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Combining Product and Process Innovation: Is Organizational Innovation the crucial complement?

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Abstract

Product and process innovation are conceptually different (Utterback and Abernathy, 1975). Product innovation is based on meeting customers? preferences by designing a new or considerably improved product, whereas process innovation relates with the enhancement of operations and supply chain (OECD, 2005). Thus, product innovation is based on differentiation or product range, while process innovation focus on efficiency (Utterback and Abernathy, 1975; Damanpour and Gopalakrishnan, 2001). The dichotomy between the two have lead past research to support the idea that firms should focus in either one innovation type, product or process, due to different organizational structure requirements (Bhoovaraghavan et al., 1996). However, evidence from the last decades shows that firms can successfully engage in both innovation types and create relationships between the two (Athey and Schmutzler, 1995; Pisano, 1996).

While most research is focused on one innovation type (Eswaran and Gallini, 1996; Weiss, 2003), some studies explore the interrelationship between product and process innovation management at the firm level (e.g., Athey and Schmutzler (1995); Pisano (1996); Martinez-Ros (1999); Damanpour and Gopalakrishnan (2001); Reichstein (2006)), though only partially explaining how product and process innovation activities interact. We aim to fill this gap in the literature by identifying firm?s characteristics that are associated to the simultaneous development of product and process innovations.

We argue that organization innovation is an important mediator in integrating both product and process innovation activities. Most research is based on just one innovation type and still the body of knowledge in organization innovation is small (Damanpour and Aravind, 2012). Thus, pretend to contribute to the literature by establishing relationships between being a product and process innovator and conducting organization innovation activities.

We model the choice between pursuing a strategy combining both product and process innovation or pursuing solely product innovation or process innovation using a probit model with selection. The selection models the firm?s decision to innovate or not. Organizational innovation is evaluated by main three variables: different combinations of new business

practices, new methods of organizing work responsibilities and decision making, and new methods of organizing external relations. Using the variables, we construct measures of internal and external organizational innovation and its depth. We put to the test those constructs using data from the Portuguese databases of the Community Innovation Survey (CIS) (from 2006 to 2010).

The results show that organizational innovation has a significant positive correlation with the probability of engaging in both product and process innovation. By each layer added to organizational innovation, probability of being engaged in complex innovation activities rises. This holds especially true for organization innovation for internal use, rather than for use in external relations. Additionally, firms that conduct more R&D activities and use advanced capital are also more prone to be engaged in product and process innovation.

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Abstract

Product and process innovation are conceptually different. Past research support the idea that firms should focus in either one innovation type due to different organizational structure requirements. However, evidence from the last decades shows that firms can successfully engage in both innovation types and create relationships between the two. We argue that strategies combining both can be achieved mainly through organization innovation.

Using the Portuguese Community Innovation Survey (CIS) (2006 up to 2010), we show that organizational innovation has a significant positive effect on the probability of combining in both product and process innovation. This effect is bold by the supermodularity between internal and external organizational, as well as a positive layering effect. Additionally, firms with R&D activities and that use advanced capital have a higher probability of combining product and process innovation.

Keywords: Product Innovation, Process Innovation, Organizational Innovation, CIS.

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1 Introduction

Product and process innovation are conceptually different (Utterback and Abernathy, 1975; Cohen and Klepper, 1996). Product innovation is based on meeting customers' preferences by designing a new or considerably improved product, whereas process innovation relates improvements of operations and supply chain (OECD, 2005). Thus, product innovation enables firms to achieve competitive advantage by differentiating their products or range of products from competition (Porter, 1985), whereas with process innovation, firms improve their efficiency. Therefor, product innovations are market driven, while process innovation are derived by efficiency and product's quality considerations (Utterback and Abernathy, 1975; Abernathy, 1978; Damanpour and Gopalakrishnan, 2001).

Firms can follow innovation strategies more focused on products or processes. However, the set of capabilities required for each are not necessarily equal, as well as, its output. The literature from 1980s in management and industrial economics supported the idea that firms should focus in one innovation type, product or process, due to different organizational structure requirements (Bhoovaraghavan et al., 1996). Yet, evidence from last decades shows that firms are engaging in both innovation types, creating relationships between the two (Athey and Schmutzler, 1995; Pisano, 1996). Likewise, research demonstrates that firms engaging only in process innovation have a lower performance than firms conducting simultaneously product and process innovation (e.g., Capon et al. (1992)).

While most research is focused on one innovation type (Eswaran and Gallini, 1996; Weiss, 2003), some studies explore the interrelationship between product and process innovation management at the firm level (e.g., Athey and Schmutzler (1995); Pisano (1996); Martinez-Ros (1999); Damanpour and Gopalakrishnan (2001); Reichstein (2006)), though only partially explaining how product and process innovation activities interact. We aim to fill this gap in the literature by identifying firm's characteristics that are associated to the simultaneous development of product and process innovations.

We argue that organization innovation is an important mediator in integrating both product and process innovation activities. Using Community Innovation Survey (CIS) fourth, fifth, and sixth waves (from 2006 up to 2010), we empirically explore the role for organizational innovation on being both product and process innovator. By addressing organizational innovation using several constructs, we demonstrate that organizational innovation aids innovation strategies combining both product and process. Moreover, we provide evidence of internal and external organizational innovation being supermodular. Additionally, we verify that each layer added to organizational innovation enhances the probability of being engaged in complex innovation activities. This holds especially for organization innovation for internal use.

This paper is organized as follows. In Section 2 we review the relevant literature that enables the establishing the bridge between technological innovation and organizational innovation. Section 3 describes the data. In section 4 we present the empirical model for hypotheses testing, discussing the selection problem. The analysis of the results in conduct in Section 5. Finally, Section 6 concludes.

2 Literature review

Innovation strategies have been thought to differ greatly across firms. Firms can pursuit technological innovation in product, process or both dimensions. Although, several definitions for product and process innovation are available in the literature, the most agreed are in line with the Oslo Manual. According to the Olso Manual, product innovation relates with a new or significant improvement in a product (or service), whereas process innovation is defined as the introduction of new or significantly improved production method or delivery system OECD (2005). Thus, product innovation is more market oriented(Kraft, 1990) and process innovation more tight to operations and supply chain management. Product innovation is then related with product differentiation or range of products (Porter, 1985) and depends on the degree of competition (Bonanno and Haworth, 1998; Weiss, 2003). If the competitive environment fosters highly differentiated products, then product innovation should be favored. Conversely, for firms in price driven competition environments, the degree of process innovation is much more relevant than product innovation. Process innovation as being closer to operation and supply chain management is built upon efficiency and product's quality (Utterback and Abernathy, 1975). Approaching product and process innovation as been thought as dichotomous due to the different organizational structure required (Bhoovaraghavan et al., 1996). Adding to that, most research is focused in one innovation type (Eswaran and Gallini, 1996), generating a large gap of the possible interaction between the two technological innovations.

The interaction effect is first empirically highlighted by Kraft (1990). Kraft (1990) identifies product innovation inducing process innovation in a sample of 56 Germany metal working firms.

However, the reverse effect is not identified; product innovation does not lead to product innovation. Naturally, the scope of his finding is narrow, so the reverse effect can still exists. Theoretically supermodularity between product and process innovation has been modeled (e.g., Milgrom and Roberts (1990); Athey and Schmutzler (1995)). Evidence of complementarity between product and process is also found by several scholars (e.g., (Milgrom and Roberts, 1995; Pisano, 1996; Martinez-Ros, 1999; Damanpour and Gopalakrishnan, 2001; Reichstein, 2006; Miravete and Pernias, 2006)). Even though combining product and process deliver higher levels of performance than simpler innovation strategies (Damanpour and Gopalakrishnan, 2001), most research is still focused on one innovation type, product or process, does not identify the kind of innovation under analysis (Eswaran and Gallini, 1996; Weiss, 2003).

Strategies combining product and process innovation require different organizational structures, thought firm are actively following those. Notably, Japanese management style tackles product and process design simultaneously (Freeman, 1995). Those practices are based on thinking the entire product and process as a unique system, resulting in an integrated approach towards product and process design. Indeed, there is evidence of quality management practices affecting positively innovation (Kim et al., 2012). Thus, organizational structure can have an important role in pursuing innovations strategies combining product and process innovation.

There is evidence of organizational structure affecting firms' innovation. Foss et al. (2011) conceptualize and empirically validate several reasons why new organizational practices aid innovation performance. Several other authors pin-point the positive importance of organizational practices in innovation output (e.g., Henderson and Cockburn (1994); Galunic and Rodan (1998); Tsai (2001)). Another important contribution to organizational structures influencing innovation comes form evidence on quality management. Grant (1996) gives the examples of successful companies as Toyota, Boeing or Benetton which combine organizational flexibility and innovation. For example, lean product is arguably a process innovation, but most of the times entails the use of new materials, new product designs (product innovation) and by consequence new practices of doing work (organizational changes) and even changes towards the relationships with partners. In essence, product and process innovation are approached simultaneously, which does envolve organizational changes. In fact, evidence show that quality management practices enhances product or process innovation (Kim et al., 2012). However, as in innovation literature there is still lack of knowledge about interaction between product and process innovation and organizational changes.

So far, we have not termed organizational changes precisely. Thus, hereafter we shall define more precisely the organizational changes described before. Often scholars termed *organizational innovation* to the development or use of a new idea or way of doing thing (Daft, 1978; Damanpour and Evan, 1984; Damanpour, 1996). As so, we define organizational innovation as the introduction of new methods of business practices, organizing the work responsibilities and decision making, and organizing external relations. This definition is in line with the Oslo Manual (OECD, 2005). Further, we will describe in depth the extend of these definition. [1]

The research focus on innovation and organizational theory are very much highlighted by the influential work of Burns and Stalker (1994). Although, other seminal studies already noticed the importance of organizational innovations (e.g., Daft (1978); Damanpour and Evan (1984); Damanpour (1991); Ettlie and Reza (1992)). The downstream literature on organizational innovation diversified and not provides a clear theoretical base (Lam, 2004). [2] Over the last years, the body of knowledge on organizational innovation has been growing. While most research bolds the positive effect of organizational innovation in firm performance Damanpour et al. (2009); Mol and Birkinshaw (2009); Camisón and Villar-López (2014), few empirical evidence about its effects exist still (Damanpour and Aravind, 2012).

For this study, we approach organizational innovation as an enabler for innovate in both product and process. In the next sections we present our model for solving the puzzle.

3 Data

The Portuguese Third Community Innovation Survey fourth, fifth and sixth waves (CIS 4, 5 and 6) provide information concerning Portuguese manufacturing and service firms and specifically about firms' innovative performance and strategy in the period from 2004 to 2010. Only those firms with more than 10 employees were eligible to answer the survey. Due to substantial pre-testing and piloting, the survey is considered to have high degree of reliability, interpretability and validity (Laursen and Salter, 2006).

The questionnaire follows the harmonized Eurostat's questionnaire, with some additional questions. The survey aims to capture innovation in a broad firm perspective, rather than examining just the invention process. A variety of innovation inputs activities are present, rather than simply R&D or intellectual property measures. Also, it includes some dimensions to characterize firms, such

[1] For a more detail review of organization innovation definitions see Camisón and Villar-López (2014).
[2] For a review of organizational innovation literature, see Lam (2004).

as, industry, exports or the number of workers. There is some firms from primary, secondary and construction sectors, however the number of firms is small (about 8%) and not representative of the private economy. Thus, we do not include those firms in our analysis.

4 Empirical model

The interrelationship between product and process innovation is our departure. We are seeking if organizational innovation can be the key component for firms being engaged on product and process innovation. Thus, let y_1^* firm's expected gain from innovation in both product *and* process innovation due to the relevant set covariates X_i. We want to estimate:

$$y_{1i}^* = (\boldsymbol{X_i\beta} + u_{1i}) > 0 \tag{1}$$

where β the vector of unknown parameters and $u \sim N(0,1)$ the error term. Naturally X_i should reflect organizational innovation, flexibility and the research capabilities to conduct innovation successfully. However, firms' decision to being engage in innovation is endogenous to being both product *and* process innovation. Given the capabilities to identify and tackle complex innovation opportunities, firm i decides to innovate or not. So, let y_2^* be the expected gain from innovation. The selection equation given by:

$$y_{2i}^* = (\boldsymbol{z_i\gamma} + u_{2i}) > 0 \tag{2}$$

with z_i being the vector exogenous variables related with the decision for firm i, γ the unknown parameters and $u_{2i} \sim N(0,1)$.

Due to selection:

$$corr(u_1, u_2) = \rho \tag{3}$$

So, y_{1i}^* is observed only if y_{2i}^* is also observed. We can estimate Equation 1 using a probit with selection (Van de Ven and Van Praag, 1981). Let y_{1i} denote the observed choice of firm i towards innovation (process *and* product = 1 and 0 otherwise) and y_{2i} the observed choice of innovation (innovation = 1 and 0 otherwise).

The estimations give the probability of the process and process choice, given the set of covariates:

$$P(y_{1i} = 1|\boldsymbol{X_i}, y_{2i}) = P(\boldsymbol{X_i \beta} + u_{1i}|\boldsymbol{X_i}, y_{2i}) \tag{4}$$

The selection is considered to be the choice to innovate or not.

4.1 Depend variable

The depend variable is the decision of combine both product and process innovation. The definition of product and process innovation adopted here follows the Oslo Manual and consequently is in line with the CIS. Product innovation is defined as the introduction of a good or service new or significantly improved with respect to its characteristics or intended uses. Process innovation is the implementation of a new or significantly improved production or delivery method (OECD, 2005). These broad definitions can lead to interdependence between process and product innovations. For example, process innovations such rearranging the workplace, or improving a computer program might involve create a new product that is easier to use (Athey and Schmutzler, 1995). Thus, makes particular sense to be product and process innovator.

The variables definition is straightforward. For the selection the depend variable is to being engage in innovation (product or process) or not. For the main equation is being engaged both product and product innovation.

4.2 Covariates

The covariates are chosen considering the major characteristics of firms. The first covariate is the investment in R&D. As argued by Cohen and Levinthal (1989, 1990); Cassiman and Veugelers (2002), and Kraft (1990), higher levels of absorptive capacity enable firms to be better prepared to innovation. Firms investing in R&D should have internal and absorptive capacities. The investment in internal capabilities allows firms to identify and exploit knowledge developed by other firms, hence generating opportunities to increase their performance (Cohen and Levinthal, 1989, 1990; Zahra and George, 2002). The ability to absorb knowledge from others is expected to have an essential role on the definition of firms' innovation strategies. Contrary to studies where the focal point is R&D, we do not measure the R&D intensity or if it is done internally or externally. As so, simply control for R&D with a binary variable.

Besides R&D engagement, we include a binary covariate measuring the use of college labor. The variable captures if a firm uses college labor more intensively than the average (the variable indicates if the share of college labor is higher than 25%). This covariate measures, as before, firms' absorptive capacity in the context of more complex strategies. Also, as stated by Athey and Schmutzler (1995), well-educated workers or trained workers are more able to implement changes in products and processes. So, we expect a positive contribution to more complex innovation strategies.

Another important covariate to account for is firm size. Firm size also plays a major role in the innovation path. Size can provide firms the resources to be effectively engaged in innovation. As combining product and product innovation envolves higher complexity, more resourceful (larger) firms should be more able to be engaged on product and product innovation. In fact, Cohen and Klepper (1996) provide evidence of the relationship between R&D activities being positively correlated with firm size. In particular, process innovation investments share is positively related with firm size.

An additional contribution comes from Mansfield (1981). The author puts forward that firm size may have effect in the composition of R&D activities and, by turn, in the innovation strategies. Larger firms have more incentives to invest in process innovation as it increases cost efficiency. Moreover, larger firms are endowed with a more diversified set of skills and capabilities and have a broader range of products. Thus, introducing process innovation can reduce cost efficiency across different lines of production.

An extra dimension that deserves our attention is the use of (advanced) capital. We denote by advanced capital the use of advanced machinery, equipment, hardware, software. In the last decades, changes in organizational techniques demand more advanced capital, mainly high tech machinery or computer controlled equipment. Firms moved from a Tayloristic form to more flexible forms and to the adoption of new management paradigms such as *Just In Time* or *Total Quality Management* (Lindbeck and Snower, 1996). Capital is a complement to the firms (Brynjolfsson and Hitt, 2000), arguably helping firms to archive better set of capabilities and enhancing the creation of competitive advantages. Moreover, capital enables firms to collaborate and outsourcing/offshoring several activities of the value chain, reducing external coordination costs. Capital creates the structures for firms increase their productivity, hence tight to process innovation. However, while enhancing firm's set of capabilities capital can potentate product innovation at the same time. Hence, capital enables firms to deal with the increased complexity associated with product and process innovation strategies.

Besides, we account for a firm-level measure of whether the firm exports or not is included in order to capture the intensity of rivalry. As Kraft (1990) and Cassiman and Veugelers (2002) we also include exports as a proxy variable for the intensity of the competition since more export intensive firms typically face a more intense rivalry. Being part of a group also affects innovation. A group provides a pool of resources and risks among partners that can affect firms' innovation strategies. Additionally, we include a dummy capturing if the firm is employing at least 50% of college labor and the number of workers. Those two variables are related with the firm size and absorptive capacity to innovate. Finally, the technological output of the firms was included, taking in consideration the Eurostat's industry aggregation by technological intensity (industry dummies).

To scrutinize the role of organizational innovation on the technological innovation strategy we developed several constructs based on CIS variables. Following Olso Manual, the CIS dataset provide three variables for organizational innovation measure: new business practices for organizing procedures; new methods of organizing work responsibilities and decision making; new methods of organizing external relations with other firms or public institutions. The question behind this variables is if the firm has introduce them by the first time as result of strategic decisions. Examples of new business practices are introduction changes in operations and supply chain management (e.g., quality systems, lean production) or business re-engineering. New methods of organizing work refers to, for example, decentralization, changes in functional form or training systems. Finally, new methods of organizing external relations is tight with alliances, partnerships or outsourcing.

Built upon those three variables, we create a general variable of organizational innovation which is one if any of the three variables is one. This simple variable can measure the overall importance of organizational innovation for being simultaneous product and process innovator.

A second important construct is based in the separation between internal and external organizational innovation. Organizational innovation creates formal and informal (internal) structures along with external networks, that induces a powerful influences in the innovation activities vector (Teece, 1996). Hence, product and process innovation strategies are shaped by organizational ones. Being both internal and external organizational innovation structures important, we pay particular attention on the magnitude of their importance. Specially because innovators work often with close external suppliers for developing new technologies (Von Hippel, 1988). External sources, such as supplies, are likely to provide knowledge that can be used by innovators (Rouvinen, 2002). Hence, both organizational internal and external innovation can provide a strong base for being both product and process innovation. Because of this, we follow Garud and Kumaraswamy (1995) approach, by considering organizational innovation two dimensions: internal and external. Internal innovation relates with internal organizational innovation to the introduction of new business practices and new methods of organizing work. External if the firm introduced new methods of organizing external relations.

Finally, we create *depth* measures. We term *depth* to a operator that counts the number of organizational innovations introduced. Firms can have introduce none (depth = 0) or introduce all (depth = 3) if firms introduce new business practices, new methods of organizing work and new methods of organizing external relations. Moreover, we extend the *depth* to internal and external variable.

4.3 Descriptive statistics

We use three CIS waves, which enables us to get more robust indicators, as well as, account for macroeconomic patterns that can somehow bias the data. We start by plotting innovation measures against the hypotheses related variables in Figure 1. Overall, we can see that innovation's shares do not vary much along the CIS waves, specially from 2008 (CIS 5) to 2010 (CIS 6). Starting by organizational innovation, we can see that firms that conduct any form of organization innovation tend to innovate more in the product and process dimensions. This holds, for firms engaged in R&D activities, as well as, use of advanced capital. Although the effect for firm size dimension is not so clear. Smaller firms innovate less than larger ones, but the change is not clear as in the other graphs.

– INSERT FIGURE 1 ABOUT HERE –

In addition to the graphs, we present, in Table 1, summary statistics with mean and standard deviation of the relevant variables. We also present statistics according to being or not engaged in innovation and being or not pursuing innovation strategies of both product and process innovation. Overall, most of firms are from low-tech manufacturing (26%) along with the services: high-tech knowledge-intensive (KIS) (21%) and market knowledge-intensive (23%). High and medium-high-tech manufacturing account for 12% of the sample. If we look for innovative firms engaged in both product and process innovation, the firms' industry shares change — high-tech manufacturing firms' are the most in this condition, followed by high-tech KIS.

Overall the larger differences between firms innovating just on product or process against product and process are clearly on organizational innovation, R&D and the use of capital. Firm size doesn't appear to play a major role in here, as well as having more college graduates in the labor force. Also, neither being part of an economic group or being an exporting firm bolds the differences. Although, as one might expect the share of firms engaged in both product and process innovation is higher in all those categories. Moreover, differences in size are not substancial, especially for firms with less than 250 employees. In sum, we would expect that organizational innovation, R&D and capital should be the source for a firms being a product and process innovator, however, due to confounding factors is essential to test econometrically those hypotheses.

– INSERT TABLE 1 ABOUT HERE –

5 Results

We estimate the probit model with selection for the firm's choice of innovation strategy in both process and product innovation, given that innovates. We include several specifications of the model, including the estimation for all firms and for manufacturing and services separately. Additionally, we use variables to characterize organizational innovation activities. For all specifications the selection equation only varies by sector. In Table 2 are the marginal effects from the probit estimation of the selection equation. We expect that network effects, openness to foreign markets and intense rivalry increase the likelihood to innovation. The estimates show exactly this. Exports increase the probability to innovate (approximately 2.4%), with no substantial differences across sectors. Being part of an economic group is significant, except for the manufacturing. On average, firms in the services have more 3.7% probability of being engaged in innovation if firms belong to an economic group. Also, having a college share bigger than 25%, rises the probability by 2.5% for firms in the services, but not for manufacturing firms. Firms size controls show no differences between small, medium or large firms, while R&D and capital have a large effect on the probability of being a innovator. Firms investing in R&D activities have more than 38% of being innovators, while capital account for more than 50% in probability increase.

– INSERT TABLE 2 ABOUT HERE –

This first stage enables us to censor the sample, so that the estimated probability of being engaged in both product and process innovation strategies is restricted to innovative firms. This procedure, as underlined before, removes bias resulting from the endogenous decision of innovate, when estimating the decision to innovate in both product and process. The main equation marginal effects for the probability of being an innovator in both product and process are displayed in Table 3. At a first glance we can see that their is evidence of selection effects, as we hypothesized. Looking for the Likelihood-Ratio's (LR) p-value, we can see that we reject the null hypothesis ($H_0 : \rho = 0$) at the less than 5% for all specifications. Thus, a model that accounts for selection bias is appropriate, specially for non-manufacturing specification. Contrary to Camisón and Villar-López (2014), we approach product and process together, not creating any slack for a mediation role for process or product innovation, as well as account for the endogenous decision to innovate.

We run the several specification for all firms and for manufacturing and services separately. The different specifications reflect the several constructs of organizational innovation built. Looking for overall results and disregarding organizational innovation by now, we can check that R&D and capital coefficients are significant at the 1% level and have the largest magnitudes. The college share dummy is not significant and only larger firms appear to have a boosting significant effect in the probability of being both product and process innovator.

Regarding organizational innovation results, we can see that firms enrolled in organizational innovation (columns 1-3) have a higher probability of combining product and process innovations — around 12% increase. Decomposing organizational innovation into external and internal shows that both are important, with an edge for internal organizational innovation. This is particularly highlighted in specifications 7 to 9, where adding more layers to internal organizational innovation fosters more the probability of being both product and process innovator. But, much more interesting are the results from specification 10 to 12. In those specifications we test firms that are just conducting external, just internal and both organizational innovations. The joint effect is positive and bigger than the partial ones. This bolds a supermodular effect between internal and external organizational innovation. Albeit internal organizational innovation coefficients tend to be higher, the combination effect is much more positive. This is to our knowledge a novelty in organizational innovation literature.

Finally, we include dummies for the overall depth of organizational innovation activities (specifications 13 to 15). Depth highlights the degree of organizational innovation that firms do, so if the coefficients are positively significant the effect is commutative. In deed, that is what the results show. By which additional layer of organizational innovation, the likelihood of being a product and process innovator increases. When depth reaches its maximum, firms have more 16.6% of probability to being engaged in both product and process innovation. This value is not statistically different from the one that we obtain from R&D engagement, which is in line with Rammer et al. (2009) results: firms can compensate the absence of R&D activities with some forms of organizational innovation.

– INSERT TABLE 3 ABOUT HERE –

6 Conclusion

This paper tries to establish the link between innovation strategies and firms' characteristics. In particular, we stress on innovation strategies that pursuit both product and process innovation, paying particularly attention to organizational innovation activities. We use the Portuguese CIS 2006, 2008 and 2010 data for empirically test the role of organizational innovation in the technological innovation process. Our argument is built upon organizational innovation aiding firms to be both product and process innovators.

Empirically, we use a probit model with selection. The selection is towards the choice to innovate or not, while the main model is centered between the choice of being engaged in product and process innovation strategies or not. The analysis is based several organizational innovation constructs that can aid the firm to be both product and process innovator. Additionally, we include human capital, firm size, investment in R&D and advance capital as the main controls. The results can be divided into two parts: from selection and from the main equation. From selection, we show that openness to foreign markets, R&D and advanced capital are more important in the decision to innovate than having a more intensive firm in human capital labor or being a bigger firm. Moreover, firms' networks are only important for the services, while for manufacturing the result is not statistically significant. The second part of results are due to the main probit. We show a strong effect of organizational innovation practices in the probability of being a product and process innovator. The effect is stronger when there is a combination of both internal and external organizational innovation underlining a possibility supermodularity between them. Another important conclusion comes from the layering of organizational innovation practices. As we add layers to them, the likelihood of being a product and process innovator increases. In fact, the magnitude of all joint innovations practices is not different from investing in R&D activities. Thus, if more complex organizational innovation strategies have more positive effects of innovation in both product and process, then managerial decision should be to implement those as it enhances firm performance Damanpour et al. (2009); Mol and Birkinshaw (2009).

As further work, the possible supermodular relationship between organizational practices should be subject of more research. In addition, we aim to develop more firm level indicators of technology and labor force use, in particular the role of routinization in organizational innovation practices.

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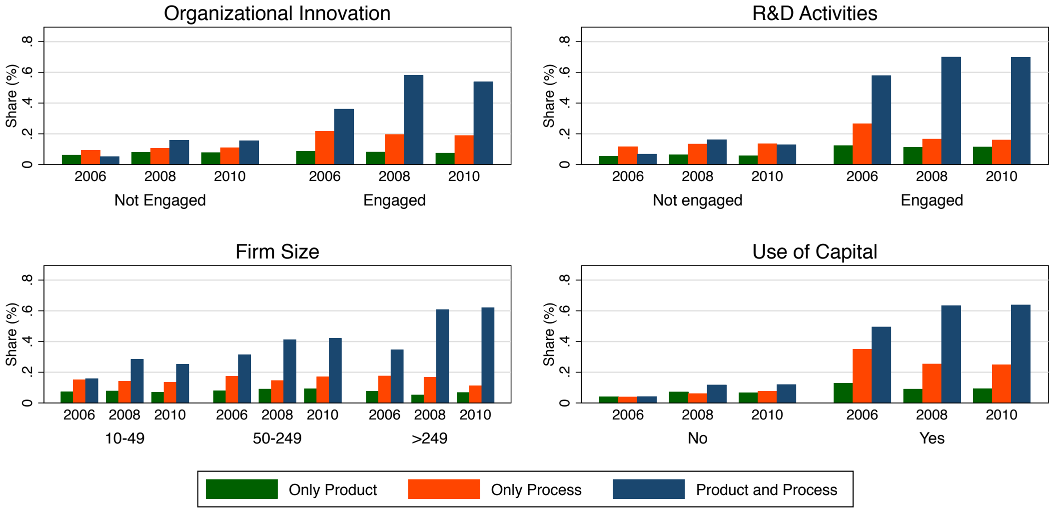

Figure 1: Technological innovation use

Table 1: Summary statistics

Variable	All	Do not innovate	Innovate: Prod. *or* Proc.	Innovate: Prod. *and* Proc.
Economic group (d)	0.267	0.185	0.290	0.379
	(0.442)	(0.389)	(0.454)	(0.485)
Exports (d)	0.538	0.448	0.562	0.661
	(0.499)	(0.497)	(0.496)	(0.473)
College (d)	0.205	0.150	0.213	0.286
	(0.404)	(0.357)	(0.410)	(0.452)
Organizational Innovation	0.460	0.215	0.573	0.763
	(0.498)	(0.411)	(0.495)	(0.425)
OI: Only internal	0.248	0.136	0.341	0.357
	(0.432)	(0.343)	(0.474)	(0.479)
OI: Only external	0.0176	0.0121	0.0228	0.0224
	(0.131)	(0.109)	(0.149)	(0.148)
OI: Internal and external	0.194	0.0673	0.210	0.384
	(0.396)	(0.251)	(0.407)	(0.486)
OI: Internal	0.443	0.203	0.551	0.741
	(0.497)	(0.402)	(0.497)	(0.438)
OI: External	0.212	0.0794	0.232	0.407
	(0.409)	(0.270)	(0.422)	(0.491)
OI: Depth internal $\{1,2\}$	0.719	0.304	0.866	1.266
	(0.869)	(0.643)	(0.864)	(0.844)
OI: Depth $\{1,2,3\}$	0.931	0.384	1.098	1.672
	(1.145)	(0.818)	(1.115)	(1.154)
R&D (d)	0.323	0.0191	0.435	0.722
	(0.468)	(0.137)	(0.496)	(0.448)
Capital (d)	0.404	0.0201	0.678	0.807
	(0.491)	(0.140)	(0.467)	(0.395)
Firm Size				
No. Workers: 10-49	0.654	0.752	0.625	0.521
	(0.476)	(0.432)	(0.484)	(0.500)
No. Workers: 50-249	0.274	0.207	0.305	0.358
	(0.446)	(0.405)	(0.461)	(0.479)
No. Workers: >249	0.0712	0.0404	0.0698	0.121
	(0.257)	(0.197)	(0.255)	(0.326)
Industry				
High-Tech Manuf.	0.0166	0.00973	0.0170	0.0271
	(0.128)	(0.0982)	(0.129)	(0.162)
Medium-High-Tech Manuf.	0.0977	0.0749	0.0953	0.136
	(0.297)	(0.263)	(0.294)	(0.343)
Medium-Low-Tech Manuf.	0.192	0.190	0.196	0.192
	(0.394)	(0.392)	(0.397)	(0.394)
Low-Tech Manuf.	0.257	0.290	0.236	0.222
	(0.437)	(0.454)	(0.425)	(0.416)
High-Tech KIS	0.210	0.189	0.204	0.247
	(0.407)	(0.392)	(0.403)	(0.431)
Market KIS	0.227	0.247	0.252	0.176
	(0.419)	(0.431)	(0.434)	(0.381)
Observations	16217	7707	3641	4869

Notes: Data from CIS 2006, 2008 and 2010. The values are the mean and standard deviation (between parentheses); OI stands for Organizational Innovation; College dummy is 1 if the share of college workers is greater or equal to 25%; Depth is a count measure of organizational innovation.

Table 2: Marginal effects of the probit model for the selection

	(1)	(2)	(3)
Selection: P(Innovate)=1			
College (d)	0.024**	0.023	0.025**
	(0.008)	(0.018)	(0.010)
Economic Group (d)	0.027***	0.009	0.037***
	(0.007)	(0.010)	(0.009)
Export (d)	0.024***	0.021**	0.026***
	(0.005)	(0.006)	(0.008)
No. Workers 50-249	0.009	0.013	0.005
	(0.006)	(0.008)	(0.009)
No. Workers >249	0.007	0.049*	-0.013
	(0.012)	(0.021)	(0.015)
R&D (d)	0.397***	0.410***	0.382***
	(0.010)	(0.014)	(0.015)
Capital (d)	0.583***	0.591***	0.573***
	(0.005)	(0.006)	(0.008)
Time dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes
Sector	All	Manufacturing	Services
Log Likelihood	-10505.667	-5836.003	-4655.659
Wald Chi-Square	1366.370	916.332	462.316
Observations	16217	9140	7077

Notes: Robust standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%; College dummy is 1 if the share of college workers is greater or equal to 25%.

Table 3: Marginal effects of the probit model with selection for innovation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
P(Product and Process)=1															
College (d)	0.021*	0.032	0.061***	0.014	0.028	0.055***	0.012	0.028	0.054***	0.014	0.027	0.055***	0.011	0.027	0.053***
	(0.010)	(0.021)	(0.013)	(0.010)	(0.021)	(0.013)	(0.010)	(0.021)	(0.013)	(0.010)	(0.021)	(0.013)	(0.010)	(0.021)	(0.013)
No. Workers 50-249	0.024**	0.007	0.031*	0.023*	0.007	0.028	0.022*	0.006	0.026	0.023*	0.007	0.028	0.022*	0.006	0.026
	(0.009)	(0.012)	(0.014)	(0.009)	(0.012)	(0.014)	(0.009)	(0.012)	(0.014)	(0.009)	(0.012)	(0.014)	(0.009)	(0.012)	(0.014)
No. Workers >249	0.074***	0.088***	0.064**	0.071***	0.085***	0.060**	0.067***	0.081***	0.058**	0.071***	0.085***	0.060**	0.067***	0.082***	0.056**
	(0.015)	(0.023)	(0.020)	(0.016)	(0.023)	(0.021)	(0.016)	(0.024)	(0.021)	(0.016)	(0.023)	(0.021)	(0.016)	(0.023)	(0.021)
R&D (d)	0.219***	0.223***	0.204***	0.213***	0.220***	0.195***	0.210***	0.217***	0.192***	0.213***	0.219***	0.196***	0.210***	0.217***	0.192***
	(0.008)	(0.011)	(0.012)	(0.008)	(0.011)	(0.013)	(0.008)	(0.011)	(0.013)	(0.008)	(0.011)	(0.013)	(0.008)	(0.011)	(0.013)
Capital (d)	0.162***	0.171***	0.150***	0.156***	0.167***	0.141***	0.153***	0.163***	0.139***	0.156***	0.167***	0.142***	0.153***	0.163***	0.138***
	(0.014)	(0.017)	(0.022)	(0.014)	(0.018)	(0.022)	(0.015)	(0.018)	(0.022)	(0.014)	(0.018)	(0.022)	(0.015)	(0.018)	(0.022)
Org. Innovation	0.122***	0.128***	0.125***												
	(0.010)	(0.013)	(0.016)												
OI: External				0.072***	0.065***	0.081***	0.059***	0.051***	0.071***						
				(0.011)	(0.015)	(0.015)	(0.011)	(0.015)	(0.015)						
OI: Internal				0.095***	0.104***	0.094***									
				(0.010)	(0.013)	(0.016)									
OI: Depth Internal = 1							0.062***	0.068***	0.064***						
							(0.012)	(0.015)	(0.018)						
OI: Depth Internal = 2							0.123***	0.137***	0.117***						
							(0.012)	(0.016)	(0.018)						
OI: Only External										0.084**	0.103**	0.048			
										(0.029)	(0.037)	(0.046)			
OI: Only Internal										0.097***	0.109***	0.089***			
										(0.011)	(0.014)	(0.017)			
OI: External and Internal										0.166***	0.167***	0.174***			
										(0.013)	(0.017)	(0.020)			
OI: Depth = 1													0.075***	0.080***	0.074***
													(0.012)	(0.016)	(0.020)
OI: Depth = 2													0.114***	0.134***	0.102***
													(0.012)	(0.016)	(0.018)
OI: Depth = 3													0.188***	0.189***	0.196***
													(0.014)	(0.019)	(0.021)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector	All	Manuf.	Services	All	Manuf.	Services	All	Manuf.	Services	All	Manuf.	Services	All	Manuf.	Services
Log Likelihood	-9698	-5346	-4312	-9676	-5339	-4294	-9662	-5330	-4289	-9676	-5338	-4293	-9660	-5329	-4286
Wald Chi-Square	809	478	383	843	480	422	873	497	438	844	484	422	874	499	440
LR ($\rho = 0$) Chi-Square	13.695	9.758	5.143	11.751	8.614	4.351	11.307	8.173	4.291	11.786	8.737	4.361	11.282	8.224	4.159
LR ($\rho = 0$) p-value	0.000	0.002	0.023	0.001	0.003	0.037	0.001	0.004	0.038	0.001	0.003	0.037	0.001	0.004	0.041
Observations	16217	9140	7077	16217	9140	7077	16217	9140	7077	16217	9140	7077	16217	9140	7077
Observation Censored	7707	4348	3359	7707	4348	3359	7707	4348	3359	7707	4348	3359	7707	4348	3359

Notes: Robust standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%; OI stands for Organizational Innovation; College dummy is 1 if the share of college workers is greater or equal to 25%; Depth is a count measure of organizational innovation.