Number of countries with a real negative GDP growth rate by year, EU27

Source: Own elaboration based on Eurostat data.

Note: Real change means that it excludes the effect of inflation.

Figure 14. Business R&D Expenditures, Million euro, constant prices (base 2005), EU27, 2005-2019



Source: Own elaboration based on Eurostat data.

Table 11. Estimated probability of firm's turnover growth in EU27, by innovation behaviour, period and country

Country	Period	N° of observations		Means		Difference of means	Standard Error	P-value	Relative diff.
		Innov	Non-Innov	Innov	Non-Innov				
AT	2020	211	202	0.413	0.076	0.337	0.010	0.000	443%
AT	2018-2019	431	353	0.702	0.250	0.452	0.008	0.000	181%
BE	2020	239	189	0.390	0.071	0.319	0.009	0.000	449%
BE	2018-2019	452	382	0.669	0.222	0.447	0.007	0.000	201%
BG	2020	145	171	0.307	0.051	0.256	0.010	0.000	502%
BG	2018-2019	344	304	0.592	0.170	0.422	0.009	0.000	248%
CY	2020	28	45	0.296	0.041	0.255	0.021	0.000	622%
CY	2018-2019	117	52	0.576	0.147	0.429	0.020	0.000	292%
CZ	2020	170	117	0.368	0.066	0.302	0.013	0.000	458%
CZ	2018-2019	329	250	0.638	0.196	0.442	0.009	0.000	226%
DE	2020	486	517	0.445	0.086	0.359	0.006	0.000	417%
DE	2018-2019	1,116	1,155	0.706	0.255	0.451	0.004	0.000	177%
DK	2020	193	174	0.457	0.107	0.350	0.012	0.000	327%
DK	2018-2019	374	281	0.722	0.269	0.453	0.009	0.000	168%
EE	2020	55	29	0.416	0.081	0.335	0.025	0.000	414%
EE	2018-2019	76	72	0.713	0.242	0.471	0.018	0.000	195%
ES	2020	592	470	0.342	0.054	0.288	0.006	0.000	533%
ES	2018-2019	1,147	1,055	0.609	0.167	0.442	0.004	0.000	265%
FI	2020	338	105	0.348	0.060	0.288	0.012	0.000	480%
FI	2018-2019	666	222	0.625	0.187	0.438	0.009	0.000	234%
FR	2020	606	570	0.374	0.067	0.307	0.005	0.000	458%
FR	2018-2019	1,196	1,098	0.649	0.203	0.446	0.004	0.000	220%
GR	2020	259	168	0.321	0.043	0.278	0.011	0.000	647%
GR	2018-2019	545	317	0.564	0.138	0.426	0.009	0.000	309%
HR	2020	112	99	0.414	0.074	0.340	0.015	0.000	459%
HR	2018-2019	239	190	0.665	0.211	0.454	0.012	0.000	215%
HU	2020	110	189	0.451	0.095	0.356	0.011	0.000	375%
HU	2018-2019	234	365	0.730	0.288	0.442	0.010	0.000	153%
IE	2020	241	209	0.416	0.083	0.333	0.009	0.000	401%
IE	2018-2019	440	445	0.716	0.260	0.456	0.008	0.000	175%
IT	2020	765	540	0.287	0.040	0.247	0.005	0.000	618%
IT	2018-2019	1,509	1,107	0.556	0.137	0.419	0.004	0.000	306%
LT	2020	120	78	0.413	0.083	0.330	0.017	0.000	398%
LT	2018-2019	245	178	0.676	0.234	0.442	0.011	0.000	189%
LU	2020	35	34	0.359	0.064	0.295	0.017	0.000	461%
LU	2018-2019	82	67	0.656	0.186	0.470	0.016	0.000	253%
LV	2020	74	54	0.389	0.060	0.329	0.020	0.000	548%
LV	2018-2019	150	137	0.632	0.172	0.460	0.013	0.000	267%
MT	2020	48	43	0.324	0.048	0.276	0.017	0.000	575%
MT	2018-2019	112	53	0.613	0.170	0.443	0.021	0.000	261%
NL	2020	346	353	0.457	0.097	0.360	0.009	0.000	371%
NL	2018-2019	703	664	0.729	0.279	0.450	0.006	0.000	161%
PL	2020	357	424	0.389	0.067	0.322	0.007	0.000	481%
PL	2018-2019	757	834	0.651	0.210	0.441	0.005	0.000	210%
PT	2020	253	156	0.345	0.060	0.285	0.011	0.000	475%
PT	2018-2019	490	346	0.631	0.175	0.456	0.008	0.000	261%

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Table 11. Estimated probability of firm's turnover growth in EU27, by innovation behaviour, period and country (Continuation)

Country	Period	N° of observations		Means		Difference of means	Standard Error	P-value	Relative diff.
		Innov	Non-Innov	Innov	Non-Innov				
RO	2020	181	123	0.412	0.086	0.326	0.014	0.000	379%
RO	2018-2019	393	200	0.679	0.211	0.468	0.011	0.000	222%
SE	2020	194	199	0.460	0.105	0.355	0.011	0.000	338%
SE	2018-2019	381	328	0.717	0.268	0.449	0.008	0.000	168%
SI	2020	87	69	0.362	0.059	0.303	0.017	0.000	514%
SI	2018-2019	154	105	0.648	0.218	0.430	0.015	0.000	197%
SK	2020	133	140	0.340	0.051	0.289	0.011	0.000	567%
SK	2018-2019	301	214	0.618	0.177	0.441	0.010	0.000	249%
EU27	2020	6,378	5,467	0.376	0.070	0.306	0.002	0.000	437%
EU27	2018-2019	12,983	10,774	0.647	0.210	0.437	0.002	0.000	208%

Source: Own elaboration.
Note: Results refer to a t-test for equality of means using the estimated marginal success probability for growth equation based on the results from Table 1.

Table 12. Results Probit regression : Y = Innovation behaviour (by innovation typology), reference year all excluding 2020

Variables	Product	Process	Organisation	Marketing
	(1)	(2)	(3)	(4)
Competition, firm age and size	Yes	Yes	Yes	Yes
Activity and country dummy	Yes	Yes	Yes	Yes
Year: 2020	-0.106***	-0.0893***	-0.00965	-0.0162
	(0.0182)	(0.0196)	(0.0182)	(0.0187)
Constant	Yes	Yes	Yes	Yes
Observations	82,613	71,442	75,957	73,666
Log pseudolikelihood	-37,344.8	-30,935.4	-34,714.9	-32,691.7
Pseudo R2	0.0373	0.0415	0.0352	0.0335
Wald test – *H0: All coefficients = 0*	3,403.5 (0.000)	3,406.7 (0.000)	3,088.6 (0.000)	2,741.1 (0.000)
% Correctly classified	60.38%	64.85%	62.00%	64.06%

Source: Own elaboration based on SAFE database.

Note: Robust standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1. Results refer to weighted regression estimation. Reference category for year is 2020. Result of Wald test includes the p-value in parentheses.

Table 13. Results Probit regression: Y = Innovation behaviour (by innovation typology), reference year 2020

Variables	Product	Process	Organisation	Marketing
	(1)	(2)	(3)	(4)
Competition, firm age and size	Yes	Yes	Yes	Yes
Activity and country dummy	Yes	Yes	Yes	Yes
Year: 2009	0.141***	0.0721*	-0.0755**	0.0422
	(0.0336)	(0.0376)	(0.0375)	(0.0360)
Year: 2011	0.130***	0.0407	-0.113***	-0.00291
	(0.0254)	(0.0279)	(0.0269)	(0.0272)
Year: 2013	0.141***	0.0921***	-0.0797***	0.0398
	(0.0262)	(0.0285)	(0.0277)	(0.0277)
Year: 2014	0.134***	0.108***	-0.0331	0.0674***
	(0.0233)	(0.0253)	(0.0242)	(0.0242)
Year: 2015	0.197***	0.189***	0.101***	0.126***
	(0.0234)	(0.0255)	(0.0238)	(0.0243)
Year: 2016	0.154***	0.116***	0.0817***	0.0645***
	(0.0232)	(0.0252)	(0.0237)	(0.0243)
Year: 2017	0.115***	0.131***	0.0754***	0.0479*
	(0.0237)	(0.0257)	(0.0238)	(0.0249)
Year: 2018	0.0494**	0.0508**	0.0420*	-0.0496**
	(0.0234)	(0.0253)	(0.0235)	(0.0244)
Year: 2019	-0.0320	-0.00104	-0.0609***	-0.137***
	(0.0234)	(0.0253)	(0.0235)	(0.0246)
Constant	Yes	Yes	Yes	Yes
Observations	82,613	71,442	75,957	73,666
Log pseudolikelihood	-37,281.1	-30,896.3	-34,633.2	-32,616.2
Pseudo R2	0.0389	0.0427	0.0375	0.0358
Wald test – *H0: All coefficients = 0*	3,569.5 (0.000)	3,511.3 (0.000)	3,216.2 (0.000)	2,895.3 (0.000)
% Correctly classified	60.49%	65.03%	62.31%	64.16%

Source: Own elaboration based on SAFE database.

Note: Robust standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1. Results refer to weighted regression estimation. Reference category for year is 2020. Result of Wald test includes the p-value in parentheses.

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