Can Small Firms Be the Leaders of Innovation?
Finding the Determinants of Product and Process Innovation

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Abstract

The determinant of innovation firm size has fostered an intensive debate in the literature with little consensus, especially when innovation is disaggregated into product and process. Moreover, the usual absence of joint innovation categories makes studies fall short in analysing the interrelationship between product and process innovations. Thus, we study the innovation-firm size relationship considering the choices of engaging in product, process, or in both innovations. Then, from the exploration-exploitation standpoint, we tackle the assumption that joint innovation strategies increase innovation performance by analysing potential trade-offs faced by different sized firms that follow both types simultaneously. Using the Portuguese Community Innovation Survey (CIS) and the Integrated Business Accounts System (SCIE), between 2008 and 2018, we find that small firms have relative advantage at introducing product innovation, medium at process innovation, and large firms at the joint category. Likewise, we observe that large firms benefit the most from joint innovation strategies, with small firms following. When we disaggregate firm size into a numerical variable, we learn that firms employing between 276 and 3,055 workers have contracted innovation performances.

Keywords: Exploitation, Exploration, Firm Size, Joint Innovation Strategies, Process Innovation, Product Innovation.

1. Introduction

Innovation management is a strategic pillar for companies and nations to foster sustainable long-term economic growth and tackle social and environmental challenges (World Bank Group, 2020, Chapter 2). Albeit the unquestionable role of innovation in societies, the literature lacks in providing a clear understanding of some of its determinants, in particular, of how firm size is related to the ability to innovate (Harrison, 1994). This relationship is underpinned by a puzzling set of different theories that highlight little consensus (Tsai & Wang, 2005).

While some scholars (e.g. Scherer [1965]) defend that being small is advantageous to the creation of patentable inventions, others (e.g. Schumpeter [1942]) argue that economic growth comes from innovation with monopoly power and large firm size. Even though large firms with market power are seen, during the first three decades after the Second World War, as the prevailing driving engine of innovative activity, a wave of new studies challenge this paradigm (Acs & Audretsch, 2005). Arrow (1962) defends that firms in competitive markets have a greater incentive to innovate. Cohen & Klepper (1996) find that, either due to the loss of managerial control or excessive bureaucratic procedure, larger firms generate fewer innovations than their smaller counterparts. The knowledge of firm's size role is further hindered when we disaggregate innovation into different types (Keupp, Palmié, & Gassmann, 2012). Hence, we carry out an empirical study on the innovation-firm size relationship, analysing in particular product and process innovations, in Portugal. Here, we include an often-overlooked aspect, the possibility of firms pursuing product and process innovation simultaneously (Ballot, Fakhfakh, Galia, & Salter, 2015).

It is widely recognized that joining both product and process innovation can yield better performance results (e.g. Ballot et al. [2015]). However, with scholars' increasing interest on the exploitation-exploration dilemma (Benner & Tushman, 2015), one should explore an under-researched issue: the possibility that firms' returns from innovations may decrease when pursuing both types of innovation simultaneously that, although related, are largely driven by different factors (Vaona & Pianta, 2008). This resembles the tension between exploitation (development of organisations' existing capabilities) and exploration (development of new technical and market expertise) of innovation activities (Lavie, Stettner, & Tushman, 2010), in which organisations capable of undertaking both innovation paths by buffering their contrasting effects are termed ambidextrous firms (Benner & Tushman, 2015).

Moreover, firms are constrained by their organizational characteristics (Jin, Li, & Wu, 2016), which raises the possibility that different firm sizes may have distinct impacts in strategies that follow product and process innovations. In order to understand the role of ambidexterity when pursuing different types of innovation, we need to acknowledge the existence of frictions in joint innovation strategies and how these depend on firm size. Hence, we carry out a subsequent analysis to explore the impact of developing product and process innovations simultaneously on innovation performance and its relationship to firm size.

This study makes use of the Community Innovation Survey (CIS), a database that has been widely deployed in the literature of the determinants of innovation (e.g. Ballot et al. [2015]). We look into the Portuguese version between 2008 and 2018. We find that small firms have an advantage at developing product innovation, medium firms at process innovation, while large firms are more likely to introduce both product and process innovations at the same time. Regarding the impact of joining product and process innovations simultaneously, we find a non-linear U-shaped curve with firm size, in which very large firms achieve the highest innovation performance, small firms follow, and those with a workforce between 276 and 3,055 employees experience contracted innovation performances.

2. Literature Review and Hypotheses

2.1 Innovation Typology

Typology frameworks aim at improving the way we manage innovation through the translation of this abstract concept into concrete classes, in order to better predict their sources and impacts (Eiriz, Faria, & Barbosa, 2014). A typology widely adopted in the determinants of innovation literature (e.g. Fonseca [2014]) and supported by the guidelines established in the OECD Oslo Manual (OECD/Eurostat, 2018) is the *Multitype Classification* framework, where innovation is classified into product and process innovation (Kotsemir & Abroskin, 2013). Product innovation is defined as a good or service that was significantly improved and transacted in the market. Process innovation is the implementation of new or significantly improved methods of production or delivery of the product. Both are further grouped in technological innovations (Kotsemir & Abroskin, 2013).

2.2 Firm Size and Innovation

The relationship between firm size and innovation has been a hotbed of theoretical speculation and empirical investigation for many decades. Covering different time periods, industries, and measures of innovative activity explains the wide range of findings across studies (Vaona & Pianta, 2008). Schumpeter shaped the period where large firms are thought to have the advantage in innovative activity. In *Capitalism, socialism and democracy*, Schumpeter (1942) argues that large enterprises with market power, especially monopolists, conduct greater growth of innovative output than smaller firms in competitive markets. However, even Schumpeter puzzled over the effect of firm size on innovation. In an earlier book, *The Theory of Economic Development*, Schumpeter (1911) develops the concept of *Creative Destruction*, where innovative activity is characterized by technological ease of entry and innovators with small economic size. Besides Schumpeter's studies, the relationship between firm size and innovation has evolved in literature as follows. Up to the 1970s, the prevalent assumption is based on an S-shaped curve — small firms have a relative low share of innovative activity, which increases in medium and large companies and then slows down among the very large ones (Pavitt, Robson, & Townsend, 1987). Later, this shape evolves towards a non-linear U-curve (Pavitt et al., 1987), which is further supported by studies applied to different geographical scopes that defend the same trend (e.g. for German data from CIS see Schmidt & Rammer [2006]).

Different arguments feed this discussion regarding both size classes. Large firms have access to more funds to invest in innovation and larger assets to pledge as collaterals which ease their access to external borrowing (Acs & Audretsch, 2005). A larger size also promotes greater independence over the external environment, providing greater flexibility for their businesses' innovation strategy (Gailly, 2011). Concerning a knowledge-based perspective, large firms access a broader range of skilled technical specialists than their smaller counterparts (Cohen & Klepper, 1996). Conversely, small firms benefit from faster decision processes in recognizing opportunities and a more adjustable organizational structure. Doing so prevents the isolation of the decision-making body from specific customer requirements and facilitates employee motivation towards innovative tasks (Rothwell, 1989). Small firms also enjoy lower levels of bureaucracy, greater flexibility to overcome unexpected scenarios, and easier internal communication than large firms, which favour their propensity to innovate (Rothwell, 1989).

The firm size-innovation relation can be further deepened, if we look at product and process innovations. Previous studies show that firm size has a positive impact on both types of innovation, meaning that larger firms are more likely to pursue them (e.g. Harrison [1994] and Tether [2002]). Yet, Cohen & Klepper (1996) attain a different relation: using process R&D expenditure as a measure of innovation, they defend that smaller firms have an advantage at pursuing product innovation, while larger firms at process innovation.

From our analysis, it is reasonable to expect a positive relation between firm size and both types of innovation and we thus hypothesise that:

H1: A firm's propensity to introduce technological innovation (either product or process innovation propensity) is positively affected by its size.

H2: A firm's propensity to introduce joint technological innovations (product and process innovation simultaneously) is positively affected by its size.

2.3 The Impact of Joint Product and Process Innovations Strategies

The literature often reinforces that joint strategies of different forms of innovation leverage higher economic value and focuses especially on the combination of product and process innovations (Ballot et al., 2015). However, this idea dwindles when considering it from a exploration-exploitation dilemma point of view: joining both product and process innovation may hamper performance if firms do not balance these through proper mechanisms (Lavie et al., 2010).

March (1991) conceptualises exploration as the engagement of organizations in search, experimentation, and variation, while exploitation as organizations' activities to increase productivity and efficiency through choice, execution, and variance reduction. Hence, exploitation is built on the firm's past, as it consists of improving the organization's existing capabilities and exploration creates the firm's future, by decoupling it from its current capabilities (Lavie et al., 2010). Resource-allocation decisions create a trade-off between exploration and exploitation of innovation activities (March, 1991). The idea of balancing both activities creates a new type of organizational strategy to distinguish firms that somehow are capable of complementing exploration with exploitation — this is termed ambidexterity (Tushman & O´Reilly, 1996). Hence, an ambidextrous firm is capable of competing in markets with low cost and high efficiency levels, while developing new products for emerging markets where speed and flexibility are key (Tushman & O´Reilly, 1996).

By bridging the exploration-exploitation theory with the decision of following product and process innovation, we argue that firms hamper their innovation performance by gathering both types of innovation. Following this, we reflect on the literature advocating for a combination of product and process innovation which leverages a higher economic value. In case of performance hindrances, ambidextrous strategies may remediate the innovation propensity strategy of each firm. Moreover, by recognizing that firms are constrained by their organizational characteristics (Jin et al., 2016), we narrow our focus to the effect of firm size. Regarding this, there is some evidence that large firms are less harmed by their decision of joining both explorative and exploitative activities through their ability to leverage a larger amount of resources (Lin, Yang, & Demirkan, 2007).

From our analysis, it is reasonable to expect that joint innovation strategies hinder innovation performance and that large firms are the least effected. We thus hypothesise that:

H3: Depending on firm size, there are frictions between product and process innovation when these two are followed simultaneously in the same firm.

H3.1: A large firm experiences fewer trade-offs than a smaller firm when both product and process innovations are followed.

3. Methods

3.1 Data

We analyse the Portuguese version of the Community Innovation Survey (CIS), between 2008 and 2018, where each version (also referred to as wave) comprises a time gap of three years. This firm-level questionnaire happens within a two-year frequency and is based on self-reported information from firm managers. To measure innovation, the CIS uses a binary variable that classifies each firm as an innovator depending on whether a firm developed at least one type of innovation during the surveyed period. Hence, a firm that introduced at least one new or significantly improved good or service is designated a product innovator. The same happens for process innovation, if a firm introduces either new or significantly improved methods of production, logistics, delivery, or supporting activities.

We pair the CIS with the *Sistema de Contas Integradas* (SCIE), a Portuguese firm-level data set that collects firms' administrative information to characterize their financial behaviour. Following this, we achieve a broader set of variables for our analyses, such as the continuous variable form of firm size. Overall, our sample consists of 32,621 observations, although this number varies across analyses due to the absence of some variables in their respective database at the beginning of our study. Moreover, there are 15,850 innovators out of which 2,532 firms introduce at least one product innovation, 4,219 introduce at least one process innovation, and 9,099 introduce both types of innovation at least one time in each CIS wave.

3.2 Econometric Models

We perform two analyses with a special focus on firm size, which is measured through the number of employees and two alternatives: a continuous variable; and a 3-level categorical variable, whose first level corresponds to small firms (10 to 49 workers), the second to medium firms (50 to 249 workers), and the last to large firms (250 workers or more).

In the first analysis, we explore the relationship between firm size and innovation. Using a multinomial probit approach, we consider three possible types of innovation: product innovation, process innovation, and joint product and process innovations. In the second analysis, we explore how product innovation performance varies when firms join both product and process innovations. We rely on a linear regression strategy, accounting for the selection bias that might arise when considering only firms that innovate. On both analyses, besides firm size, we must consider other factors that impact a firms' innovation strategy (Utterback & Abernathy, 1975). We select human capital, R&D activities, advanced capital, exports, type of industry, belonging to an economic group, and age.[1]

Human capital, is broken down into two components: training and education (also referred to as college degree). Both are measured through dummy variables where the value of one corresponds to a firm that performs training activities and if a firm's college labour is higher than the sample average. We gauge R&D activities and advanced capital through the logarithm of firms' expenditure levels, although the presence of the latter is also assessed through a dummy variable. Exports level is measured through an intensity-oriented variable that considers the importance of a firm's foreign markets — the variable takes one if the firm's largest geographical market is outside Portugal, and zero if it is a national market. Industry-related effects are contemplated in a 4-level categorical variable based on the Eurostat aggregation of the manufacturing and service industries according to their technological or knowledge intensity. This framework sets high-tech manufacturing, low-tech manufacturing, knowledge-intensive service, and less-knowledge intensive service firms. The economic group determinant embodies a dummy variable structure: we observe the value one if the company belongs to a group such as this, and zero otherwise. Finally, age is a numerical variable representing in the logarithm how old each firm is.

[1] Note that these factors do not comprise an extensive list of all those already present in the literature, as it goes outside of our scope.

3.2.1 Determinants of Product, Process, or Joint Innovation

For the first analysis, we particularize the multinomial probit model as follows.

$$P(y = j|\boldsymbol{X}), \qquad j = 0, 1, 2, 3.$$

$$y_j^* = \beta_0 + \beta_1 Firm\ Size + \beta_2 College\ Degree + \beta_3 R\&D\ Activities + \beta_4 Exports\ Intensity + \beta_5 Economic\ Group + \beta_6 Advanced\ Capital + \beta_7 Age + \beta_8 Industry + \boldsymbol{\gamma Time} + u_j$$

Equation 1 | Multinomial probit model for probability of product, process, or joint innovation.

Where, the latent variable y_j^* determines if a firm engages in innovation type j, whose levels represent each type of innovation (product, process, or the joint product and process innovation) plus the decision of not innovating. Regarding the independent variables, apart from firm size, we include college degree, representing the human capital determinant, R&D activities, exports intensity, the economic group, advanced capital, the firm's age, industries' technology or knowledge intensity level, and time dummies for each CIS wave.

3.2.2 Innovation Performance of Joint Strategies and Firm Size

In the second analysis, since innovation performance is only observed for firms that develop innovation, we face a possible selection bias if innovative firms have unobserved characteristics that are (positively) correlated with performance. To account for this, we follow the model developed by Heckman (1979). We first use a probit model for the firm's decision of introducing product innovation, correcting the potential selection problem (Cameron & Trivedi, 2005). Then, we use a multiple regression model, to find the effect on product innovation performance when firms deploy joint innovation strategies and how this effect is influenced by firm size. We particularize the following:

- Selection equation:

$$P(y_{Product\ Innovation} = 1\ |\boldsymbol{X}) = G(\beta_0 + \beta_1 Firm\ Size + \beta_2 Process\ Innovation + \beta_3 College\ Degree + \beta_4 R\&D\ Activities + \beta_5 Exports\ Intensity + \beta_6 Economic\ Group + \beta_7 Advanced\ Capital + \beta_8 Age + \beta_9 Industry + \boldsymbol{\gamma Time})$$

Equation 2 | Selection equation in Heckman's model.

- Regression equation:

$$y_{Product\ Innovation\ Performance} = \beta_0 + \beta_1 Firm\ Size + \beta_2 Process\ Innovation + \beta_3 (Process\ Innovation \times Firm\ Size) + \beta_4 Training + \beta_5 College\ Degree + \beta_6 R\&D\ Activities + \beta_7 Economic\ Group + \beta_8 Advanced\ Capital + \beta_9 Age + \beta_{10} Industry + \boldsymbol{\gamma Time} + u$$

Equation 3 | Outcome equation in Heckman's model.

In the first equation, the dependent dummy variable measures whether the firm introduced product innovation. The explanatory variables are the same of Equation 1 plus the dummy variable for process innovation, although advanced capital is this time measured through its dummy variable. Exports intensity represents an exclusion restriction since the interrelationship between the variables of both equations leads to an identification problem (Enders, 2010). The regression equation's dependent variable is product innovation performance, which is defined as the logarithm of the total revenue from the sale of product innovations using GPD deflators. Additionally, this equation introduces the interaction between process innovation and the number of employees to give us the impact of firm size on innovation performance when process is joined to product innovation. The variable training is also included in the regression equation.

4. Results

4.1 Determinants of Product, Process, or Joint Innovation

In Table 1, we present the marginal effects of a multinomial probit model for the probability of engaging in product, process, or joint innovation, where the base outcome is no innovation. We find that, *ceteris paribus*, for product innovation exclusively, large firms are 2.5 percentage points less likely to introduce product innovations than small firms, on average, while the propensity of medium firms is not significantly different than firms with fewer than 50 employees. For process innovation, medium firms have a higher probability of innovating than small firms, with a difference of 1.5 percentage points, on average, while large firms do not present a significant difference to small firms. Concerning the joint class, on average, large firms have a probability of 4.8 percentage points higher than small firms of engaging in both types of innovation, while, for medium firms, we do not find significant results.

Table 1 | Marginal effects of the determinants of innovation.

MARGINAL EFFECT ANALYSIS			
VARIABLES	1 | Product Innovator	2 | Process Innovator	3 | Product & Process Innovator
Firm Size: 50-249 workers	-0.005	0.015***	0.001
	(0.004)	(0.005)	(0.006)
Firm Size: >=250 workers	-0.025***	0.003	0.048***
	(0.007)	(0.010)	(0.013)
College Degree	0.012***	0.005	0.034***
	(0.004)	(0.005)	(0.005)
R&D Expense (log)	0.008***	0.003***	0.029***
	(0.000)	(0.000)	(0.000)
Exports Intensity	-0.006	0.002	0.017***
	(0.004)	(0.005)	(0.006)
Economic Group	0.009**	-0.003	0.019***
	(0.004)	(0.005)	(0.006)
Advanced Capital Expense (log)	0.005***	0.017***	0.030***
	(0.000)	(0.000)	(0.000)
Age (log)	0.007***	-0.002	-0.001
	(0.002)	(0.002)	(0.002)
Industry: Low-tech manuf.	-0.027***	0.025***	-0.031***
	(0.007)	(0.007)	(0.009)
Industry: KIS	-0.002	0.003	-0.057***
	(0.008)	(0.008)	(0.010)
Industry: LKIS	-0.021***	0.043***	-0.050***
	(0.007)	(0.007)	(0.010)
Time Dummies	Yes	Yes	Yes
Observations	32,101	32,101	32,101
Chi2	4,571.223		
Log pseudolikelihood	-27,263.611		

*Marginal effects from a multinomial probit model (robust standard errors in parentheses). The type of innovation is a dependent categorical variable with four levels. Marginal effects for non-innovators are not displayed; * significant at 10%, **significant at 5%, and *** significant at 1%.*

4.2 Innovation Performance of Joint Strategies and Firm Size

In Model 4 of Table 2, we deploy a Heckman's selection model in which we consider beforehand the decision to engage in product innovation (the selection equation) and only then estimate the product innovation performance model (the outcome equation). As our main interest relies on the outcome equation, we do not display the results of the selection equation.

The results show that the independence between the two equations is rejected (ρ=0 is rejected at the 5% level), confirming our assumption that the error terms of both equations are correlated. Additionally, we see that all firms increase their performance by pursuing product and process innovations simultaneously; yet, the increase is not linear since it is larger for small (58.7%) and large (89.8% by adding up 31.1% and 58.7%) than for medium firms (41.2% by adding up 58.7% and -17.5%). Disaggregating firm size into its continuous form and using it with a second-degree polynomial gives us a clearer image of this relationship (Model 5 in Table 2).

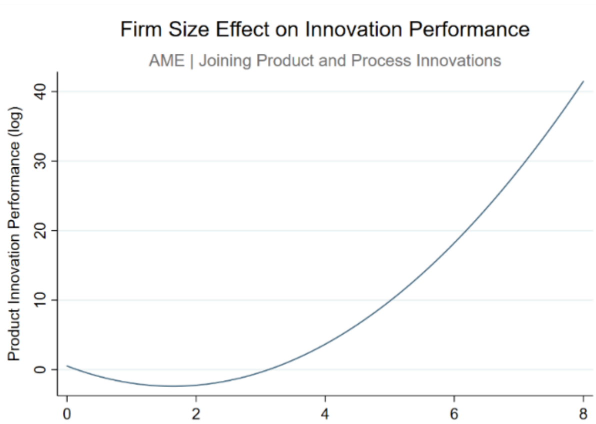

Figure 1 | Firm size effect on innovation performance based on the coefficient estimates of Heckman's selection model.

Table 2 | Coefficient estimates of Heckman's selection model.

COEFFICIENT ANALYSIS		
VARIABLES / ALTERNATIVES	4 | Outcome Eq. Product innovation performance (log)	5 | Outcome Eq. Product innovation performance (log)
Firm Size (Dummy): 50-249 workers	1.489***	
	(0.072)	
Firm Size (Dummy): >=250 workers	2.534***	
	(0.141)	
Process Innov.*Firm Size (Dummy): 50-249 workers	-0.175**	
	(0.075)	
Process Innov.*Firm Size (Dummy): >=250 workers	0.311**	
	(0.143)	
Process Innovation	0.587***	0.968***
	(0.061)	(0.080)
Firm Size		5.591***
		(0.439)
Firm Size^2		-1.224***
		(0.238)
Process Innov.*Firm Size		-3.830***
		(0.470)
Process Innov.*Firm Size^2		1.150***
		(0.237)
Training	0.130***	0.153***
	(0.029)	(0.031)
College Degree	0.382***	0.404***
	(0.034)	(0.038)
R&D Expense (log)	0.052***	0.086***
	(0.005)	(0.006)
Economic Group	0.535***	0.977***
	(0.039)	(0.049)
Advanced Capital	0.237***	0.353***
	(0.042)	(0.047)
Age (log)	0.006	0.132***
	(0.018)	(0.021)
Industry: Low-tech, manufacturing	-0.406***	-0.374***
	(0.051)	(0.055)
Industry: KIS	-0.754***	-0.922***
	(0.061)	(0.067)
Industry: LKIS	-0.050	-0.200***
	(0.059)	(0.063)
Constant	11.378***	10.630***
	(0.153)	(0.189)
ρ	0.316**	0.418**
	(0.047)	(0.047)
Time Dummies	Yes	Yes
chi2	4,396.323	3,043.230
Log pseudolikelihood	-33,136.130	-34,009.170
Observations	32,101	32,101
Selected	11,500	11,500
Non Selected	20,601	20,601

*Coefficients estimates of Heckman's selection model maximum likelihood estimator (robust standard errors in parentheses). Dependent variable is the sales of innovative products. Only the outcome equation is displayed. In Model 4, firm size is a categorical variable. In Model 5, firm size is a continuous variable divided by 1000 in order to readjust the size of the coefficients; * significant at 10%, **significant at 5%, and *** significant at 1%.*

To better understand the quadratic and interaction terms, we plot their variation over firm size in Figure 1, where we observe a nonlinear relationship and see that: $f(x) = 0 \Leftrightarrow x = 0.276 \vee x = 3.055$. This means that firms with a workforce between 276 to 3,055 employees see their innovation performance declining as a result of pursuing both types of innovation.

5. Discussion

5.1 Determinants of Product, Process, or Joint Innovation

Few studies consider the possibility of pursuing product and process innovations simultaneously, as ours does. Hence, having more small firms engaging in product innovation or medium firm in process innovation may be biased towards large firms' preference for joining both types instead of a single one. Our results support Cohen & Klepper (1996) and Scherer and Ross (Cohen [2010]), who consider small firms as the engine of innovative activity. Concerning process innovation, our result contradicts a significant stream of literature that supports that large firms are more likely to engage in this type of innovation (e.g. Hall et al. [2009] and Tether [2002]). However, we are not displaced on what Scherer observes for R&D: the share of process innovation relative to product innovation increases as firm size grows (Vaona & Pianta, 2008). Despite all this, we reject our first hypothesis: firm size is not positively related to the propensity to engage either in product or process innovation separately. Conversely, we do not reject our second hypothesis: a firm's propensity to introduce product and process innovation simultaneously is positively affected by its size.

5.2 Innovation Performance of Joint Strategies and Firm Size

Our results are aligned with the findings of Ballot et al. (2015) and Schmidt & Rammer (2006): joint innovation strategies enhance firms' innovation performance. Still, large firms have a higher increase than small and medium firms, possibly due to the greater amount of resources available, as Lin, Yang, & Demirkan (2007) suggest. Conversely, medium firms benefit less than small ones. A possible reason for this effect is small firms' agile and task-oriented behaviour that may leverage a greater flexibility for the process of deploying both types of innovation at the same time (Cohen, 2010). We take a further leap into this interaction when we disaggregate the variable firm size. While, through the categorical variable, we see that every firm has an incentive to join both product and process innovation, we now observe that some firms are indeed hamstrung by this strategy. Firms employing between 276 and 3,055 workers in our sample are associated to performance hindrances when they join product and process innovations. In these cases, to adopt ambidextrous strategies may be a possible remedy (Benner & Tushman, 2015). These findings do not reject the third hypothesis: for some sizes, to join product and process innovations creates frictions in innovation performance. Likewise, the sub hypothesis is also not rejected: a large firm experiences fewer trade-offs than a smaller firm. In fact, as firms grow larger, the impact of following joint innovation strategies start to reward firms' innovation performance instead of leading to frictions.

6. Conclusion

First-hand, we aim to study the innovation-firm size relationship in Portugal, analysing, in particular, product and process innovations. Second, we assess the effect of firm size on innovation performance when firms engage in joint innovation strategies. Although we implement our analysis on Portuguese data, our findings and recommendations are not only limited to Portugal. We aim to encourage the development and implementation of new measures to foster innovation in any economy where this study may prove suitable.

In both analyses, we provide sustained evidence that joint innovation strategies must be researched in higher depth to broaden policymakers' agenda towards the determinants, benefits, and downsides of this type of innovation. Furthermore, our study presents a pattern of specialization by different firm sizes towards each type of innovation that should motivate the revision of current policy, in order to tackle possible flaws that exclusively support innovative activity initiated by large firms. We also contribute to the literature by developing an unexplored perspective of the decision of pursuing joint innovation strategies. To bring new light to the understanding of the role of firm size in mastering possible trade-offs is of further interest for policymakers and managers alike, since it would allow the development of strategies and case studies to guide new practitioners in the field.

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