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Organizational changes and innovation: firm-level evidence from European countries

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ORGANIZATIONAL CHANGES AND INNOVATION: FIRM-LEVEL EVIDENCE FROM EUROPEAN COUNTRIES[*]

ABSTRACT	
In questo lavoro analizziamo empiricamente la relazione fra l'implementazione di cambiamenti organizzativi e la performance innovativa delle imprese nei paesi Europei. Si ritiene, infatti, che le imprese che sviluppano innovazioni organizzative e che dedicano maggiori risorse a questo aspetto, possano generare e utilizzare nuove conoscenze e tecnologie in maniera più efficiente. Ad oggi, i cambiamenti organizzativi delle imprese hanno ricevuto scarsa considerazione nella letteratura empirica. I nostri risultati, tuttavia, evidenziano che tali cambiamenti sono fondamentali nei processi di innovazione tecnologica delle imprese.	In this paper, we empirically explore the relationship between the implementation of major organisational changes and the technological innovation performance of firms in European countries. Indeed, firms adopting organisational innovations and devoting more resources to this aspect are supposed to be in a better position for generating and using new skills and technologies in a more efficient way. Despite this, up until now, firms' organizational changes have received less attention in the empirical literature. Our results support that their role in the technological innovation process of firms may be crucial.
Innovazione – Cambiamenti organizzativi	**Innovation – Organizational changes**

1. In this paper we focus on the relationship between the implementation of major organisational changes within firms in European countries and their technological innovation performance. According to OECD (2005), organisational innovation is a broad concept that encompasses the implementation of a new organisational method in firms' business practices, workplace organisation, and management structures intended to facilitate external relations and collaboration with external partners.

In theory, firms devoting more resources to organisational innovation are in a better position to efficiently use new skills and technologies. However, despite a longstanding awareness of the relationship between organisational and technological innovation (Rothwell et al., 1974; Nelson and Winter, 1982), the former has generally

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[*] Saggio sottoposto a referaggio secondo il sistema del doppio cieco.

received less attention by researchers compared to latter (Evangelista and Vezzani, 2010; LeBas, 2015), mainly due to the lack of available data (organisational innovation has made its way into the Community Innovation Survey only in 2005).

On the whole, the economic literature has less to say about the effects of organisational innovation on firms' technological innovation performance. The empirical evidence - emerged so far from the fewer studies which have tried to extend the analysis of innovation beyond the pure technological domain - seems to indicate that organisational and technological innovations are complement rather than substitutes: firms that are active in technological innovation usually introduce complementary new or improved organisational practices (see for instance Lokshin et al., 2008; Corrocher et al., 2009; Battisti and Stoneman, 2010). If most of these studies focus on the way technological innovation leads to organisational changes within firms (Henderson and Clark, 1990; Dougherty, 1992), more recent research has also emphasised the role of the latter for the purpose of improving the technological innovation performance of firms (Lokshin et al., 2008; Mothe and Nguyen-Thi, 2010, 2012).

Given all of the above, by using firm-level data on European countries provided by the *Innobarometer* 2016, in this paper we examine the effects of organisational changes on the introduction of product and process innovation. Compared to previous research, in order to better evaluate the overall organisational "effort" of firms and given the availability of data, we not only consider the implementation of organisational innovations but also the total amount of financial resources devoted to the improvements of organisational and business processes. The implications at the level of policy of such a study are straightforward. So far, organisational factors have been rarely considered as a policy issue, namely as a prerequisite to foster firms' innovativeness; nevertheless, if the effects of organisational changes on firms' innovation performance are relevant, policy makers aiming at supporting innovation should be called for more targeted initiatives encouraging the diffusion of more advanced organisational practices among firms.

The rest of the paper is organised as follows. In the next section, we briefly discuss the theoretical background. In section three we provide an overview of the data and variables, and in section four we explain the empirical strategy. Section five summarises the empirical results, whilst in the last section we enhance the main conclusions and policy implications.

2. So far, a relatively scarce attention has been paid to the role played by organisational changes in the innovative activity of firms. This is mainly due to the lack of available data, but also to the conventional wisdom that, in accordance with the linear model of innovation, tends to emphasise the scientific content of innovation only, namely the role of the knowledge generated and accumulated through heavy

investments in Research and Development (R&D) and mostly applied in high-tech firms. In contrast with this view, in this study we agree that organisational changes are likely to be a more important driver of technological innovation than any other traditional input of innovation (e.g. R&D, human capital, external cooperation etc.). Indeed, a firm's ability to innovate starts with the choice of the strategy which, in turn, primarily depends on its organisational competences: these define the processes, the structures and behaviours that shape how a firm actually searches for innovation opportunities and selects what to do for translating these opportunities into new ideas and concrete new products and processes.

In theory, the adoption of new and more advanced organisational practices is likely to increase not only firms' efficiency, but also the flexibility and the opportunities for workplace learning, skills upgrading and use of "creativity" by individual workers which, in turn, can spur technological innovation performance and competitiveness. Indeed, a higher efficiency allowed by a better organisation of production activities is crucial for improving firms' competitive advantage and profitability, which provides means to increase investments in technological activities: not only internal R&D, but also external cooperation for innovation and the direct acquisition of externally developed new knowledge and technologies.

Since innovation is often function of the firms' employees' efforts (what is known as "employee-driven innovation"), it may also directly depend on organisational systems designed to enhance opportunities for workers to learn and discover (Lundvall and Lorenz, 2010). This occurs when employees are incentivized to not only do their assigned tasks, but to also develop the way they work and to share ideas and thoughts, which should strengthen their motivation and commitment (see among others Chen and Huang, 2009; Beugelsdijk, 2008; Cozzarin, 2017). However, as far as the benefits of such changes in firms' organisation are concerned, the empirical literature still gives us little guidance, and therefore further research is needed.

From the preceding discussion, our hypothesis is that the implementation of organisational innovations, as well as higher investments in organisation and business process improvements, have a positive influence on the introduction of both product and process innovations by firms.

3. This paper uses data from the *Innobarometer* 2016, a firm-level survey based on interviews conducted in the period 2013–2015 with key decision makers of companies on behalf of the European Commission. The sample comprises companies employing 1 or more persons in manufacturing (NACE category C), services (NACE categories G, H, I, J, K, L, M, N, R) and the other industrial activities (NACE categories D, E, F). Our analysis considers the 28 European Union (EU) countries plus Switzerland.

The innovation activities of firms are defined drawing on the responses to the following questions in *Innobarometer* 2016:

- Has your company introduced new or significantly improved goods (*product innovation*) since January 2013?
- Has your company introduced new or significantly improved services (*service innovation*) since January 2013?
- Has your company introduced new or significantly improved processes, for instance new production processes or distribution methods (*process innovation*), since January 2013?

Grounding on these questions, we construct three binary variables to distinguish between different types of innovation outcome. *Product innovation*, taking values 1 if the firm has introduced product innovations, 0 otherwise; *Service innovation*, taking values 1 if the firm has introduced service innovations, 0 otherwise; and *Process innovation*, taking values 1 if the firm has introduced process innovations, 0 otherwise.

To explore the relationship between organizational changes and the innovation performance of firms, we draw on responses to the following questions:

- Has your company introduced new or significantly improved organizational methods since January 2013?
- Since January 2013, what percentage of its total turnover has your company invested in organisation or business process improvements?

Therefore, we construct two variables describing firms' organizational changes. *Organization innovation* is a binary variable taking values 1 if the firm has introduced new or significantly improved organizational methods, 0 otherwise. Moreover, *Organization investments* is an ordered variable taking value 1 if, during the last three years, the firm has invested in organizational and business process improvements the 0% of its total turnover, value 2 if the firm has invested less than 1% of its total turnover, value 3 if the firm has invested 1 to 5% of its total turnover and value 4 if the firm has invested more than 5% of its total turnover.

Further regressors are included in the analysis to account for factors that are expected to influence the ability of firms to introduce new product and/or processes. We introduce a measure for innovation input, the ordered variable *Research & Development*, taking value 1 if, during the last three years from January 2013, the firm has invested in R&D the 0% of its total turnover, value 2 if the firm has invested less than 1% of its total turnover, value 3 if the firm has invested 1 to 5% of its total turnover and value 4 if the firm has invested more than 5% of its total turnover. We also include the ordered variable *Fixed Investments*, taking value 1 if, during the last three years from January 2013, the firm has invested in the acquisition of machines, equipment, software or licenses the 0% of its total turnover, value 2 if the firm has invested less than 1% of its total turnover, value 3 if the firm has invested 1 to 5% of its total turnover and value 4 if the firm has invested more than 5% of its total turnover. Another factor that needs to be considered in the analysis is the training provided to employees, that can clearly improve their ability to develop innovations. Therefore, we define the ordered variable *Training*, taking value 1 if, during the last three years from January 2013, the firm has invested in training the 0% of its total turnover, value 2 if the firm has invested less than 1% of its total turnover, value 3 if the firm has invested 1 to 5% of its total turnover and value 4 if the firm has invested more than 5% of its total turnover.

It is also widely documented that the exporting status positively influences firms' innovative behaviour. Therefore, we include the binary variable *International market*, taking value 1 if the firm has a positive turnover deriving from sales on international markets, 0 otherwise. To capture some age effect, we introduce the variable *Young*, equal to 1 if the firm was established after January 1, 2010, 0 otherwise. On one side, young firms should be more prone to explore new and unfamiliar knowledge sources, as they generally have few established technological competences to exploit and build upon. However, on the other side, more mature firms should have a greater knowledge and expertise accumulated over time that should positively influence their capability to introduce new products and/or processes. As firms being part of a group are expected to be more innovative since they can more easily benefit from intra-group knowledge spillovers and internal access to finance, we include the variable *Group*, equal to 1 if the firm is part of a group, 0 otherwise. Further firms' characteristics are captured by: *Turnover growth* an ordered variable that takes value 1 for firms whose turnover has fallen by more than 25% since 2013, value 2 for firms whose turnover has fallen by between 5% and 25%, value 3 for firms whose turnover has remained approximately the same, value 4 for firms whose turnover has risen by between 5% and 25%, and value 5 for firms whose turnover has risen by more than 25%; and *Firm size*, an ordered variable that takes value 1 for firms with 1 to 9 employees, 2 for firms 2 with 10 to 49 employees, 3 for firms with 50 to 249 employees, 4 for firms with 250 to 499 employees, and 5 for firms with 500 or more employees.

Finally, country and industry dummies are included to control for the different technological opportunities available to firms depending on their geographical area or industrial sector. The industry dummies follow the *Nomenclature statistique des activités économiques* (NACE) Rev. 2 at 2-digit level.

After data cleaning, due to missing values, we end up with 11,241 valid observations at firm-level across European countries. In Table 1 we provide some descriptive statistics of the variables included in our analysis.

Table 1. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
(1) Product innovation	11,241	0.409	0.492	0	1
(2) Service innovation	11,241	0.451	0.498	0	1
(3) Process innovation	11,241	0.391	0.488	0	1
(4) Organizational innovation	11,241	0.407	0.491	0	1
(5) Organizational investments	11,241	2.223	1.046	1	4
(6) Research & Development	11,241	1.710	1.014	1	4
(7) Fixed Investments	11,241	2.709	1.070	1	4
(8) Training	11,241	2.357	0.975	1	4
(9) International market	11,241	0.350	0.477	0	1
(10) Young	11,241	0.127	0.333	0	1
(11) Group	11,241	0.232	0.422	0	1
(12) Turnover growth	11,241	3.274	1.026	1	5
(13) Firm size	11,241	1.871	0.984	1	5

The 45% of sampled firms has introduced *service* innovations, followed by the 41% of firms having introduced *product* innovations, while *process* innovations have been introduced by the 39% of sampled firms.

Regarding organization changes, the 41% of firms has introduced *organizational innovations*. Moreover, the organizational investments belong, approximately, to category 2, meaning that firms have invested less than 1% of total turnover in organizational and business process improvements.

About the other investments made by sampled firms, those in R&D appears to be lower than investments in fixed assets, such us acquisition of machines, equipment, software or licenses, and in training. Only the 35% of sampled firms has some positive turnover from selling goods or services on the international markets; the 12.7% of firms are young and the 23.2% belongs to a group. On average, the turnover growth belongs, approximately, to category 3, meaning that the turnover of sampled firms has remained stable since 2013. Finally, the firm size is close to category 2, indicating that sampled firms have, on average, 10 to 49 employees.

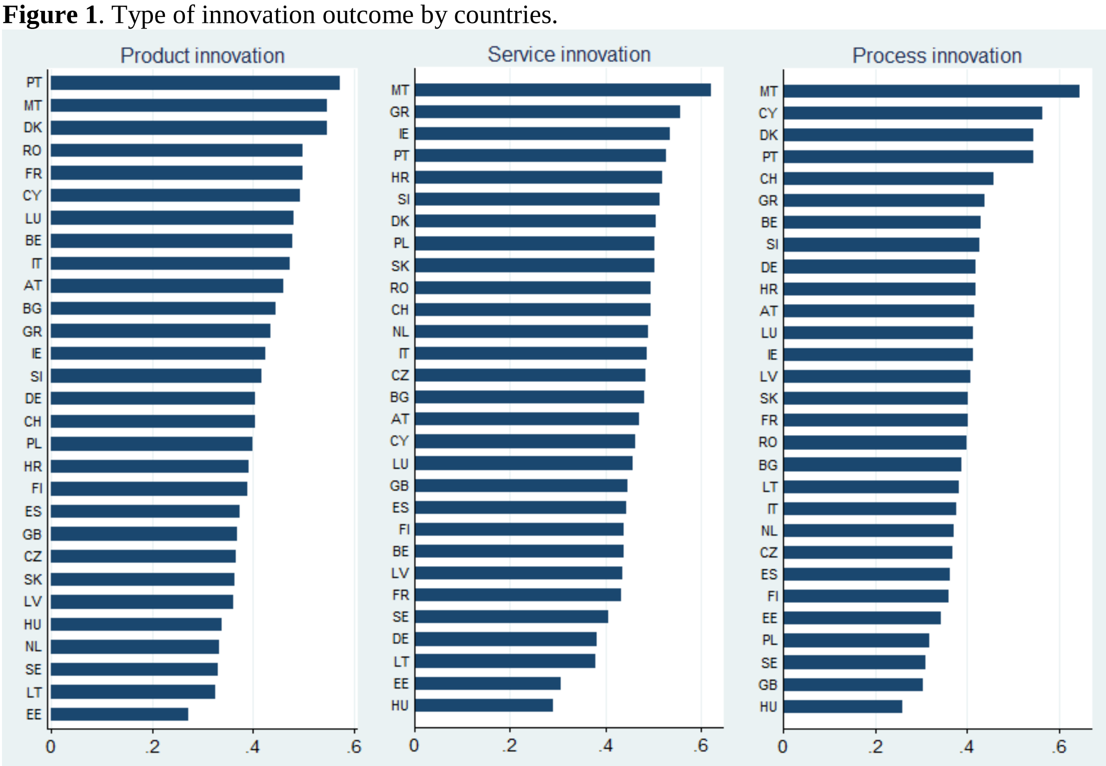
In Table 2 we report the correlation matrix.

Table 2. Correlation matrix.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1)	1												
(2)	0.291	1											
(3)	0.345	0.390	1										
(4)	0.261	0.387	0.431	1									
(5)	0.233	0.321	0.346	0.408	1								
(6)	0.295	0.234	0.296	0.222	0.321	1							
(7)	0.129	0.180	0.214	0.188	0.288	0.202	1						
(8)	0.136	0.227	0.205	0.238	0.394	0.275	0.302	1					
(9)	0.133	0.049	0.164	0.091	0.096	0.220	0.100	0.062	1				
(10)	-0.003	0.034	-0.014	0.004	0.013	-0.007	-0.007	-0.022	-0.041	1			
(11)	0.085	0.061	0.139	0.106	0.103	0.120	0.033	0.120	0.176	-0.070	1		
(12)	0.096	0.145	0.155	0.127	0.145	0.125	0.176	0.154	0.127	0.138	0.089	1	
(13)	0.097	0.100	0.218	0.185	0.164	0.181	0.189	0.207	0.234	-0.158	0.415	0.144	1

From Figure 1 to Figure 3 we provide additional statistics disaggregated by country on the key variables of our analysis, the dependent variables *Product innovation*, *Service innovation* and *Process innovation* and the regressors of interest, *Organizational innovation* and *Organizational investments.*

Figure 1. Type of innovation outcome by countries.

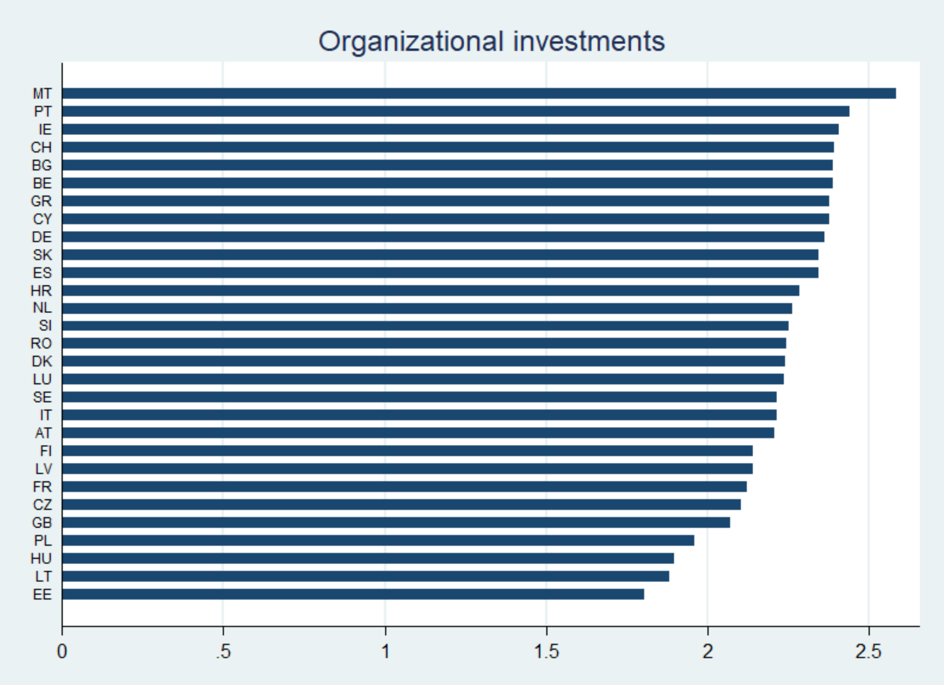


Source: Authors' elaboration on Innobarometers 2016.

Figure 2. Organizational innovation by countries.

Source: Authors' elaboration on Innobarometers 2016.

Figure 3. Organizational investments by countries.



Source: Authors' elaboration on Innobarometers 2016.

By comparing the figures above, it emerges that countries exhibiting the highest *product*, *service* and *process* innovation intensity are also those with the highest organizational innovation intensity and with, on average, the greatest level of investments in organizational and business process improvements. In the specific, Malta and Portugal appear to be the countries with the highest intensity of technological, organizational innovation and the greatest level of investments in organizational improvements.

4. We assume that firm *i* engages in innovation if $y_i^* > 0$, where y_i^* is the difference between expected profits from introducing an innovation and expected profits from not to do so. We cannot observe the profits of firm *i*, but we can observe whether firm *i* has introduced an innovation. The decision of firm *i* to engage in innovation is described by Equation (1):

$$y_i = \begin{cases} 1 & \text{if } \; y_i^* = x_i'\beta + \epsilon_i > 0 \\ 0 & \text{if } \; y_i^* = x_i'\beta + \epsilon_i \leq 0 \end{cases} \tag{1}$$

where y_i^* is the unobserved latent variable, x_i is the vector of firm-level explanatory variables, β is the related vector of coefficients and ϵ_{im} the error term. The dependent variable y_i is a binary variable taking value 1 if firm *i* innovates, and value 0 if firm *i* does not innovate.

For the estimations, given the binary nature of the dependent variable, we specify a multivariate probit model with three equations for the types of innovation outcome: *product innovation*, *service innovation* and *process innovation*. The multivariate approach has some advantages in studying the innovation of firms. It allows: to model complementary decisions since firms might simultaneously achieve different type of innovation outcomes, to control for potential correlation of the error terms and to make a comparison among variables shared across equations (Santamaria et al. 2012). To verify the appropriateness of the multivariate approach, the likelihood ratio test on the null hypothesis that the correlation coefficients ρ of the error terms are jointly equal to zero is performed.

Our empirical strategy shows some limitations - due to the cross-sectional nature of data and the simultaneity of innovative output and input variables - that would not allow us to clear the causal direction among them, though appropriate to detect structural associations.

Finally, the coefficients are obtained through maximum likelihood estimator.

5. In Table 3 we show the results obtained through the multivariate probit modelling. The covariance matrix at the bottom of the table shows that the correlation coefficients of the error terms ρ are highly significant. The likelihood ratio test on the

null hypothesis that ρ are jointly equal to zero is strongly rejected. Hence, strong support for the choice of multivariate probit approach is provided.

Table 3. Results from multivariate probit analysis.

Explanatory variable		Dependent variable		
		Product innovation	**Service innovation**	**Process innovation**
Organizational innovation		0.4562***	0.7702***	0.8763***
		(0.0333)	(0.0292)	(0.0307)
Organizational investments		0.0974***	0.1795***	0.1986***
		(0.0164)	(0.0153)	(0.0147)
Research & Development		0.2903***	0.1365***	0.1980***
		(0.0159)	(0.0149)	(0.0148)
Fixed investments		0.0581***	0.0777***	0.1130***
		(0.0137)	(0.0123)	(0.0127)
Training		0.0139	0.0905***	0.0091
		(0.0158)	(0.0159)	(0.0177)
International market		0.1254***	-0.0500	0.1523***
		(0.0309)	(0.0316)	(0.0312)
Young		0.0094	0.1025**	-0.0259
		(0.0423)	(0.0410)	(0.0408)
Group		0.0868**	0.0141	0.1184***
		(0.0365)	(0.0364)	(0.0369)
Turnover growth		0.0562***	0.0965***	0.0955***
		(0.0133)	(0.0128)	(0.0138)
Firm size		-0.0186	-0.0032	0.0970***
		(0.0168)	(0.0171)	(0.0159)
Country dummies		yes	yes	yes
Industry dummies		yes	yes	yes
		ρ1	ρ2	ρ3
	ρ1	1		
	ρ2	0.293***	1	
	ρ3	0.310***	0.365***	1
Log likelihood ratio test of H_0: ρ21 = ρ31 = ρ32 = 0				
LR $X^2(3)$			1,070.29***	
Log pseudolikelihood			-17,979.221	
Observations			11,241	

Cluster-robust standard errors at country-industry level are reported in parentheses. The grouping criteria industries is: 1 = Manufacturing; 2 = Electricity, gas, steam and air conditioning supply; 3 = Water supply, sewerage, waste management and remediation activities; 4 = Construction; 5 = Wholesale and retail trade, repair of motor vehicles and motorcycles; 6 = Transportation and storage; 7 = Accommodation and food service activities; 8 = Information and communication; 9 = Financial and insurance activities; 10 = Real estate activities; 11 = Professional, scientific and technical activities; 12 = Administrative and support service activities; 13 = Arts, entertainment and recreation.

*** p<0.01, ** p<0.05, * p<0.10

Fully confirming our conjecture, organizational changes are found to be highly relevant for the technological innovation performance of firms. In the specific, the variable *Organisational innovation* turns out to be positively and highly significantly (p-value <0.01) associated with all the three types of innovation outcome. Interestingly, the coefficient of *Organisational innovation* is approximately two times greater for *process* and *service* innovation compared to *product* innovation. Moreover, the variable *Organisational investments* is highly significantly (p-value <0.01) and positively associated with the all the three types of innovation outcome. As before, the coefficient of *Organisational investments* is approximately two times greater for *process* and *service* innovation compared to *product* innovation.

Therefore, from our results it emerges the complementary nature of *product*, *service* and *process* innovations with *organizational* innovations: a good organisation of production activities may matter just like (or even more than) any other traditional innovatory element with respect to boosting firms' innovativeness. The organizational changes appear to be of particular importance for *service* and *process* innovations.

All the control variables included in our model - accounting for various firms' activities or characteristics expected to influence innovation - are confirmed to play a role. More in detail, the variables *Research and Development* and *Fixed Investments* are both positively and highly significantly (p-value <0.01) associated with all the three types of innovation outcome, though, across equations, the size of the coefficient of the former variable is more than double that of the latter. Actually, as widely recognized by scholars, R&D plays two decisive roles: (1) stimulating the internal generation of new knowledge and innovation; and (2) enhancing the absorptive capacity of firms and, thus, the effective transmission of external knowledge and technologies (Griffith et al. 2004). The positive role of *Fixed investments* is also in line with the literature, since this indicator accounts for trade of new technologies embodied in physical capital, which is likely to be one of the most important channel of innovation diffusion.

The variable *Training* of personnel is positively and highly significantly (p-value <0.01) associated with one of the three types of innovation outcome, namely *service innovation*. Although less considered in most studies on firms' innovation, the role of job training is crucial for both firms with a greater endowment of highly-educated workers, since people who have received a better education generally have a higher potential to learn and develop a greater knowledge (Hitt et al., 2001; Hatch and Dyer, 2004; Rauch et al., 2005) as well as to adapt more rapidly and efficiently to the new tasks (Blundell et al., 1999); and for firms using training as a substitute for formal education, namely to make up for limited investments in highly-qualified personnel or to account for a skill (education) mismatch, which occurs when the actual level of workers' qualification is lower than what required by their job.

Firms' innovation performance is also strongly influenced by exports (*International Market*) and by success on the market in terms of sales growth

(*Turnover growth*). As for the former variable, the result emerged confirms the positive effect of international competition on firms' ability to introduce *product* and *process* innovation, likely via a *learning by exporting* effect fostered by the exposure to a superior foreign technology, as well as through economies of scale, which can better enable the firms to cover the large fixed costs of undertaking R&D (Narula and Zanfei, 2003; Harris and Moffat, 2011). Turning to the variable *Turnover growth*, it appears to be positively and highly significantly (p-value <0.01) associated with all the three types of innovation outcome. This finding supports that firms' innovativeness is strongly and positively related to the "pull" effect of expanding demand on the market. In this respect, it is worth to mention that the role of demand is not obvious: indeed, on the one hand, it may sustain the growth of innovative turnover and thus provide firms with better incentives to innovate by offering greater opportunities for the success of new products; on the other hand, a strong demand growth may also reduce the competitive pressure to innovate (see Bogliacino and Pianta, 2013).

The variable *Young* is positively and significantly (p-value<0.05) associated only with one of the three types of innovation outcome, namely *service* innovation. In this regard, young firms are more likely to introduce *service* innovation than mature firms since they have a few established technological competences (knowledge and expertise accumulated over time); consequently, they may be more prone to "exploration" of new and unfamiliar knowledge sources (Sorensen and Stuart, 2000). The variable *Group* is positively and significantly associated with two of the three types of innovation outcome (*product* and *process* innovation), thus confirming the widely recognised advantages for firms' innovativeness stemming from intra-group knowledge spillovers and internal access to finance (Filatotchev et al, 2003). Finally, the variable *Firm size* is positively and significantly associated only with one of the three types of innovation outcome, namely *process* innovation.

6. By using firm-level data provided by *Innobarometer* 2016, the empirical analysis carried out in this paper contributes to shed light on the role that organisational changes play in the technological innovation processes of firms. The results obtained fully confirm our hypothesis, namely that the adoption of significant organisational innovations within firms as well as the overall investments aimed at improving their organisational structure and business processes do matter for firms' innovation performance. Indeed, major organizational changes are found to influence the likelihood of introducing all the three types of innovations by firms and, particularly, service and process innovations.

Clearly, these results should be considered in the light of some limitations, which mainly pertain to the cross-sectional nature of the data employed, that does not allow to investigate dynamic relationships and to interpret the results in terms of causality. Nevertheless, some relevant policy implications can be drawn. All in all, governments aiming at promoting and supporting firms' innovativeness should also focus on the promotion of organizational innovation: indeed, it is clear that firms' ability to innovate does not only depend on R&D spending or on making analogous investments (e.g. in human capital, external cooperation, or to directly purchase new technologies embodied in physical capital); rather, it also stems from strategies that effectively integrate and make the best use of the various firms' internal and external innovative inputs. Of course, addressing these issues is not an easy task, since potentially huge differences across firms, sectors and countries, must be identified and taken into account. This is an aspect that would need further research. The preliminary evidence presented in this paper, however, should contribute to a better identification of the relevant policy issues.

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