Multi-Layer Profit Sharing and Innovation

Filippo Belloc
Department of Economics and Statistics
University of Siena
Piazza San Francesco 7, 53100
Siena, Italy

Abstract

In this paper, we measure whether contractual profit sharing (PS) influences firm innovation and, if yes, how. We disentangle PS effects for different and possibly conflicting interest groups within the firm. We exploit the fact that PS schemes rarely cover the workers all together, but more often than not are used at some layer in the corporate hierarchy and not at others. Based on the analysis of a representative sample of Italian firms, the key contribution of the study is to show that the structure of PS plans matters significantly for innovation. While PS for managers is associated with little or no improvement in innovation activity, PS for non-managers spurs the probability of observing innovation by about 5% to 15%. This may reflect different discount factors of employees at different firm layers. We also document how PS effects, particularly for non-managers, change depending on other firm level variables, such as size, unionization, exposure on international markets, the span of managerial control and some characteristics of the workforce. Policy implications are discussed.

Keywords: profit sharing, innovation, incentive pay, teamwork.
JEL classification: J33, K31, M52, O31.

Acknowledgments. I thank seminar participants at NTNU and CBS. For useful comments and discussions, I thank Colin Green, Takao Kato, Frank Mullins and Niels Westergaard-Nielsen. I also thank the Italian National Institute for Public Policy Analysis (INAPP) for providing me with access to the RIL database (Employer and Employee Survey). This paper was partly drafted during an academic visit at NTNU, whose hospitality I acknowledge with gratitude. Any remaining errors are my own. Financial support from the University of Siena is gratefully acknowledged. Address: Piazza San Francesco 7, 53100 - Siena, Italy. Email: filippo.belloc@unisi.it.

1 Introduction

Industrial organization research is increasingly concerned with the structure of firms and how it shapes decision-making (Delmastro, 2002; Colombo and Delmastro, 2004), particularly when it involves innovation (Kastl *et al.*, 2013). While a rich field of study has focused on the interaction between internal innovation incentives and competitive pressure, caused by intra-firm tensions (Wickelgren, 2005) or by external competition (Vives, 2008; Correa and Ornaghi, 2014; Beneito *et al.*, 2015; Ghosh *et al.*, 2017; Symeonidis, 2020), other works have looked at the role played by compensation schemes (see Manso (2017) for a survey of the main related aspects).

In particular, pay contracts based on profit sharing (PS, hereafter), which directly link employee pay to firm profits, are extensively used in many countries as a contractual device aimed at improving short-run performance of firms.[1] On average, PS is found to be positively related to productivity (Doucouliagos *et al.*, 2019). Yet, surprisingly little empirical evidence is available on the link between PS and innovation. Moreover, how innovation is influenced by more complex PS regimes, with PS being adopted only for a given layer in the corporate hierarchy and not in others, remains largely unexplored.[2] Uncharted is also whether and to which extent PS effects change across industries and react to firm characteristics, such as size, unionization, and exposure on international markets.

In this paper, we examine whether the adoption of PS may improve process and product innovation performance at the firm level. In addition, we analyse whether PS has differential effects depending on the employee layer it is used at. Since PS is typically based on short-run indicators of firm profits (at the very bottom, this is what differentiates PS from other types of group incentive pay, such as stock ownership and options plans), how it may influence long-run measures of performance, including innovation output, is not obvious.

Innovation projects may require the firm to perform poorly in the short-run but allow it to gain greater profits in the future. Hence, for PS schemes to stimulate effort in innovative undertakings, the employee time horizon is critical. PS may boost innovative effort, to the

[1] Kruse *et al.* (2010) report that, in the US, about one-third of employees are eligible for bonuses based on company performance in 2002 (34%) and 2006 (38%) and that 62% of firms adopt PS plans in 2002. In EU-28 countries, the average proportion of firms with more than 10 employees offering PS schemes is 14.3% in 2009 and 30.2% in 2013 (European Commission, 2014).

[2] To the best of our knowledge, only Aerts *et al.* (2015) have measured the impact of PS on innovation. Their data, covering a sample of German firms, do not disentangle between PS schemes used at different layers, and the paper only looks at the average impact of PS. They find that PS has a positive effect on product innovation and no effect on process innovation. Less recently, Harden *et al.* (2010) have analysed data from one large US company and detected a positive correlation between PS and subjective measures of a workplace culture supportive of innovative efforts.

extent that employees have sufficiently longtime horizons, thereby believing to be there when innovation rewards will be monetized and distributed. At the same time, for those with shorter horizons, postponing profits may be suboptimal. Thus, to use PS at a layer rather than at another may matter, if employees at different layers have also different time horizons and discount factors. Moreover, multi-layer PS (i.e. PS is adopted at more than one layer at the same time) may induce tension between those who want to explore innovative business strategies and those preferring methods that ensure reasonable payoffs in the short-run but prevent extra-profits in the future.

We analyse this issue by looking at a large sample of firms, operating in manufacturing and service sectors in Italy, where both time and cross-sectional variation in the use of PS is present. The data are obtained from the Employer and Employee Survey (EES) conducted in 2010 and 2015 by the National Institute for Public Policy Analysis (INAPP) in Italy, and cover about 54500 pooled observations and 20500 panel observations over the period 2009-2014. Based on these data, Figure 1 shows the extensive margins of a set of measures of innovative activity across firms adopting PS only at the managerial layer (MPS), only at the non-managerial layer (EPS), at both layers (MLPS) or not adopting PS at any layer. Firms using only EPS or MLPS are showed to be at least twice as innovative as those using only MPS or no PS. This is puzzling, if one considers that non-managerial employees are usually deemed more conservative and risk averse than managers (Bloom and Van Reenen, 2011).

[insert Figure 1 about here]

In the paper, we test whether this picture is robust to a systematic econometric analysis. We find that, while PS at the managerial layer has no effect on innovation, PS at the non-managerial layer spurs the probability of making process and product innovation by about 5% to 15%. When PS is used at both layers, estimated effects do not change substantially with respect to the policy of using PS only for non-managers. If anything, the use of alternative mechanisms of incentive pay based on individual performance, which are observed to couple PS in many firms, jeopardize innovation. In addition, we show that PS effects on innovation change crucially depending on other firm level variables, such as size, unionization, exposure on international markets, the span of managerial control and some characteristics of the workforce.

We maintain that the main channel behind the positive association between PS and innovation relates to the improved employee behaviour at the workplace under contractual PS due to increased effort, peer-pressure, greater collaboration among co-workers and, more in general, stronger worker incentives to undertake upskilling activities. Although we do not aim at digging into the mechanisms possibly activating PS effects on innovation, additional estimations show that non-managerial PS is positively associated with in-firm training activities, thereby suggesting that PS may spur initiatives of worker upskilling, and that such activities may drive most of the effect of PS on innovation.

Clearly, there are also important endogeneity concerns. First, firms may choose to adopt PS based on past innovation records or unobservable technology factors, which may correlate with both PS and current innovation (Fitzroy and Kraft, 1995). Second, depending on unobservable idiosyncratic abilities, workers may self-select across firms with different pay policies, with PS attracting workers with particular attitudes (Lazear, 2000a, 2000b). In our analysis, we tackle both issues. We deal with reverse causality and selectivity by using an IV estimation, propensity score matching, and dynamic specifications where PS effects are modelled with sufficiently long lags and both past innovation and past technological investments are controlled for. Furthermore, we account for possible worker sorting by controlling for a set of workers' and CEOs' characteristics and for the dynamics of voluntary separations. Fortunately, our data contain a rich array of information that allow mitigating endogeneity concerns without exotic identification strategies. In any event, in the paper we also explain that both selectivity and worker sorting are most likely to run against the causality direction we argue for, leading to downward bias of the estimates. Moreover, the results from measuring PS effects conditional on other firm level variables will be showed to be broadly consistent with our preferred interpretation.

This study is positioned at the intersection between two literatures.

First, we contribute to the body of research that has sought to relate the innovation performance of the firm to the long-term versus short-term orientation of incentive pay schemes. This literature mainly focuses on compensation of managers. Holthausen *et al.* (1995) analyse the effect of compensation of divisional CEOs. They find that the long-term components of compensation (as measured by accounting performance and valuations for stock-based contracts) have a modest but positive relation with patent counts deflated by total sales. Lerner and Wulf (2007) examine compensation schemes of the heads of corporate research and development. They find that long-term incentives (such as stock options and restricted stock) are associated with more heavily cited patents and patents of greater originality, while short-term incentives (namely, bonus divided by total compensation) are unrelated to innovation. Manso (2011) and Ederer and Manso (2013) show that optimal incentive schemes motivating innovation exhibit tolerance for early failure, which can be obtained by combining stock options with long vesting periods, option repricing, golden parachutes, and managerial entrenchment. They also show that rewarding short-term financial results may create disincentives for innovation. Other papers have investigated the interplay between corporate innovation and long-term compensation schemes for non-executive employees, generally pointing to a greater positive effect of employee stock options with respect to standard short-run pay-for-performance contracts (Ederer, 2013; Chang *et al.*, 2015). Several issues remain unexplored though, particularly if one considers that innovation requires effort by workers at different levels in the corporate organization and involves a heterogeneous set of tasks (Holmstrom, 1989). Does short-term managerial compensation influence the power of incentives for non-managers, if also non-managers are rewarded based on performance? How does the span of managerial control over non-managers affect the magnitude of this interaction?[3] And which is the influence of exposure on international markets, owner's identity and CEO's characteristics, such as age, gender and education? We provide an answer to these and other related questions.[4]

Second is the literature on the link between group versus individual incentive pay and firm productivity. A number of papers, starting from Fitzroy and Kraft (1987), have showed that group incentive pay (including PS) promotes teamwork and collaboration among workers, whereas individual incentive pay may engender counterproductive rivalry.[5] Under contractual PS in particular, since productive effort yields positive externalities to workers, cooperation to increase productivity may be greater. Although PS may be subject to the free-rider problem (Drago and Garvey, 1998), thereby discouraging high ability workers from joining the firm, most of the empirical literature finds positive correlations between PS and various measures of firm productivity, such as value added, output per worker and TFP (Doucouliagos *et al.*, 2019). PS has been found having positive effects also on reduced absenteeism, workers' perception of the discretionary effort of co-workers, loyalty to the firm, willingness to work hard, the frequency of suggestions to improve efficiency (Blasi *et al.*, 2010) and peer-monitoring against shirking co-workers (Freeman *et al.*, 2010). There is however a substantial dearth of evidence on whether PS also influences long-run measures of performance, such as innovation, and, if

[3] Nikiforakis *et al.* (2019) showed that, in a controlled laboratory setting, managers may coerce their subordinates into exerting inefficient or undesired levels of effort in a self-serving way, when they can obtain individual bonuses from doing so.

[4] A related stream of literature has showed that how managerial compensation schemes influence firm performance may be moderated by the corporate governance system (e.g., Kato (1997)).

[5] A simple model exploring how group incentive pay may induce cooperation is proposed by Itoh (1992). More in general, Burdín *et al.* (2018) show, in a principal-agent framework, how agent (i.e. worker) effort may be improved by reciprocity and trust in organizational schemes that do not rely on direct control by the principal.

yes, how. Moreover, the vast majority of studies (including Aerts *et al.* (2015), focusing on innovation) examines the average impact of PS, without disentangling the specific effect of PS for different – and, possibly, conflicting – interest groups within the firm. Related to this, despite the large attention devoted to the dilution of incentives under PS (Prendergast, 1999), often referred to as the "1/N problem", to the best of our knowledge there are no attempts at measuring to what extent PS effects on firm performance decrease with increasing number of workers involved. As for innovation, typically requiring efforts by multiple workers, such issue might be critical. We aim also at filling this gap.[6]

Our results suggest that PS on average may help, and at a minimum does not harm, innovation performance. The magnitude of the effect, however, may change greatly depending on the layer(s) where PS is used at, with PS at the non-managerial layer being the most effective. The policy implications of this finding are easy to see. Business strategists should not shy away from extending PS programs to non-managers. Even if PS links employee pay to short-run profits, when adopted for non-managers PS may activate incentive mechanisms that work well with respect to innovation. On the side of legal and labour policy making, our findings point to improving institutional devices that induce a larger use of PS, such as tax exemptions on company-wide cash bonuses for employees. Tax incentives have been found to be an important driver in the adoption of other types of group incentive pay (e.g., Employee Stock Ownership Plans in the US over the 1980s) by previous related research (Blasi and Kruse, 1991; Beatty, 1994). Clearly, we also must emphasize that our findings cannot be directly translated in specific policy instructions, given the impossibility to establish causality unambiguously in the absence of fully exogenous discontinuities in the PS plans observed in the data. At the same time, however, the design of our baseline analysis and the robustness checks make it hard to think about alternative interpretations of the findings that would point to substantially different policy prescriptions.

The remaining of the paper is organized as follows. Section 2 introduces the institutional context and explains briefly how the bargaining system over employee pay is structured in Italy. In Section 3 we motivate the empirical analysis on a theoretical ground, by means of a simple and illustrative model of multi-layer PS and innovation. In Section 4 we describe the data used in the econometric analysis. The regression model, the main threats to identification and the estimation results are presented in Section 5, where we also explore the interaction

[6] Incidentally, our study also adds to the literature on the relationship between the organization of corporate hierarchies and compensation structures over multiple layers (Rosen, 1982; Rajan and Wulf, 2006; Caliendo *et al.*, 2015).

between PS and other firm characteristics. Section 6 concludes.

2 Institutional background

In Italy, collective bargaining over employees' compensation takes place at two levels (two-tier bargaining). At the higher one (often referred to as the I-level), negotiations are conducted between representatives of firms associations and trade unions at a sectoral or national level and are intended to set minimum pay and to ensure that wages keep pace with prices. At the lower level (II-level), negotiations are conducted at the firm/establishment level and are aimed at providing mechanisms for the employees to share-in gains from improved productivity at the company level.[7] Although it being less common, bargaining at the II-level can be conducted for more employers together on a district or territorial basis.

Italy has no specific legislation designed to regulate PS plans, which can be adopted by firms on a voluntary basis. However, firms that want to adopt PS at any layer need to adhere to a II-level agreement. Since II-level agreements may be negotiated separately for employees at different layers in the corporate hierarchy, PS programs may be in fact provided at any layer (i.e., for executives, non-executive managers, non-managerial supervisors, white-collars, and/or blue-collars) regardless of whether also workers at an upper or lower layer join a PS scheme. However, given that employees at a same layer must be subject to a same labour contract, when PS applies at a given layer, it has to cover the employees at that layer all together.

Typically, PS as provided by a II-level agreement takes the form of cash bonuses to be paid based on short-term (in most cases, yearly-based) performance, measured at a company-wide level. In particular, PS introduces a variable cash premium to be added to the baseline wage that is fixed at the I-level. If the firm reaches some negotiated threshold of profits, then a cash bonus is paid in addition to the baseline wage. When profits do not cross the threshold, wages are paid according to the I-level contract and negative adjustments are not allowed (i.e. the so-called "favorability principle" applies).

3 Theoretical motivation

In this Section, we sketch a simplified framework to illustrate the tension between non-innovative and innovative action plans by firm agents in a two-layer decision problem, under possible PS.

[7] II-level negotiations may also cover other issues unrelated to pay: namely, equal opportunities, health insurance, fringe benefits, and workplace safety.

The purpose of this theoretical exercise is to motivate the empirical analysis in a way that is coherent with the institutional context our data refer to, not to produce testable predictions.

A stylized firm is composed by a managerial layer and a non-managerial layer. We assume that the employees have homogeneous preferences within layers. Hence, we study the behaviour of employees at each layer as the one of a representative agent. We denote with subscript M a managerial agent and with E a non-managerial agent. Both representative agents are risk-neutral and live for two periods. In t_1, the agent decides his action plan. Two actions are available: a default action (D) and an innovative project (S) which is a potentially superior action. The agent can undertake only one or both actions. Denote the type of action with superscript j. When an agent takes an action j, the maximum private benefits (i.e. the total output, when the action is successful) he can obtain from it in each period are π^j. The output from D generates a flow of payments across periods, that is $\tau\pi^D$ in t_1 and $(1-\tau)\pi^D$ in t_2. Action S does not generate output in t_1 but only output π^S in t_2, with $\pi^S > \pi^D$. The discount factor is δ_i. Both actions imply some sunk costs c_i^j to be entirely incurred by agent i in t_1. For clarity of exposition, normalize c_i^D to zero, and consider c_i^S as the extra-cost associated to action S. This extra-cost may be thought of as the cost due to some increased effort required by action S, in the form of improved teamwork or more effective monitoring of peers. Alternatively, c_i^S may be the opportunity cost in t_1 associated with the time spent for helping co-workers or for developing additional human capital. While action D is perfectly contractible and therefore it is always undertaken by agents, the outcome of action S is unpredictable and impossible to contract upon (as in Aghion and Tirole (1994)). The probability of success for action S is p^S. Let $\mathbb{E}_i[p^S]$ denote the expectation of p^S by agent i.[8]

A PS policy may be adopted at only one layer (M or E) or at both layers. The firm can also decide not to adopt PS at any layer. If a PS policy is adopted, it is as follows. When the output per-period from action j is above a given (exogenous) threshold $\overline{\pi}$, a share α_i of the extra-output $\Delta\pi \equiv \pi^j - \overline{\pi}$ is distributed to each agent covered by the PS scheme, with $\alpha_M + \alpha_E = 1$. When PS is adopted only at layer i and $\pi^j > \overline{\pi}$, the agent i gets a share α_i of the extra-output, whilst a share $1 - \alpha_i$ of it is retained by the firm. We abstract away from the interests of outside owners and treat PS policies as exogenous. We assume that $\pi^S > \overline{\pi}$ and $\pi^D = \overline{\pi}$.

[8]To simplify the notation, we are not considering explicitly the issue of the number of employees involved at each layer (i.e. the "1/N problem"). This is not crucial to our argument. Nevertheless, the output π^j from any action can be considered here as net of possible free-riding. Clearly, with free-riding, the higher the number of workers at each layer, the lower the per-capita gains from any action.

Possible payoffs for agent i, with and without PS at layer i, are:

$$U_i^j = \begin{cases} \tau\pi^D + \frac{(1-\tau)\pi^D}{1+\delta_i} & \text{if } j = D \\ -c_i^S + \tau\pi^D + \frac{\overbrace{\mathbb{E}_i[p^S]\Delta\pi\alpha_i}^{\text{with PS}} + (1-\tau)\pi^D}{1+\delta_i} & \text{if } j = S \end{cases} \tag{1}$$

It is straightforward to observe that, without PS, action S is always suboptimal. With PS, action S is optimal for agent i if $U_i^S > U_i^D$, that is, if:

$$\delta_i < \frac{\mathbb{E}_i[p^S]\Delta\pi\alpha_i - c_i^S}{c_i^S} \equiv \overline{\delta}_i \tag{2}$$

Condition (2) is weaker (and the likelihood of an innovative undertaking higher) when, all else being equal, agent i has a greater expectation of succeeding with action S or the extra-output from action S is greater, when the profit-sharing rule α_i is more favourable to layer i, and when the fixed cost of action S or the discount factor is lower. Since there are no reasons to assume that the idiosyncratic components in (2) are equal across layers, it is also realistic to expect that representative agents at different layers may find it optimal to undertake different action plans.

To see how action decisions at layer i may change when PS is used at both layers rather than only at layer i, let us extend this simple framework by assuming that both agents may voluntary leave the firm between t_1 and t_2. Non-managers have no outside options and, if quitting, they get a reservation wage $\omega_E = 0$ in t_2; hence, they never quit if behaving rationally. Instead, if a manager quits, in t_2 the value of his outside option is $\omega_M \geq 0$, which equals the net output of the firm in t_1 (i.e. the sum of the agents' payoffs in t_1).[9] The present value (ω_{Mt1}) of the outside option for the manager is:

$$\omega_{Mt1} = \begin{cases} \frac{2\tau\pi^D}{1+\delta_M} & \text{if } j = D \text{ for both agents} \\ \frac{2\tau\pi^D - c_M^S - c_E^S}{1+\delta_M} & \text{if } j = S \text{ for both agents} \\ \frac{2\tau\pi^D - c_M^S}{1+\delta_M} & \text{if } j = S \text{ for } M \text{ and } j = D \text{ for } E \\ \frac{2\tau\pi^D - c_E^S}{1+\delta_M} & \text{if } j = S \text{ for } E \text{ and } j = D \text{ for } M \end{cases} \tag{3}$$

Suppose that $\delta_i < \overline{\delta}_i \; \forall i$ (i.e. under PS at layer i, strategy S is the best strategy for agent i as an alternative to possible voluntary separation). Then, the optimal strategy for agent M

[9] That managers can rely on outside options whilst bargaining withing the firm is a common feature of incomplete contracts models in the theory of the firm (e.g., De Meza and Lockwood (1998)).

is to undertake action D in t_1 and then leaving the firm in t_2 when doing so he obtains more than under the best alternative strategy, i.e.:

$$0 < \begin{cases} \frac{2\tau\pi^D-(1-\tau)\pi^D-\mathbb{E}_M[p^S]\Delta\pi\alpha_M-c_E^S}{1+\delta_M} + c_M^S & \text{if MLPS is used} \\ \frac{2\tau\pi^D-(1-\tau)\pi^D-\mathbb{E}_M[p^S]\Delta\pi\alpha_M}{1+\delta_M} + c_M^S & \text{if only MPS is used} \\ 2\tau\pi^D-(1-\tau)\pi^D - c_E^S & \text{if only EPS is used} \\ 2\tau\pi^D-(1-\tau)\pi^D & \text{if PS is not used at any layer} \end{cases} \tag{4}$$

where we exploited the fact that, when PS is not used at layer i, agent i never chooses action S. By looking at the first two lines of (4), it is easy to see that the conditions making a voluntary leave optimal for agent M differ depending on whether PS is used only at layer M or at both layers. The intuition is simple: the action plan of E has an effect on the output of the firm in t_1 and this influences the value of the M's outside option. By backward induction, it follows that the PS policy at layer E (i.e., only MPS or MLPS is used) also have an impact on the decision between action D and action S in t_1 for agent M.

Moreover, from (3), it is straightforward to notice that the value of the outside option for M is higher when both agents undertake action D. Suppose that an EPS policy is in place and that the manager can influence the cost of action S for agent E, for instance by making human capital investments by E more difficult and therefore more costly or refusing to provide some complementary investment.[10] According to (2), if c_E^S increases, the likelihood that agent E chooses S decreases. Then, if agent E takes action D (i.e., condition (2) does not hold for E), this effectively increases the value of the M's outside option. However, if agent E takes action S (i.e., condition (2) continues to hold even after M having manipulated c_E^S), the increase in c_E^S reflects into a lower value of ω_{Mt1}. Hence, while it happens that M has an incentive to influence c_E^S under EPS, thereby inducing agent E to take an action rather than another, it is also true that there is not a unique optimal direction of this influence towards increasing or reducing c_E^S.

Taken together, these theoretical insights suggest that whether (possibly multi-layer) PS policies influence innovation at the firm level – and, if yes, in what direction – is an empirical question, which is addressed next.

[10] The ability of the managers to do so may depend on various factors, including the span of control over non-managers.

4 Data

The empirical analysis is based on data from the Employer and Employee Survey (EES) conducted in two waves, 2010 and 2015, by the National Institute for Public Policy Analysis (INAPP) in Italy. The EES-INAPP data cover a representative sample of partnerships and limited liability companies operating in the non-agricultural private sector in Italy. After data cleaning, the pooled and the longitudinal samples used in the analysis amount to 54550 pooled observations and to 20612 panel observations (i.e. 10306 firms) respectively. The EES-INAPP dataset includes a large amount of firm-specific information, including information on the use of PS programs at the firm-level, innovation activity, and a rich array of firm characteristics.

As for the innovation activity, both the 2010 and the 2015 EES-INAPP waves contain a question about whether the firm has made a process and/or a product innovation in the 3-year time window preceding the survey (i.e., over the years 2007-2009 for the 2010 wave and the years 2012-2014 for the 2015 wave). See Table 1 for a detailed definition.[11]

[insert Table 1 about here]

For most of the other information collected through both waves, the data refer to the year preceding the survey. As for the adoption of PS programs, we consider whether the firm adheres to a II-level agreements providing a variable pay linked to the company-wide performance. In particular, the EES-INAPP data allow detecting the presence of a PS program for each layer in the corporate hierarchy, by disentangling employees according to whether they are CEOs or executive managers, non-executive managers, non-managerial supervisors, white-collars, or blue-collars. In our empirical analysis, we group CEOs or executive managers and non-executive managers in the "managerial employee layer" and non-managerial supervisors, white-collars and blue-collars in the "non-managerial employee layer". The adoption of a PS scheme refers to 2009 for the 2010 wave and to 2014 for the 2015 wave of the EES-INAPP survey.

Table 2 contains descriptive statistics measuring the extensive margin of PS in our sample of firms. PS is widely used at the managerial employee layer (MPS), mostly due to PS programs for CEOs and executives, which are used by about 49.2% of firms, while only 2.12% of firms use PS for non-executive managers.[12] PS at the non-managerial layer (EPS) is used much

[11] This notion of innovation encompasses both patentable and unpatented innovations (e.g. trade secrets).

[12] The rarity of PS for non-executive managers is unsurprising in light of the fact that 82.84% of firms in the sample report not to have non-executive managers. Relatedly, not all PS is created equal, with PS for managers and non-managers possibly differing in a number of details (Kato and Kauhanen, 2018), which we fail to observe in the EES-INAPP data.

less frequently than MPS, i.e. by about 4.46% of firms, and to a similar extent across non-managerial supervisors, white-collars and blue-collars (3.29%, 4.23% and 4.4%, respectively). While 48.91% of firms use PS at only one layer and 51.75% use PS at any layer, only 2.84% of firms use PS at both layers, i.e. multi-layer PS (MLPS).

[insert Table 2 about here]

A rich array of other firm characteristics is also available. In particular, we consider, with reference to the year preceding the survey, whether the firm invested in R&D and/or in automation (namely, computers, process robotization, ICT), workforce's and CEO's characteristics (as measured by sex, age and education), the type of the owner (a family or an individual, a financial institution, another firm, or other), the span of control (number of non-managerial employees to managerial employees ratio), the unionization rate (unionized employees to total employees ratio), the rate of voluntary separations (number of employees who voluntary exit the firm to total employees ratio), whether the firm uses individual-based performance-related-pay (i.e., an additional wage component to be added to the baseline pay is determined based on the performance of the individual worker), whether the firm is a limited liability company or a partnership, the firm size (as measured by the total number of employees and total revenues), whether the firm is an exporter and belongs to a group, and the number of years since incorporation.

Descriptive statistics about all our variables of interest are reported in Table 3, where firms adopting only EPS, only MPS, MLPS and no PS are split-up. As already shown in Figure 1, firms using only EPS or MLPS are on average more likely to make any between process and product innovation and more likely to invest in R&D and automation with respect to those using only MPS or no PS. Firms with only EPS or MLPS also have a larger share of the workforce with tertiary education and aged more than 50 years, along with a higher likelihood to have more educated and older CEOs, they are less likely to be family owned, more likely to be unionized, to belong to a group and to be exporters, less likely to be partnerships, more likely to adopt also individual PRP schemes, tend to show a much higher size and a larger span of control, show a slightly lower rate of voluntary separations and have a slightly higher age. Figure 2 shows the extensive margin of PS policies across sectors.

[insert Table 3 about here]

[insert Figure 2 about here]

Interestingly enough, as for firms' average characteristics for which international comparable data are available – namely, adoption of PS contracts, size, unionization and sector of activity – the descriptive picture provided the EES-INAPP data does not differ substantially from the one obtained over a European sample of firms covered by the 2013 wave of the European Company Survey (European Commission, 2014).

5 Empirical analysis

5.1 Baseline regression model

The objective of our empirical analysis is to study whether PS influences innovation activity, as measured by the introduction of any between a process and a product innovation, and, if it is so, to which extent PS effects change depending on the layer in the corporate hierarchy where they apply.

We begin by considering the following baseline regression model:

$$\begin{aligned} \text{Innovation}_{f,w} = \beta_0 + \beta_1\,\text{MPS}_{f,w-1} + \beta_2\,\text{EPS}_{f,w-1} + \mathbf{bX}_{f,w-1} + \\ \text{sector FE}_{f,w} + \text{region FE}_{f,w} + \varepsilon_{f,w} \end{aligned} \quad (5)$$

where innovation is measured by means of a dummy variable equal to 1 if the firm makes any (process or product) innovation and 0 otherwise, $\text{MPS}_{f,w-1}$ and $\text{EPS}_{f,w-1}$ are two dummies for the use of PS at the managerial and at the non-managerial employee layer respectively, and where $\mathbf{X}_{f,w-1}$ is a vector of time-varying firm-specific controls. Sectoral and region-specific FE allow to absorb cross-sectional variation in the unobservable technological and market characteristics of the environment where the firm operates. These unobservable sources of heterogeneity may be related with both innovation and PS. For example, Laursen and Foss (2005) show that pay-for-performance schemes are more likely to be adopted in more uncertain and innovative environments.

Then, we measure the marginal effects of PS at the managerial and non-managerial employee layers on innovation as:

$$\left.\frac{\partial \Pr(\text{Innovation}_{f,w}=1)}{\partial \text{MPS}_{f,w-1}}\right| \text{E}\left(\text{EPS}_{f,w-1}, \mathbf{X}_{f,w-1}\right) \tag{6}$$

$$\text{and} \quad \left.\frac{\partial \Pr(\text{Innovation}_{f,w}=1)}{\partial \text{EPS}_{f,w-1}}\right| \text{E}\left(\text{MPS}_{f,w-1}, \mathbf{X}_{f,w-1}\right) \tag{7}$$

In Equation (5) as well as both in Equation (6) and in Equation (7), the subscript f denotes the firm and w the EES-INAPP wave. Details about the time structure of the model are discussed below.[13]

5.2 Identification issues

We are not aware of exogenous institutional discontinuities in the adoption of PS plans, which could be used to identify causality unambiguously. Hence, we need to tackle the two main concerns that may confound PS effects on innovation, i.e. reverse causality and endogenous worker sorting, by means of more standard approaches.

5.2.1 Reverse causality

One may suspect that, if firms use PS to influence innovation performance, then past innovation may influence the current adoption of PS schemes. This concern may be amplified in our context, because in each EES-INAPP wave, while the use of PS is detected in a year t, innovation is measured over a time window spanning the t, $t-1$ and $t-2$ periods, which partly precede the possible adoption of PS.

We verify whether past innovation activity as measured in the 2010 EES-INAPP wave (i.e. the introduction of any between product and process innovation in the 2007-2009 period) correlates significantly with the adoption of PS in 2014, measured in the 2015 EES-INAPP wave. Specifically, we construct a "PS-change" variable which equals 1 if the firm didn't use PS in 2009 but was showed to use PS in 2014, -1 if the firm was using PS in 2009 but wasn't showed to use PS in 2014, and 0 otherwise (the firm used or didn't use PS both in 2009 and 2014). We then calculate the pairwise correlation coefficient $\rho_{inn}^{PS\_change}$ between PS-change and innovation activity measured in the 2010 EES-INAPP wave (i.e. over the 2007-2009 period) and test its

[13]Since PS is typically in the form of cash bonuses paid based on profits, our estimated effects on innovation are naturally narrowed to innovations that translate into higher profits or are expected to do so. Hence, empty innovation strategies, which aim at extending innovation records but do not increase profits, should not flow in the marginal effects estimated here. This makes the issue of weighting innovation quality (e.g., by means of patent citations) less relevant in our study.

statistical significance. If the adoption of PS in 2014 was an endogenous response to innovation under-performance in 2007-2009, then the correlation between PS-change and past innovation activity should be negative and significant. Reassuringly, we obtain $\rho_{inn}^{PS\_change} = -0.0068$, with p-value $= 0.5196$ (H_0: $\rho_{inn}^{PS\_change} = 0$).[14]

It is worthwhile noticing however, that, under a positive correlation of innovation performances of a same company over time, the adoption of a PS scheme following previous innovation under-performance would cause a downward bias in our estimated effects. Hence, as for non-managerial employees in particular, since we will argue in favour of a positive effect of PS on innovation, the magnitude of the estimated effect of PS has to be intended as lower than the true effect, should reverse causality being present.

In any event, we address possible endogeneity in several ways.

First, we include our variables of interest about PS adoption at different layers, as well as all the other controls, as 1-wave lagged in the model. This implies that the estimated effects of MPS and EPS refer to the relationship between the use of PS in 2009 and innovation activity in the 2012-2014 period. Since innovation programs often require some years before being completed, innovation output as observed over 2012-2014 can be safely attributed to firm's characteristics as observed in 2009. Notice that, by using for each firm one observation for innovation output and one (1-wave lagged) observation for the use of PS, fixed-effects cannot be included in the model. In our preferred model specifications, we deal with firm heterogeneity, by using a large vector of time-varying firm-specific controls.[15]

Second, we include an auto-regressive term of order 1 (AR(1)) in the model, for absorbing all variation in innovation performance over the 2012-2014 period due to innovation activity over the years from 2007 to 2009. Doing so, we clean the estimated effects of using PS in 2009 for the unobservable component measuring the possible endogenous adoption of PS in 2009 in response to innovation activity in 2007-2009.

Third, in an alternative model specification, we take advantage of the longitudinal observations covered by the 2007 EES-INAPP wave and check whether our estimates change significantly after splitting our sample based on whether the firm has being innovative in the period

[14] Aerts *et al.* (2015), on a sample of German companies, find that firms that were already more innovative may be more likely to introduce PS. We do not detect this type of correlation in our data.

[15] Prendergast (1999) alerts to be wary of simple fixed-effect estimates as a way of eliminating unobserved heterogeneity in this context. Relevant firm-specific effects here are time-varying, because related to firms' technology investments and past innovation activity (selectivity) and possible worker sorting. As explained below in the paper, we deal with selectivity and worker sorting by means of a set of time-varying firm-specific controls (which also cover managerial abilities, as reflected into CEOs' education and age) and alternative estimation strategies. In any event, we include sector and region dummies among the covariates in all our model specifications, to soak up heterogeneity due to firm fixed effects related to the type of production and geographical location.

2004-2006. Specifically, we run our model separately on two sub-samples of firms, collecting respectively those that showed any between product and process innovation in 2004-2006 and those without any innovation record in 2004-2006.[16]

Fourth, we verify whether the inclusion of additional controls for past innovative investments affect our estimates. Fitzroy and Kraft (1995) showed that firms may choose their most appropriate incentives, according to technology factors that are usually unobserved. If it is so, then direct productivity comparisons in a sample of heterogeneous firms under-estimate the benefits experienced by firms adopting PS schemes (this issue is often referred to as "selectivity"). We address this, by controlling for whether the firm in 2009 has undertaken any investment in R&D or in automation (computers, softwares to be used in production, digitalization of procedures, ICT or other types of process robotization). In fact, even if innovation output over 2007-2009 is uncorrelated with the use of PS in 2014, the technological obsolescence as for 2009 might influence pay schemes observed in 2014, particularly to the extent that the employees oppose process technology upgrading, thereby pushing firms to adopt group-incentive pay more extensively. In addition, by controlling for automation and digitalization of procedures, we are able to clean, at least partly, our estimated effects for the influence of monitoring complexities which might drive the choice of PS (Fitzroy and Kraft, 1995).

Fifth, finally, we use a Propensity Score Matching (PSM) method (Rosenbaum and Rubin, 1983) as an alternative estimation strategy. Since we can observe a rich array of firm characteristics, we can also construct a sufficiently large vector of covariates so that all variables that influence PS adoption and innovation outcomes simultaneously can be assumed to be observed. Hence, a PSM method can be safely implemented and any difference in innovation between the treatment and control groups can be measured as due to PS and not to differences in other firm characteristics.

5.2.2 Worker sorting

The second main issue we have to deal with is the possibility that workers with heterogeneous unobservable abilities self-select into firms, depending on the PS policy adopted by the firm. A large literature explains that more productive workers may be attracted by firms using incentive pay contracts, if such contracts allow better workers to gain from their greater abilities (e.g.,

[16] Unfortunately, the 2007 EES-INAPP wave cannot be used to extend longitudinally the model estimated with Equation (5), because many of the control variables as reported in the 2007 EES-INAPP wave are not directly comparable with those of the 2009 and the 2015 EES-INAPP waves. More importantly, the 2007 EES-INAPP wave does not allow distinguishing individual-based from group-based performance-related-pay and does not contain information on the layer where incentive contracts apply.

Lazear (2000a) and Lazear (2000b)). This argument may run against attributing causality to our estimates, should unobservable worker sorting correlate with innovation.

Previous literature, however, has showed that more productive workers tend to be attracted by individual-based incentive pay, which allows them to see their greater abilities directly reflected into a higher pay (Cadsby *et al.*, 2007). Instead, PS – and, more generally, group-incentive pay – may discourage the participation of high-ability workers, who may want not to share the results of their improved effort with less productive colleagues. Related to this, Burdín (2016) found that high-ability individuals are more likely to quit from egalitarian pay regimes. Moreover, low-ability workers may cluster into firms adopting PS more largely, to the extent they expect to benefit from free-riding. Taken together, these results suggest that sorting of better workers may negatively correlate with the adoption of PS plans by firms. As a result, if better workers are also more innovative, endogenous self-selection should bias our estimated PS effects downward.

At the same time, pay policies may also induce better workers to self-select into firms adopting PS. Aerts *et al.* (2015) argue that more cooperative workers may prefer working in firms using PS for purely behavioural reasons, related to unobservable preferences for redistribution. If these workers are more productive, irrespective of the presence of a PS scheme, estimated PS effects may be biased upward, due to a spurious positive correlation between PS and innovation.

Following the simple intuition of Bartolucci *et al.* (2018) that better workers have better wages (this requires partial monotonicity of wages in the worker type), we test whether firms using PS pay higher (lower) average wages, and so have presumably more (less) productive workers. Based on data from the 2011 EES-INAPP wave, from which we extract information for constructing the PS variables used in Equation (5), we obtain the average wage paid to workers as the ratio between the total wage bill and the total number of employees and calculate the pairwise correlation coefficients ρ^{MPS}_{wage} and ρ^{EPS}_{wage} between the use of MPS and EPS, respectively, and average wages. We find $\rho^{MPS}_{wage} = 0.0007$, with p-value $= 0.9287$ (H_0: $\rho^{MPS}_{wage} = 0$), and $\rho^{EPS}_{wage} = 0.0005$, with p-value $= 0.9491$ (H_0: $\rho^{EPS}_{wage} = 0$). In words, whatever its direction, endogenous worker sorting across firms, as induced by PS policies and reflected into different average wages paid by firms, does not seem to be present in our data significantly.[17]

[17]Clearly, this does not mean that worker sorting is absent and that the results of our correlation test here are conclusive. If present, the negative effect of adverse worker sorting on average wages may be offset by the positive effect through compensating wage differentials (i.e. wages may also increase to compensate for added risk due to PS). Moreover, vertically integrated firms with high growth potential may have both lower-than-average wage bill due to a high share of workers at the grassroots but higher-than-average innovation outcomes thanks to a productive research division, this confounding possible worker sorting effects. We will partially

We anyway absorb variation due to observable heterogeneity, possibly proxying unobservable workers' abilities, by including controls for the share of employees aged more than 50 years and with tertiary education. To the extent that these characteristics correlate with workers' abilities (Henneberger *et al.*, 2007), they also allow to partly control for unobservable heterogeneity (yet, we verified that the sub-sample mean of both these variables does not differ across firms using EPS and those not using PS). In addition, in Equation (5) we include controls for the CEO being more than 50 years old, male/female and with tertiary education, as they may be correlated with particular types of workers. Since we can distinguish between voluntary exits and separation for other reasons (such as layoff or retirement), we include in our regression model also a control for the rate of voluntary separations, obtained as the ratio between the number of employees who voluntary exit the firm and total employees.

Finally, we add the use of individual-based performance-related-pay (PRP) as a regressor in Equation (5) to soak up variation in alternative incentive pay mechanisms, which may be adopted by the firm to boost individual workers' effort or to attract more productive workers. PS schemes and individual-based PRP may arise together in our institutional context, as both contractual regimes are negotiated at the same bargaining level. Thanks to data availability, we can distinguish the type of the pay scheme, thereby controlling for individual-based PRP separately from PS.

5.3 Baseline results

Baseline estimated marginal effects are presented in Table 4. In all the model specifications, a large vector of 1-wave lagged controls is added to the model, covering individual-based PRP, rate of voluntary separations, workforce's and CEO's characteristics (sex, education and age), main owner's type, corporate form, span of control, whether the firm belongs to a group and is an exporter, firm's size (both in terms of employees and total revenues) and age, sectoral and regional dummies. Only active companies are considered (firms in bankruptcy or financial distress are excluded). Moreover, one dummy for 1-wave lagged investments in R&D, one for 1-wave lagged investments in automation and an AR(1) term are added in columns [2], [3] and [4], respectively. The last two columns in Table 4 report the results obtained on sub-samples, collecting firms without any innovation record over 2004-2006 (column [5]) and those showing

tackle this possibility below, by employing finer definitions of managerial and non-managerial layers in our baseline estimation analysis.

any between product and process innovation over 2004-2006 (column [6]).

[insert Table 4 about here]

We find that PS at the managerial employee layer (MPS) is associated with a statistically insignificant marginal effect on innovation, while the effect of PS at the non-managerial employee layer (EPS) is always positive and significant. These results are robust across the model specifications considered. It is worthwhile noting that the magnitude of the marginal effect of EPS is slightly reduced after controlling for R&D investments, investments in automation and past innovation performance, precisely from 0.082 (in column [1]) to 0.061, 0.058 and 0.051 (columns [2] to [4]). This may suggest that selectivity, to the extent it is reflected into predetermined technological heterogeneity, does influence the estimated relationship between EPS and innovation, but it is unlikely to explain this relationship entirely. Moreover, after splitting the sample depending on whether the firm has been innovative between 2004 and 2006, we detect a positive within-group effect of EPS in both sub-samples. In all the model specifications where it is included, the adoption of individual-based PRP is associated to a negative and statistically insignificant parameter (significant only in column [4]). This is coherent with the result of Lerner and Wulf (2007), showing that short-term individual-based incentives do not stimulate innovation output.

We also test whether our basic results hold under broader and narrower definitions of layers. Since we have information on the adoption of PS policies on individual hierarchical levels even within layers, we can manipulate the extension of both the managerial and non-managerial layers. We first isolate the CEO level and dissect the effects of the CEO's pay policy, distinguishing whether the CEO is paid based on PS, shares or stock options, or based on both. Then, with respect to our preferred definition of the managerial layer used so far, we consider a broader definition, which includes non-executives and non-managerial supervisors (consequently, the non-managerial layer includes in this case only white and blue collars), and a narrower definition including only non-executives (here, the non-managerial layer covers non-managerial supervisors and white and blue collars). The results are reported in Table 5. Column [1] reports the results under the broader definition of the managerial layer, while columns to [2] to [5] report the results under the narrower definition of the managerial layer and include the controls for the technological characteristics of the firm as added one-by-one to the model. The results remain substantially similar to those presented in Table 4. Both under narrower and broader definitions, PS at the managerial layer is always associated with a statistically insignificant effect on innovation and PS at the non-managerial layer is always associated with a positive and significant effect. Interestingly enough, when non-managerial supervisors are covered by the non-managerial layer, the coefficient of EPS is slightly higher than when non-managerial supervisors are included in the managerial layer (compare columns [1] and [2]). Finally, the effect of the pay policy of the CEO is insignificant.[18]

[insert Table 5 about here]

Propensity score matching. Besides controlling for past innovation outcomes and technological investments, we use here a Propensity Score Matching (PSM) method as an alternative strategy to circumvent possible selectivity effects (i.e. the possibility that the probability of a firm using PS depends on predetermined firm characteristics). PSM, first introduced by Rosenbaum and Rubin (1983), in this context is based on estimating propensity score $e(\mathbf{M}_{f,w})$, for firm f at time w, as the conditional probability of adopting PS given a vector of observed covariates $\mathbf{M}_{f,w}$, i.e. $e(\mathbf{M}_{f,w}) = \Pr(PS_{f,w} = 1|\mathbf{M}_{f,w})$ where $PS =$ MPS, EPS. If a firm adopting PS (treated) and a firm not using PS (control) have the same propensity score, the observed covariates are controlled for. Hence, any difference in innovation between the treatment and control groups (i.e. the average treatment effect on the treated, or ATT) can be attributed to PS and not to differences in the observed covariates.

PSM requires that selection is solely based on observable characteristics of firms and that all variables that influence PS adoption and innovation outcomes simultaneously are observed (this is the conditional independence assumption). Clearly, this is a strong assumption. However, since we can observe a rich array of firm characteristics, we can construct a set of covariates $\mathbf{M}_{f,w}$ sufficiently large to assume that this condition holds. Besides independence, we also make sure the common support condition is met. This is required to rule out perfect predictability of PS given $\mathbf{M}_{f,w}$, i.e. firms with the same $\mathbf{M}_{f,w}$ values need to show a positive probability of both using and not using PS. Assuming that the conditional independence assumption holds and given that there is overlap between both treated and control groups, the PSM estimator for ATT is simply the mean difference in innovation outcomes over the common support, weighted by the propensity score distribution of firms.

[18] Related to this, Manso (2011) shows that optimal innovation-motivating incentive schemes for executives can be implemented via a combination of stock options with long vesting periods, option repricing, golden parachutes, and managerial entrenchment. Information on these more complex pay schemes is not provided in the EES-INAPP data.

Formally, we proceed as follows. We fit the logit model

$$\Pr(PS_{f,w} = 1|\mathbf{M}_{f,w}) = \Phi\{h(\mathbf{M}_{f,w})\} \quad \text{with} \quad PS_{f,w} = \text{MPS}_{f,w}, \text{EPS}_{f,w} \tag{8}$$

where Φ denotes the logistic cumulative density function and $h(\mathbf{M}_{f,w})$ is the specification including all the covariates in $\mathbf{M}_{f,w}$.[19] The sample is split into k equally spaced intervals of the propensity score. Within each interval, the algorithm tests that the average propensity score of treated and control firms does not differ; if the test fails in one interval, the interval is split in half and the test is run again. This process continues until, in all intervals, the average propensity score of treated and control firms does not differ. At this point, within each interval, treated and control firms will be on average observationally identical (the means of each characteristic do not differ between treated and control firms). Hence, observations with the same propensity score have the same distribution of observable characteristics independently of PS status and, for a given propensity score, adoption of PS can be considered as good as random. As for matching each firm using PS to one or more firms not using PS based on propensity score, we use various methods: namely, Radius Matching, Kernel Matching, and Stratification Matching.[20]

[insert Table 6 about here]

The results are presented in Table 6. ATT estimates obtained with Radius Matching, Kernel Matching, and Stratification Marching are reported respectively from column [1] to column [3]. Since MPS and EPS effects are obtained separately, they are reported in two separate panels in Table 6. Reassuringly, the results obtained with the PSM method are in line with those from our baseline analysis. MPS effects are statistically insignificant, while EPS effects are always significant, under all the matching methods, and surprisingly stable, ranging from 0.111 to 0.117.

[19] Vector $\mathbf{M}_{f,w}$ includes: the firm has made any between process and product innovation over 2007-2009, share of female workers, share of the workforce with tertiary education, share of the workforce aged 50+ years, the firm adopts individual-based PRP, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, years since incorporation, the firm belongs to a trade association, an employee representation body is established in the firm, the firm adheres to a I-level collective agreement, the firm adheres to a II-level collective agreement, region dummies, sector dummies. In the analysis of MPS (EPS), EPS (MPS) is also included among the covariates.

[20] See Becker and Ichino (2002) for details on these matching methods.

5.4 Effects of multi-layer PS

In the baseline analysis, we measured the marginal effects of MPS and EPS on innovation, without taking care of the fact that these effects may change depending on whether PS schemes are used under mutual exclusivity across layers (i.e., PS is used only at the managerial layer and not at the employee layer, or PS is used only at the employee layer and not at the managerial layer) or simultaneously at both layers (i.e., the firm adopts multi-layer PS). This is what we investigate here.

As showed in Table 2, firms may choose different PS strategies across layers, with the possibility of adopting PS at both layers. We address how multi-layering influences PS effects on innovation as follows.

We construct a set of four mutually exclusive dummies, measuring whether PS is used only at the managerial layer (referred to as "only MPS" in the analysis presented next), only at the employee layer ("only EPS"), at both layers ("MLPS") or not used at any layer ("no PS"), and consider "no PS" as the benchmark category in the following regression model:

$$\begin{aligned}\text{Innovation}_{f,w} = \beta_0 + \beta_1 \text{ Only MPS}_{f,w-1} + \beta_2 \text{ Only EPS}_{f,w-1} + \beta_3 \text{ MLPS}_{f,w-1} + \\ \mathbf{bX}_{f,w-1} + \text{ sector FE}_{f,w} + \text{region FE}_{f,w} + \varepsilon_{f,w}\end{aligned} \tag{9}$$

Differently from the analysis conducted on Equation (5), since our PS variables of interest are mutually exclusive in Equation (9), here the marginal effects of each PS variable will be conditional on the other PS variables in the model being zero. We then verify whether the effect of PS at the employee layer, which has been showed to be positive and significant in our baseline analysis, is reduced (or increased) when PS is used at both layers or if it does not change. To do so, we perform a χ^2-test of equality of parameters, by testing against the null hypothesis H_0: $\beta_3 - \beta_2 = 0$.

The same endogeneity concerns discussed about our baseline analysis apply also in this regression context. Moreover, they may be amplified here by the fact that firms may rearrange the multi-layer structure of PS regimes in response to certain innovation outcomes. This makes a strategy based on including controls for previous innovation activity less useful. When multi-layering is concerned, endogeneity may be relevant both about the decision of adopting PS at any layer and about the decision of which layer PS should be used at. At the same time, it is difficult (or impossible) to clearly argue why bad or good past innovation records should increase the likelihood of adopting PS at a specific layer or MLPS itself and, therefore, how and to which extent controls for previous innovation clean the estimated effects for possible reverse causality and selectivity.

An instrumental variable (IV) strategy is more appropriate in this case. However, all the three PS variables included on the right-hand-side of Equation (9) should be instrumented, what would require three independent and valid instruments. Hence, to check the robustness of our results in an IV regression, we follow a simpler strategy. First, we split the sample based on whether the firm uses or does not use MPS in 2009 and consider EPS in 2009 as the main regressor of interest. When a firm in the group of those using MPS also uses EPS, this equals adopting MLPS; when a firm in the group of those not using MPS uses EPS, this equals adopting only EPS. Second, we instrument EPS for both groups (only one instrument is required here). As an instrument for EPS, we use the sectoral share of firms adhering to II-level agreements in 2006, which is shown to be weakly correlated with innovation performance in 2012-2014 ($\rho_{inn}^{IV} = 0.1195$). Moreover, while on the one side the adoption of PS at the firm level is not a determinant of the sectoral coverage of II-level agreements, on the other side the sectoral pattern of II-level agreements is likely to influence the PS policy of individual firms within the sector. Possible firm self-selection across the groups of firms with and without MPS is not a concern, because we look at the marginal effect of EPS within groups. Formally, we run the following additional model, for firms showing $\text{MPS}_{f,w-1} = 0$ and $\text{MPS}_{f,w-1} = 1$ separately:

$$\begin{aligned}\text{Innovation}_{f,w} = \beta_0 + \beta_1\ \text{EPS}_{f,w-1}(\text{instrumented}) +\\ \mathbf{bX}_{f,w-1} +\ \text{sector FE}_{f,w} + \text{region FE}_{f,w} + \varepsilon_{f,w}\end{aligned} \tag{10}$$

The results are presented in Table 7. Column [1] lists the results obtained from estimating Equation (9) without controlling for past innovation performance, while the AR(1) term is included in column [2]. For both the models presented in column [2] and column [3], the χ^2-test of equality of parameters (namely, β_2 and β_3 of Equation (10)) has been run and the results are displayed. Columns [3] and [4] report the results obtained after splitting the sample depending on the MPS policy (first-stage results are also showed).

[insert Table 7 about here]

In columns [1] and [2], we find that the adoption of only MPS appears not to influence innovation probability in a statistically significant way. On the other side, the use of only EPS is associated with a positive and statistically significant effect. The policy of adopting PS at both layers (MLPS) is associated with a positive effect as well. This suggests that, when the firm chooses to couple EPS with MPS, the effect of PS at the non-managerial employee layer remains positive and significant. The χ^2-test of equality of parameters, moreover, tells us that the difference between the coefficient of having only EPS and that of MLPS is statistically insignificant, i.e. multi-layering does not reduce EPS effects significantly. In columns [3] and [4], we report the results of the IV estimation. Here, only the effect of EPS (instrumented) is estimated. Usual IV diagnostic tests for instrument relevance and exogeneity are passed. Reassuringly, we find that EPS is associated with a positive and significant effect in both groups of firms with and without MPS, what is coherent with the previous finding. This also rules out that the possible selection of firms into the two sub-samples matters for our IV analysis, since, whatever the direction of unobservable selectivity towards different MPS policies, EPS effects are showed to have a same sign and similar significance within groups.

Furthermore, by comparing the results in column [1] with those in columns from [2] to [4], we find that individual-based PRP is associated to a negative and statistically significant parameter, once past innovation performance is controlled for.

As a simple way to check whether our results here are driven by the model specification, as presented in Equation (9) where the use of PS at the managerial and non-managerial layers and at both layers is captured by mutually exclusive variables, we run an additional regression analysis where a standard interaction term is included. We consider:

$$\begin{aligned}\text{Innovation}_{f,w} = \beta_0 + \beta_1\, \text{MPS}_{f,w-1} + \beta_2\, \text{EPS}_{f,w-1} + \beta_3\, \text{MPS}_{f,w-1} \times \text{EPS}_{f,w-1} + \\ \mathbf{bX}_{f,w-1} + \text{ sector FE}_{f,w} + \text{region FE}_{f,w} + \varepsilon_{f,w} \qquad (11)\end{aligned}$$

where, differently from Equation (9), the marginal effect of the interaction term MPS $\times$ EPS has to be read as the effect of coupling MPS with EPS with respect to using only MPS or only EPS conditional to the average use of MPS and EPS. The results are in Table 8, with columns from [1] to [4] reporting the estimates obtained respectively without and with controls for past technological investments and innovation outcomes over 2007-2009. Coherently with the results reported in Table 7, the use of EPS together with MPS is not associated with an increase in the probability of innovating with respect to the use of only EPS.

[insert Table 8 about here]

5.5 Additional results

5.5.1 Disentangling PS effects on process and product innovation

One may wonder whether PS influences process and product innovation to different extents. For instance, while both product and process innovations induce higher profits, process innovation may also be labour saving. Thus, workers under a PS regime may shift their effort towards tasks that stimulate product innovation at the expenses of the activities that may improve the likelihood of process innovation. Related to this, previous research has showed that PS may have no effect on process innovation, as measured by the development or the implementation of procedures improving the production process (Aerts *et al.*, 2015). Moreover, typical investment plans for process and product innovation may show different length. If workers at different layers expect to appropriate the returns from a successful innovation over different time horizons and take their effort decisions accordingly, EPS and MPS may have differentiated impacts across different types of innovation.

The EES-INAPP data allow disentangling process and product innovation. Hence, we can run Equation (5) and Equation (9) considering process and product innovation activities in the 2012-2014 period as two alternative dependent variables. We follow the same identification strategy as for the analysis of PS effects on any type of innovation and consider the same model variants. The results are reported in Table 9 and Table 10.

[insert Table 9 about here]

[insert Table 10 about here]

We find that EPS has a positive and significant effect on both process and product innovation, both when measured conditional on the average use of MPS (as in Table 9) and when measured with respect to not adopting PS at any layer (as in Table 10). When MPS and EPS are adopted at the same time (MLPS), the estimated effect of PS is again positive and significant on both process and product innovation, with the difference between the policy of adopting MLPS and that of having only EPS being statistically insignificant.

Since the estimated effects are marginal, they can be directly compared between models, when the underlying sample of firms is the same. Hence, from Table 9, we observe that the magnitude of the effect of EPS on process innovation (column [1]) is similar to that of the EPS effect on product innovation (column [2]). When only firms without innovation records in 2004-2006 are considered, EPS effects on process innovation (column [3]) are slightly lower than for product innovation (column [5]); the opposite is when the analysis is restricted to firms with some innovation record in 2004-2006 (columns [4] and [6]). From Table 10, we see that having only EPS has a slightly higher effect on process (column [1]) than on product (column [2]) innovation, while MLPS effects are slightly stronger on product (column [2]) than on process (column [1]) innovation. In all the model specifications considered, MPS is always associated with an insignificant parameter for both types of innovation.

5.5.2 Size of the workforce and the "1/N problem"

One major obstacle restraining the adoption of PS is the concern about worker free-riding. Under a PS regime, when the cost of individual effort is high, workers gain from shirking if they expect their colleagues doing their own job properly (Drago and Garvey, 1998). This is the issue often referred to as the "1/N problem": the larger size of the workforce is, the greater the dilution of incentives is. Moreover, if monitoring the shirker is costly for who monitors, with the benefits accruing to all the others, free-riding may also affect monitoring, what exacerbates the "1/N problem". If PS is adopted at different layers, with individuals at different layers having different objective functions, free-riding and monitoring across layers may further endanger the incentive effects of PS schemes.

Since monitoring and peer-pressure may be stronger at smaller workplaces, standard theory predicts that PS should be easier to establish and maintain in smaller firms relative to larger ones (Kandel and Lazear, 1992).

Descriptive evidence from our data, however, suggest that PS is much more likely adopted by larger firms, particularly for non-managerial employees. In Figure 3, we plot the share of firms adopting MPS (left-hand-side panel) and EPS (right-hand-side panel), over firm-size classes in terms of managerial and non-managerial employees, respectively. Both panels in Figure 3 show that MPS and EPS are more largely used by firms with larger managerial and non-managerial employee layers.

[insert Figure 3 about here]

In light of the standard theory about the "1/N problem", this evidence is puzzling. Thus, we run a formal statistical test to verify whether PS effects on innovation are weaker in larger firms. In particular, we focus on EPS, given that MPS effects are found statistically insignificant in our previous analysis.

We consider again Equation (5) and assume that $\Pr(\text{Innovation}_{f,w} = 1)$ is given by

$$\Pr(\text{Innovation}_{f,w} = 1) = \frac{e^{\beta x}}{1 + e^{\beta x}} \tag{12}$$

where $\beta x = \beta_0 + \beta_1 \,\text{MPS}_{f,w-1} + \beta_2 \,\text{EPS}_{f,w-1} + \mathbf{bX}_{f,w-1}$ sector $\text{FE}_{f,w}$+region $\text{FE}_{f,w}$. We measure the conditional marginal effects of EPS as

$$\frac{\partial \Pr(\text{Innovation}_{f,w} = 1)}{\partial \text{EPS}_{f,w-1}} = \frac{e^{\beta x}}{(1 + e^{\beta x})^2} \frac{\partial (\beta x)}{\partial \text{EPS}_{f,w-1}}$$
$$\text{at} \quad \left[\text{MPS}_{f,w-1} = (0\;1) \middle| \#\text{ of non-managerial employees}_{f,w-1}, \text{E}(\mathbf{X}_{f,w-1})\right] \tag{13}$$

We report our estimation results graphically in Figure 4. We find that the marginal effect of adopting EPS on the probability of making any innovation, both with and without multi-layering, is about 8% for firms below 20000 non-managerial employees. Above 20000 employees, the marginal effect of EPS decreases and is nearly zero at about 100000 employees. This result suggests that incentives induced by PS dilute with the number of employees, but the "1/N problem" is significant only for very large firms.

[insert Figure 4 about here]

To corroborate this finding, we run a placebo test as follows. After estimating Equation (5), we measure the conditional marginal effects of EPS as

$$\frac{\partial \Pr(\text{Innovation}_{f,w} = 1)}{\partial \text{EPS}_{f,w-1}} = \frac{e^{\beta x}}{(1 + e^{\beta x})^2} \frac{\partial (\beta x)}{\partial \text{EPS}_{f,w-1}}$$
$$\text{at} \quad [\text{MPS}_{f,w-1} = (0\;1) | \text{Total revenues}_{f,w-1}, \text{E}(\mathbf{X}_{f,w-1})] \tag{14}$$

If dilution of incentives is actually driven by the size of the workforce, then EPS effects should not reduce with other measures of a firm's size, such as total revenues. The results of this placebo exercise are shown in Figure 5.

[insert Figure 5 about here]

Across a wide range of size classes in terms of total revenues, from zero to even above 10 million euro, marginal EPS effects remain strongly stable, with EPS effects under multi-layering (i.e. where also MPS applies) being slightly lower than without multi-layering.

In conclusion, it is worth mentioning that previous theoretical research has showed how, if worker efforts are complementary, until a certain size effort levels may even increase with the number of workers, as additional workers increase the productivity of current workers (Adams, 2006; Heywood and Jirjahn, 2009). This may be more likely for innovative productions, where teamwork by complementary workers is important, and may explain our empirical finding that the "1/N problem" is substantial only for very large firms.

5.5.3 Interactions with other firm's characteristics

We now repeat a similar exercise, by estimating the marginal effects of EPS, both with and without multi-layering, conditional on a set of other firm's characteristics. We consider Equation (5) and measure the conditional marginal effects of EPS as

$$\frac{\partial \Pr(\text{Innovation}_{f,w} = 1)}{\partial \text{EPS}_{f,w-1}} = \frac{e^{\beta x}}{(1+e^{\beta x})^2} \frac{\partial(\beta x)}{\partial \text{EPS}_{f,w-1}}$$
$$\text{at} \quad [\text{MPS}_{f,w-1} = (0\ 1) | V_{f,w-1}, \text{E}(\mathbf{X}_{f,w-1})] \tag{15}$$

where $V_{f,w-1}$ is alternatively the share of the workforce with tertiary education, the share of the workforce aged 50+ years, a set of CEO's characteristics (gender, age and education), the type of the owner, corporate form and age, the span of control, a dummy variable measuring whether the firm is an exporter, the unionization rate, a dummy for the adoption of individual-based PRP and a set of sectoral dummies. The results are shown in Figure 6 and Figure 7.

[insert Figure 6 about here]

We obtain an interesting picture of how EPS effects change depending on firm's characteristics. The main findings are commented next.

We find that the average characteristics of the workforce, as captured by employee average age and education, matter significantly. EPS effects are weaker when adopted in firms with an older workforce, what may reflect a shorter time horizon of the workers. When the share of employees aged more than 50 years increases, the incentive due to PS towards exerting effort in innovative projects with a possibly long duration decreases. Also a larger share of employees with tertiary education reduces EPS effects. The reason behind this finding may be that more educated employees tend to have improved innovative attitudes and greater productive abilities, so that the additional effect due to EPS may be lower.

On the other side, CEO's age, education and gender do not appear to affect the interplay between EPS and corporate innovation, even when PS is used also for managers (including CEOs themselves). As for age at least, this is interesting, as one might have expected to see incentivized older CEOs being more concerned about reported earnings at the expenses of innovation (Dechow and Sloan, 1991; Driver and Guedes, 2017). Statistically insignificant are also the age of the company, the corporate form and the type of the main owner (as measured by family ownership against other types of owners). In particular, firms owned by a family or an individual are typically closely held firms, that enjoy shorter hierarchical chains and more effective monitoring (e.g., Mueller and Philippon (2011)). As a result, incentive pay may be less important for stimulating employee efforts.

The span of control (i.e. the ratio between non-managerial and managerial employees) tends to improve EPS effects until the threshold of about 500 non-managerial employees per manager, which is well above the median value observed in our data. This may suggest that, while a larger managerial control is likely to be associated with improved managerial abilities, a too large number of managers with respect to non-managers (i.e. a low span of control) may allow managerial pressure towards short-run strategies to dominate. Related to this, previous literature showed that, under PS, the quality of relations between managers and non-managers may be spoiled (Green and Heywood, 2010).

When individual-based PRP is adopted together with PS, EPS effects remain substantially unchanged. It is true that, when also individual-based PRP is used, working effort may shift towards tasks that increase individual output at the expenses of company-wide performance (such as innovation). However, the empirical consequences of this seem to be negligible in our data.

EPS effects are strongly reduced in more unionized companies. Precisely, EPS effects on innovation are about 8% when the unionization rate is below 1%, but they decrease rapidly as unionization increases. A possible reason why it is so is that unions may introduce alternative mechanisms for the employees to negotiate on wages and to share-in innovation revenues. Thus, where unions are strong, incentive contracts count less.

Exposure on international markets appears complementary to PS. For exporters, the magnitude of EPS effects is about 10% higher than for non-exporters. An explanation is that access to larger markets increases the rewards from successful innovation, thereby improving EPS incentives.

Finally, in Figure 7 we show the sector-specific marginal effects of EPS, both with and without multi-layering.

[insert Figure 7 about here]

We do not find strong variation across sectors. Nevertheless, the sectors with the lowest estimated effect of EPS are those that typically show a very low contribution by specialized workers and that do not significantly rely on qualified human capital, namely transport and construction. This appears coherent with our argument of EPS influencing innovation mainly through a mechanism of human innovative effort.

5.5.4 PS and upskilling

Although we do not aim at digging into the mechanisms driving the association between EPS and innovation, the EES-INAPP data used in this study allow us to explore empirically one possible channel, namely the improved incentive of workers to undertake upskilling initiatives under PS.[21]

An important tool of worker upskilling consists of in-firm training activities, i.e. activities aimed to improving the human capital of the worker conducted at the firm-level. Previous research found that training is most essential to innovation, particularly when it guarantees access to leading-edge knowledge thereby increasing a firm's propensity to innovate (Bauernschuster *et al.*, 2009; Dostie, 2017). Related to this, Acemoglu (1997) showed that workers are more willing to invest in their skills and to favour formal upskilling initiatives at the workplace if they expect the firm to innovate and their wages to increase in the future due to innovation.

Here we study if and how in-firm training initiatives influence the relationship between PS and innovation. We take advantage of both the 2010 and the 2015 EES-INAPP wave and construct an additional dummy variable equal to 1 when the employees undertake in-firm training activities and 0 otherwise. Then, we run two simple exercises. First, we measure the empirical association between the adoption of PS plans and in-firm training. If PS favours upskilling activities, then the relationship between PS and training initiatives should be positive. Specifically, we run a logit model where the dependent variable is the in-firm training dummy and where the main independent variables are dummies reflecting the 1-wave lagged adoption of MPS and EPS. Second, we run an augmented version of Equation (5) where we include on the right-hand-side both the in-firm training dummy and its interaction with the 1-wave lagged adoption of EPS and MPS. If PS influences innovation by improving worker innovative effort

[21] Other channels may include greater peer-pressure and improved cooperation among team workers.

and/or by making this effort more productive through in-firm training activities, PS effects on innovation should disappear when in-firm training is controlled for.

The results are collected in Table 11. In columns [1] to [4], the dependent variable is the in-firm training dummy and we study how it is influenced by PS. In particular, we control for alternative proxies of past innovation performance in columns [1] to [3], and add the full set of controls in column [4]. In column [5], the dependent variable is the innovation dummy and we study how PS effects on innovation change with the inclusion of a control for in-firm training (both linear and interacted).

[insert Table 11 about here]

From columns [1] to [4, we observe that EPS is positively associated with in-training activities in all the model specifications considered, while MPS is never associated to a statistically significant effect. Notice that the effect of EPS on training remains significant and substantially unchanged even when the model controls for past process or product innovation, automation investments and R&D activities altogether, with the effect of these control variables being positive and significant too. This suggests that EPS is associated to an independent effect on the undertaking of training activities, which is additional to the effect due to improved technologies possibly used by the firm. In column [5], we find that in-firm training activities are associated with innovation in a positive and statistically significant way. Importantly, such upskilling initiatives pick-up the effect of EPS, which loses its statistical significant even without controlling for past innovation performance.

In conclusion, these findings are consistent with the idea that non-managerial PS may induce a higher innovation probability by stimulating worker effort in acquiring new knowledge and by facilitating upskilling activities, which include in-firm training and human capital development programs.

6 Conclusions

In this paper, we showed that PS for non-managers is positively correlated with improved process and product innovation at the firm level. Managerial PS, at best, is associated with little or no improvement in innovation activity. Our results help documenting how PS may have differential effects on long-run measures of corporate performance, such as innovation, depending on the layer in corporate hierarchy it is used at. This variation in PS effects may be due to employees at different layers showing different discount factors or different idiosyncratic costs associated with innovation. Since we cannot distinguish bottom-up and top-down innovations in the data, our results are also compatible with the possibility that much of innovation in our sample of Italian firms is continuous improvement at the grassroots level rather than discrete innovation at the top. As such, PS for managers may appear as less relevant because of the type of innovation Italian firms deal with the most.

In any event, our findings point to the fact that the optimal contracts that motivate innovation may be fundamentally different across the different layers of the corporate hierarchy. From a compensation policy point of view, this suggests that pay contracts motivating innovation should be implemented by means of different compensation schemes across firm layers. For managers, optimal incentive schemes that motivate innovation may be obtained via a combination of other instruments, more directly linked to long-run performance, such as those suggested by Manso (2011), including stock options with long vesting periods, option repricing, golden parachutes and managerial entrenchment. For non-managers, standard group incentive pay, even if linked to short-run profits, such as PS, may show less ambiguous effects on the incentives to motivate innovation, particularly if it is bottom-up.

We also explored whether PS effects change depending on other firm characteristics, and, if yes, how. Exposure to international markets, younger workforce, medium-high span of control and reduced unionization are showed to boost non-managerial PS effects to a large extent. This exercise is useful to grasp what could be the net effect of PS in other countries, based on observing average firm characteristics. For instance, we found that the "1/N problem" may be of some economic significance only in very large firms. This suggests that free-riding is unlikely to be a critical concern in Italy, where the average size of firms is below 10 employees (Istat, 2018). This figure does not change much in the majority of European countries, where more than 9 out of 10 (92.7%) enterprises in the non-financial business economy are micro enterprises employing fewer than 10 persons (Eurostat, 2018). Hence, free-riding issues under PS may be expected to be of a similar magnitude in other European countries as in Italy.

Some important questions, outside the scope of this study, remain still unanswered. Why large firms are observed to adopt PS plans more likely than smaller ones, both at the managerial and non-managerial layer, if they experience employee free-riding the most? It is also puzzling that companies offering PS schemes in Italy are highly unionized, whilst unions may at the same time try to use alternative mechanisms to share-in the gains from improved productivity (this is what may be behind our finding of reduced PS effects in more unionized firms). Related to this, previous international evidence is rather mixed. Freeman and Kleiner (1990) and Kruse (1996) find that PS plans are less common among unionized workers in the US, while Gregg and Machin (1998) find that employee ownership is more common in unionized companies in the UK. With a meta regression analysis, Doucouliagos *et al.* (2019) show that unions may improve PS effects on short-run productivity. Whether unionization may instead act as a substitute for PS with respect to long-run performance and innovation, as our results seem to suggest, may deserve further investigation.

Finally, future research may consider exploring more deeply the mechanisms that link PS to improved innovation. We implemented a number of empirical expedients to account for selectivity and worker sorting and to isolate what is presumably the effect of improved behaviour at the workplace, be it in the form of increased individual effort, stronger peer-pressure or more effective teamwork. However, a cleaner identification of causality requires unambiguously exogenous shocks in the use of PS, which we could not observe with our data. This is a limit of our study pointing to the need for finer data, should the relationship between PS and innovation be the object of additional attention.

References

[1] Acemoglu, D. (1997) Training and Innovation in an Imperfect Labour Market. *Review of Economic Studies*, 64: 445-464.

[2] Adams, C.P. (2006) Optimal Team Incentives with CES Production. *Economics Letters*, 92: 143-148.

[3] Aerts, K., Kraft, K. and Lang, G. (2015) Profit Sharing and Innovation. *Industrial and Corporate Change*, 24(6): 1377-1392.

[4] Aghion, P. and Tirole, J. (1994) The Management of Innovation. *Quarterly Journal of Economics*, 109(4): 1185-1209.

[5] Bartolucci, C., Devicenti, F. and Monzon, I. (2018) Identifying Sorting in Practice. *American Economic Journal: Applied Economics*, 10(4): 408-438.

[6] Bauernschuster, S., Falck, O. and Heblich, S. (2009) Training and Innovation. *Journal of Human Capital*, 3(4): 323-353.

[7] Beatty, A. (1994) An Empirical Analysis of Corporate Control, Tax and Incentive Motivations for Adopting Leveraged Employee Stock Ownership Plans. *Managerial and Decision Economics*, 15(4): 299-315.

[8] Becker, S.O. and Ichino, A. (2003) Estimation of Average Treatment Effects Based on Propensity Scores. *The Stata Journal*, 2(4): 358-377.

[9] Beneito, P., Coscollá-Girona, P. and Rochina-Barrachina, M.E. (2015) Competitive Pressure and Innovation at the Firm Level. *Journal of Industrial Economics*, 63(3): 422-457.

[10] Blasi, J.R. and Kruse, D.L. (1991) *The New Owners: The Mass Emergence of Employee Ownership in Public Companies and What It Means to American Business.* New York: Harper Business.

[11] Blasi, J.R., Freeman, R., Mackin, C. and Kruse, D.L. (2010) Creating a Bigger Pie? The Effects of Employee Ownership, Profit Sharing, and Stock Options on Workplace Performance. In Kruse, D.L., Freeman, R. and Blasi, J.R. (Eds.) *Shared Capitalism at Work*, NBER. Chicago: The University of Chicago Press.

[12] Bloom, N. and Van Reenen, J. (2011) Human Resource Management and Productivity. In Ashenfelter, O. and Card, D. (Eds.) *Handbook of Labor Economics*, Elsevier.

[13] Burdín, G. (2016) Equality Under Threat by the Talented: Evidence from Worker-Managed Firms. *The Economic Journal*, 126(594): 1372-1403.

[14] Burdín, G., Halliday, S. and Landini, F. (2018) The Hidden Benefits of Abstaining from Control. *Journal of Economic Behavior and Organization*, 147(594): 1-12.

[15] Cadsby, B., Song. F. and Tapon, F. (2007) Sorting and Incentive Effects of Pay for Performance: An Experimental Investigation. *The Academy of Management Journal*, 50(2): 387-405.

[16] Caliendo, L. Monte, F. and Rossi-Hansberg, E. (2015) The Anatomy of French Production Hierarchies. *Journal of Political Economy*, 123(4): 809-852.

[17] Chang, X. Fu, K., Low, A. and Zhang, W. (2015) Non-Executive Employee Stock Options and Corporate Innovation. *Journal of Financial Economics*, 115: 168-188.

[18] Colombo, M.G. and Delmastro, M. (2004) Delegation of Authority in Business Organizations: An Empirical Test. *Journal of Industrial Economics*, 52(1): 53-80.

[19] Correa, J.A. and Ornaghi, C. (2014) Competition & Innovation: Evidence from U.S. Patent and Productivity Data. *Journal of Industrial Economics*, 62(2): 258-285.

[20] Delmastro, M. (2002) The Determinants of the Management Hierarchy: Evidence from Italian Plants. *International Journal of Industrial Organization*, 20: 119-137.

[21] De Meza, D. and Lockwood, B. (1998) Does Asset Ownership Always Motivate Managers? Outside Options and the Property Rights Theory of the Firm. *Quarterly Journal of Economics*, 113(2): 361-386.

[22] Dechow, P.M. and Sloan, R.G. (1991) Executive Incentives and the Horizon Problem: An Empirical Investigation. *Journal of Accounting and Economics*, 14(1): 51-89.

[23] Dostie, B. (2017) The Impact of Training on Innovation. *Industrial and Labor Relations Review*, 71(1): 64-87.

[24] Doucouliagos, H., Laroche, P., Kruse, D.L. and Stanley, T.D. (2019) Is Profit Sharing Productive? A Meta-Regression Analysis. *British Journal of Industrial Relations*, in press.

[25] Drago, R. and Garvey, G.T. (1998) Incentives for Helping on the Job: Theory and Evidence. *Journal of Labor Economics*, 16(1): 1-25.

[26] Driver, C. and Guedes, M.J.C. (2017) R&D and CEO Departure Date: Do Financial Incentives Make CEOs More Opportunistic? *Industrial and Corporate Change*, 26(5): 801-820.

[27] European Commission (2014) The Promotion of Employee Ownership and Participation. Study prepared by the Inter-University Centre for European Commission's DG MARKT.

[28] Ederer, F. and Manso, G. (2013) Is Pay-for-Performance Detrimental to Innovation? *Management Science* 59(7): 1496.1513.

[29] Ederer, F. (2013) Incentives for Parallel Innovation. Yale School of Management: Yale University, unpublished manuscript.

[30] Eurostat (2018) *Structural Business Statistics (SBS)*. Luxembourg: Eurostat.

[31] Fitzroy, F.R. and Kraft, K. (1987) Cooperation, Productivity and Profit Sharing. *Quarterly Journal of Economics*, 102(1): 23-35.

[32] Fitzroy, F.R. and Kraft, K. (1995) On the Choice of Incentives in Firms. *Journal of Economic Behavior and Organization*, 26: 145-160.

[33] Freeman, R. and Kleiner, M. (1990) The Impact of New Unionization on Wages and Working Conditions. *Journal of Labor Economics*, 8(1): 8-25.

[34] Freeman, R., Kruse, D.L. and Blasi, J.R. (2010) Worker Responses to Shirking under Shared Capitalism. In Kruse, D.L., Freeman, R. and Blasi, J.R. (Eds.) *Shared Capitalism at Work*, NBER. Chicago: The University of Chicago Press.

[35] Ghosh, A., Kato, T. and Morita, H. (2017) Incremental Innovation and Competitive Pressure in the Presence of Discrete Innovation. *Journal of Economic Behavior and Organization*, 135: 1-14.

[36] Green, C. and Heywood, J.S. (2010) Profit Sharing and the Quality of Relations with the Boss. *Labour Economics*, 17(5): 859-867.

[37] Gregg, P.A. and Machin, S.J. (1998) Unions and the Incidence of Performance Linked Pay Schemes in Britain. *International Journal of Industrial Organization*, 6(1): 91-107.

[38] Harden, E.E., Kruse, D.L. and Blasi, J.R. (2010) Who Has a Better Idea? Innovation, Shared Capitalism, and Human Resources Policies. In Kruse, D.L., Freeman, R. and Blasi, J.R. (Eds.) *Shared Capitalism at Work*, NBER. Chicago: The University of Chicago Press.

[39] Henneberger, F., Poza, A.S. and Ziegler, A. (2007) Performance Pay, Sorting, and Outsourcing. IZA Discussion Paper No. 3019.

[40] Heywood, J.S. and Jirjahn, U. (2009) Profit Sharing and Firm Size: The Role of Team Production. *Journal of Economic Behavior and Organization*, 71(2): 246-258.

[41] Holthausen, R.W., Larcker, D.R. and Sloan, R.G. (1995) Business Unit Innovation and the Structure of Executive Compensation. *Journal of Accounting and Economics*, 19(2-3): 279-313.

[42] Holmstrom, B. (1989) Agency Costs and Innovation. *Journal of Economic Behavior and Organization*, 11: 305-327.

[43] Istat (2018) *Annuario Statistico Italiano 2018*. Rome: Istat.

[44] Itoh, H. (1992) Cooperation in Hierarchical Organizations: An Incentive Perspective. *Journal of Law, Economics and Organization*, 8(2): 321-345.

[45] Kandel, E. and Lazear, E.P. (1992) Peer-Pressure and Partnerships. *Journal of Political Economy*, 100(4): 801-817.

[46] Kastl, J., Martimort, D. and Piccolo, S. (2013) Delegation, Ownership Concentration and R&D Spending: Evidence From Italy. *Journal of Industrial Economics*, 61(1): 84-107.

[47] Kato, T. (1997) Chief Executive Compensation and Corporate Groups in Japan: New Evidence from Micro Data. *International Journal of Industrial Organization*, 15: 455-467.

[48] Kato, T. and Kauhanen, A. (2018) Performance Pay and Enterprise Productivity: The Details Matter. *Journal of Participation and Employee Ownership*, 1(1): 61-73.

[49] Kruse, D. (1996) Why Do Firms Adopt Profit-Sharing and Employee Ownership Plans. *British Journal of Industrial Relations*, 34(4): 515-538.

[50] Kruse, D.L., Blasi, J.R., Park, R. (2010) Shared Capitalism in the U.S. Economy: Prevalence, Characteristics, and Employee Views of Financial Participation in Enterprises. In Kruse, D.L., Freeman, R. and Blasi, J.R. (Eds.) *Shared Capitalism at Work*, NBER. Chicago: The University of Chicago Press.

[51] Laursen, K. and Foss, N. (2005) Performance Pay, Delegation, and Multitasking under Uncertainty and Innovativeness: An Empirical Investigation. *Journal of Economic Behavior and Organization*, 58(2): 246-276.

[52] Lazear, E. (2000a) The Power of Incentives. *American Economic Review*, 90(2): 410-414.

[53] Lazear, E. (2000b) Performance Pay and Productivity. *American Economic Review*, 90(5): 1346-1361.

[54] Lerner, J. and Wulf, J. (2007) Innovation and Incentives: Evidence from Corporate R&D. *The Review of Economics and Statistics*, 89(4): 634-644.

[55] Manso, G. (2011) Motivating Innovation. *Journal of Finance*, 66(5): 1823-1869.

[56] Manso, G. (2017) Creating Incentives for Innovation. *California Management Review*, 60(1): 18-32.

[57] Mueller, H.M. and Philippon, T. (2011) Family Firms and Labor Relations. *American Economic Journal: Macroeconomics*, 3: 218-245.

[58] Nikiforakis, N., Oechssler, J. and Shah, A. (2019) Managerial Bonuses and Subordinate Mistreatment. *European Economic Review*, 119: 509-525.

[59] Prendergast, C. (1999) The Provision of Incentives in Firms. *Journal of Economic Literature*, 37(1): 7-63.

[60] Rajan, R.G. and Wulf, J. (2006) The Flattening Firm: Evidence from Panel Data on the Changing Nature of Corporate Hierarchies. *The Review of Economics and Statistics*, 88(4): 759-773.

[61] Rosen, S. (1982) Authority, Control, and the Distribution of Earnings. *The Bell Journal of Economics*, 13(2): 311-323.

[62] Rosenbaum, P.R. and Rubin, D.B. (1983) The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika*, 70(1): 41-55.

[63] Symeonidis, G. (2020) Competition, Innovation and the Use of Innovations. *Journal of Industrial Economics*, 67(3-4): 565-592.

[64] Vives, X. (2008) Innovation and Competitive Pressure. *Journal of Industrial Economics*, 56(3): 419-469.

[65] Wickelgren, A.L. (2005) Managerial Incentives and the Price Effects of Merges. *Journal of Industrial Economics*, 53(3): 327-353.

Table 1: Definition of innovation.

Type of innovation	Description
Product innovation	Product or service innovation consisting in the market introduction of a product or service that is technologically new (or substantially improved) in terms of performance, technical and functional features, or ease of use, with respect to products or services currently produced and supplied by the same firm
Process innovation	Process innovation consisting in the adoption of a production process or a production management practice that is technologically new (or substantially improved), including substantial improvements of production techniques (tangible or intangible) and of the organization of the production process aimed to increase quality standards, environmental sustainability, labour health conditions and economic efficiency of the production process itself

Definitions as provided in the EES-INAPP questionnaire.

Table 2: Extensive margin of multi-layer PS.

	# of cases using PS	share in the sample
Managerial employee layer		
PS for CEO / general or executive managers	26747	49.20%
PS for non-executive managers	1070	2.12%
MPS	27345	50.13%
Non-managerial employee layer		
PS for non-managerial supervisors	1657	3.29%
PS for white-collars	2129	4.23%
PS for blue-collars	2216	4.40%
EPS	2434	4.46%
Multi-layering		
PS at only one layer	28681	48.91%
PS at both layers (MLPS)	1549	2.84%
PS at any layer	28230	51.75%

Descriptive statistics are obtained over the pooled sample covering the 2010 and 2015 waves of the EES-INAPP data. The size of the pooled sample is 54550 observations (10306 firms are followed longitudinally across the two waves, amounting to 20612 panel observations; the remaining 33938 observations are cross-sectional).

Table 3: Average characteristics of firms using PS.

	FIRMS USING ONLY EPS	FIRMS USING ONLY MPS	FIRMS USING BOTH EPS & MPS	FIRMS WITHOUT PS
INNOVATION ACTIVITY				
Invested in R&D (0/1)	0.412 (0.492)	0.057 (0.232)	0.436 (0.496)	0.109 (0.312)
Invested in automation (0/1)	0.607 (0.488)	0.146 (0.353)	0.579 (0.493)	0.221 (0.415)
Introduced process innovation (0/1)	0.549 (0.497)	0.227 (0.419)	0.609 (0.488)	0.295 (0.456)
Introduced product innovation (0/1)	0.584 (0.493)	0.288 (0.453)	0.647 (0.477)	0.346 (0.475)
Introduced any innovation (0/1)	0.658 (0.474)	0.341 (0.474)	0.729 (0.444)	0.412 (0.492)
WORKFORCE'S CHARACTERISTICS				
Share of employees with tertiary education	0.118 (0.155)	0.089 (0.203)	0.176 (0.181)	0.115 (0.208)
Share of employees 50+ years old	0.268 (0.154)	0.196 (0.259)	0.280 (0.151)	0.211 (0.219)
CEO'S CHARACTERISTICS				
The CEO has tertiary education (0/1)	0.546 (0.155)	0.220 (0.414)	0.645 (0.478)	0.294 (0.455)
The CEO is 50+ years old (0/1)	0.704 (0.456)	0.624 (0.484)	0.729 (0.444)	0.628 (0.483)
The CEO is male (0/1)	0.935 (0.246)	0.838 (0.367)	0.949 (0.219)	0.854 (0.352)
OWNER TYPE				
A family or an individual (0/1)	0.497 (0.500)	0.927 (0.258)	0.397 (0.489)	0.831 (0.374)
A financial institution (0/1)	0.217 (0.413)	0.035 (0.185)	0.331 (0.470)	0.074 (0.262)
Another firm (0/1)	0.156 (0.363)	0.027 (0.162)	0.182 (0.386)	0.062 (0.241)
Other type of owner (0/1)	0.128 (0.334)	0.008 (0.092)	0.088 (0.283)	0.032 (0.176)
SPAN OF CONTROL				
# of employees / # of managers	60.132 (64.974)	14.099 (59.771)	67.395 (96.054)	40.929 (87.325)
INDUSTRIAL RELATIONS				
Unionization rate	0.376 (0.270)	0.116 (0.240)	0.357 (0.238)	0.150 (0.254)
Rate of voluntary separations	0.024 (0.060)	0.054 (0.361)	0.026 (0.145)	0.058 (0.473)
The firm uses individual-based PRP (0/1)	0.313 (0.464)	0.011 (0.106)	0.323 (0.468)	0.015 (0.124)
CORPORATE FORM				
The firm is a limited company (0/1)	0.974 (0.159)	0.415 (0.492)	0.962 (0.190)	0.801 (0.399)
The firm is a partnership (0/1)	0.036 (0.159)	0.585 (0.492)	0.038 (0.190)	0.199 (0.399)
OTHER CHARACTERISTICS				
# of employees	373 (5004.69)	28 (192.29)	570 (3726.14)	36 (178.900)
Total revenues (mln euro)	263.88 (4619.80)	8.46 (78.50)	137.11 (558.88)	12.37 (126.41)
The firm is an exporter (0/1)	0.522 (0.499)	0.142 (0.349)	0.587 (0.492)	0.251 (0.433)
The firm belongs to a group (0/1)	0.454 (0.498)	0.076 (0.266)	0.630 (0.482)	0.131 (0.338)
# of years since incorporation	35.754 (18.238)	25.436 (24.311)	37.240 (30.748)	26.877 (26.047)

Descriptive statistics are obtained over the pooled sample covering the 2010 and 2015 waves of the EES-INAPP data. The size of the pooled sample is 54550 observations (10306 firms are followed longitudinally across the two waves, amounting to 20612 panel observations; the remaining 33938 observations are cross-sectional). Standard deviation in parentheses.

Table 4: Marginal effects of PS on any innovation: basic results.

	[1] The firm makes any inn.	[2] The firm makes any inn.	[3] The firm makes any inn.	[4] The firm makes any inn.	[5] The firm makes any inn.	[6] The firm makes any inn.
MPS	0.008	0.008	0.011	0.011	-0.014	0.012
	(0.012)	(0.012)	(0.012)	(0.012)	(0.022)	(0.022)
EPS	0.082***	0.061**	0.058**	0.055**	0.086**	0.112**
	(0.027)	(0.027)	(0.027)	(0.021)	(0.043)	(0.053)
Individual-based PRP	-0.034	-0.044	-0.040	-0.049*	-0.025	-0.017
	(0.031)	(0.031)	(0.031)	(0.029)	(0.055)	(0.066)
Investments in R&D	NO	0.165***	NO	NO	NO	NO
		(0.017)				
Investments in automation	NO	NO	0.108***	NO	NO	NO
			(0.012)			
AR(1)	NO	NO	NO	0.215***	NO	NO
				(0.009)		
Other firm-level controls	YES	YES	YES	YES	YES	YES
Sector and region dummies	YES	YES	YES	YES	YES	YES
EES-INAPP waves	2010/15	2010/15	2010/15	2010/15	2010/15	2010/15
Innovation over 2004-2006	ANY	ANY	ANY	ANY	=0	=1
# of obs.	7051	7018	7018	7051	2461	1759
Estimation	LOGIT	LOGIT	LOGIT	LOGIT	LOGIT	LOGIT

Statistical significance: * =10%, ** =5%, *** =1%. The entries are marginal effects. Standard errors are in parentheses. The dependent variable is a dummy for the firm making any between product and process innovation. Both MPS and EPS are 1-wave lagged. Controls for individual-based PRP, investments in R&D and investments in automation are 1-wave lagged. Other firm-level controls (1-wave lagged) include: rate of voluntary separations, share of the workforce with tertiary education, share of the workforce aged 50+ years, the CEO is male, the CEO has tertiary education, the CEO is aged 50+ years, the controlling owner is a family or an individual, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, total revenues, years since incorporation. Only active companies are included (firms in bankruptcy or financial distress are excluded).

Table 5: Marginal effects of PS on any innovation: alternative extensions of layers.

	[1] The firm makes any inn.	[2] The firm makes any inn.	[3] The firm makes any inn.	[4] The firm makes any inn.	[5] The firm makes any inn.
MPS (non-executives + non-managerial supervisors)[a]	0.018				
	(0.044)				
EPS (white/blue collars)	0.074**				
	(0.036)				
MPS (non-executives)[a]		-0.035	-0.042	-0.033	-0.037
		(0.053)	(0.053)	(0.012)	(0.051)
EPS (white/blue collars + non-managerial supervisors)		0.087***	0.067**	0.063**	0.056**
		(0.028)	(0.029)	(0.029)	(0.028)
CEO's pay based on PS	0.010	0.010	0.009	0.011	0.013
	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
CEO's pay based on shares/stock options	0.006	0.006	0.011	0.019	0.018
	(0.075)	(0.075)	(0.074)	(0.074)	(0.073)
CEO's pay based on PS and shares/stock options	-0.008	-0.005	-0.004	-0.001	-0.002
	(0.050)	(0.050)	(0.050)	(0.050)	(0.049)
Individual-based PRP	-0.037	-0.037	-0.047	-0.042	-0.048
	(0.031)	(0.031)	(0.032)	(0.031)	(0.030)
Investments in R&D	NO	NO	0.164***	NO	NO
			(0.017)		
Investments in automation	NO	NO	NO	0.105***	NO
				(0.012)	
AR(1)	NO	NO	NO	NO	0.216***
					(0.009)
Other firm-level controls	YES	YES	YES	YES	YES
Sector and region dummies	YES	YES	YES	YES	YES
EES-INAPP waves	2010/15	2010/15	2010/15	2010/15	2010/15
# of obs.	6928	6928	6896	6896	6928
Estimation	LOGIT	LOGIT	LOGIT	LOGIT	LOGIT

Statistical significance: * =10%, ** =5%, *** =1%. The entries are marginal effects. Standard errors are in parentheses. The dependent variable is a dummy for the firm making any between product and process innovation. Variables on the use of MPS (excluding the CEO) and EPS and about CEOs' pay are 1-wave lagged (the benchmark category for the dummies about CEOs' pay is a dummy for fixed remuneration). Controls for individual-based PRP, investments in R&D and investments in automation are 1-wave lagged. Other firm-level controls (1-wave lagged) include: rate of voluntary separations, share of the workforce with tertiary education, share of the workforce aged 50+ years, the CEO is male, the CEO has tertiary education, the CEO is aged 50+ years, the controlling owner is a family or an individual, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, total revenues, years since incorporation. Only active companies are included (firms in bankruptcy or financial distress are excluded). [a] CEOs excluded.

Table 6: Marginal effects of PS on any innovation: Propensity Score Matching.

	ATT: MPS EFFECTS		
	[1]	[2]	[3]
	The firm makes any inn.	The firm makes any inn.	The firm makes any inn.
MPS	0.023	0.015	0.016
	(0.026)	(0.026)	(0.026)
EES-INAPP waves	2010/15	2010/15	2010/15
# of obs. (treated + control)	2233	2253	2253
t	0.877	0.567	0.622
Common support	YES	YES	YES
Balancing property	SATISFIED	SATISFIED	SATISFIED
Matching ATT estimators	RADIUS	KERNEL	STRATIFICATION
	ATT: EPS EFFECTS		
	[1]	[2]	[3]
	The firm makes any inn.	The firm makes any inn.	The firm makes any inn.
EPS	0.117**	0.111**	0.114**
	(0.052)	(0.057)	(0.075)
EES-INAPP waves	2010/15	2010/15	2010/15
# of obs. (treated + control)	555	587	587
t	2.228	1.925	2.504
Common support	YES	YES	YES
Balancing property	SATISFIED	SATISFIED	SATISFIED
Matching ATT estimators	RADIUS	KERNEL	STRATIFICATION

Statistical significance: * =10%, ** =5%, *** =1%. Standard errors in parentheses are bootstrapped. The dependent variable is a dummy for the firm making any between product and process innovation. Vector $\mathbf{M}_{f,w}$ of covariates includes: the firm has made any between process and product innovation over 2007-2009, share of female workers, share of the workforce with tertiary education, share of the workforce aged 50+ years, the firm adopts individual-based PRP, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, years since incorporation, the firm belongs to a trade association, an employee representation body is established in the firm, the firm adheres to a I-level collective agreement, the firm adheres to a II-level collective agreement, region dummies, sector dummies. In the analysis of MPS (EPS), EPS (MPS) is also included among the covariates. Only active companies are included (firms in bankruptcy or financial distress are excluded).

Table 7: Marginal effects of PS on any innovation: multi-layering.

	[1] The firm makes any inn.	[2] The firm makes any inn.	[3] The firm makes any inn. MPS=0	[4] The firm makes any inn. MPS=1
Only MPS	0.005	0.009		
	(0.012)	(0.012)		
(β_2) Only EPS	0.077**	0.053*		
	(0.031)	(0.030)		
(β_3) MLPS	0.102***	0.066*		
	(0.037)	(0.036)		
EPS (instrumented)			4.054***	2.763*
			(0.415)	(1.521)
H_0: $\beta_3 - \beta_2 = 0$ [p-value]	[0.577]	[0.750]		
Individual-based PRP	-0.038	-0.050*	-1.441***	-0.950*
	(0.031)	(0.029)	(0.153)	(0.517)
AR(1)	NO	0.212***	0.309***	0.516***
		(0.009)	(0.118)	(0.139)
Other firm-level controls	YES	YES	YES	YES
Sector and region dummies	YES	YES	YES	YES
EES-INAPP waves	2010/15	2010/15	2010/15	2010/15
# of obs.	7379	7379	4248	3180
Estimation	LOGIT	LOGIT	IV-LOGIT	IV-LOGIT
Anderson LR stat. (IV relevance) [p-value]			13.937	12.660
			[0.000]	[0.000]
			First-stage	
II-level agreements in 2006 (sector avg.)			0.353***	0.339***
			(0.068)	(0.070)

Statistical significance: * =10%, ** =5%, *** =1%. The entries are marginal effects. Standard errors are in parentheses. The dependent variable is a dummy for the firm making any between product and process innovation. Variables measuring only MPS, only EPS, MPLS, MPS and EPS (instrumented) are 1-wave lagged. The control for individual-based PRP is 1-wave lagged. Other firm-level controls (1-wave lagged) include: rate of voluntary separations, share of the workforce with tertiary education, share of the workforce aged 50+ years, the CEO is male, the CEO has tertiary education, the CEO is aged 50+ years, the controlling owner is a family or an individual, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, total revenues, years since incorporation. Only active companies are included (firms in bankruptcy or financial distress are excluded).

Table 8: Marginal effects of multi-layer PS on any innovation: alternative specifications.

	[1] The firm makes any inn.	[2] The firm makes any inn.	[3] The firm makes any inn.	[4] The firm makes any inn.
MPS	0.007	0.007	0.010	0.012
	(0.012)	(0.012)	(0.012)	(0.012)
EPS	0.077**	0.057**	0.052*	0.052*
	(0.032)	(0.033)	(0.032)	(0.026)
MPS × EPS	0.013	0.011	0.015	-0.003
	(0.047)	(0.047)	(0.047)	(0.045)
Individual-based PRP	-0.035	-0.045	-0.041	-0.046
	(0.031)	(0.031)	(0.032)	(0.030)
Investments in R&D	NO	0.165***	NO	NO
		(0.017)		
Investments in automation	NO	NO	0.108***	NO
			(0.012)	
AR(1)	NO	NO	NO	0.215***
				(0.009)
Other firm-level controls	YES	YES	YES	YES
Sector and region dummies	YES	YES	YES	YES
EES-INAPP waves	2010/15	2010/15	2010/15	2010/15
# of obs.	7051	7018	7018	7051
Estimation	LOGIT	LOGIT	LOGIT	LOGIT

Statistical significance: * =10%, ** =5%, *** =1%. The entries are marginal effects. Standard errors are in parentheses. The dependent variable is a dummy for the firm making any between product and process innovation. Both MPS and EPS (and their interaction) are 1-wave lagged. Controls for individual-based PRP, investments in R&D and investments in automation are 1-wave lagged. Other firm-level controls (1-wave lagged) include: rate of voluntary separations, share of the workforce with tertiary education, share of the workforce aged 50+ years, the CEO is male, the CEO has tertiary education, the CEO is aged 50+ years, the controlling owner is a family or an individual, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, total revenues, years since incorporation. Only active companies are included (firms in bankruptcy or financial distress are excluded).

Table 9: Marginal effects of PS on process and product innovation: basic results.

	[1] The firm makes process inn.	[2] The firm makes product inn.	[3] The firm makes process inn.	[4] The firm makes process inn.	[5] The firm makes product inn.	[6] The firm makes product inn.
MPS	0.014	0.007	0.006	0.001	-0.010	-0.005
	(0.011)	(0.011)	(0.021)	(0.019)	(0.022)	(0.020)
EPS	0.056**	0.041*	0.070*	0.155***	0.143***	0.100**
	(0.022)	(0.024)	(0.038)	(0.042)	(0.041)	(0.047)
Individual-based PRP	-0.048*	-0.014	0.028	-0.060	-0.003	0.016
	(0.026)	(0.028)	(0.049)	(0.057)	(0.054)	(0.057)
Investments in R&D	0.059***	0.097***	NO	NO	NO	NO
	(0.015)	(0.016)				
Investments in automation	0.032***	0.040***	NO	NO	NO	NO
	(0.012)	(0.012)				
AR(1)	0.168***	0.211***	NO	NO	NO	NO
	(0.009)	(0.009)				
Other firm-level controls	YES	YES	YES	YES	YES	YES
Sector and region dummies	YES	YES	YES	YES	YES	YES
EES-INAPP waves	2010/15	2010/15	2010/15	2010/15	2010/15	2010/15
Innovation over 2004-2006	ANY	ANY	=0	=1	=0	=1
# of obs.	7005	7004	2461	1720	2461	1759
Estimation	LOGIT	LOGIT	LOGIT	LOGIT	LOGIT	LOGIT

Statistical significance: * =10%, ** =5%, *** =1%. The entries are marginal effects. Standard errors are in parentheses. The dependent variable is a dummy for the firm making any between product and process innovation. Both MPS and EPS are 1-wave lagged. Controls for individual-based PRP, investments in R&D and investments in automation are 1-wave lagged. Other firm-level controls (1-wave lagged) include: rate of voluntary separations, share of the workforce with tertiary education, share of the workforce aged 50+ years, the CEO is male, the CEO has tertiary education, the CEO is aged 50+ years, the controlling owner is a family or an individual, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, total revenues, years since incorporation. Only active companies are included (firms in bankruptcy or financial distress are excluded).

Table 10: Marginal effects of PS on process and product innovation: multi-layering.

	[1] The firm makes process inn.	[2] The firm makes product inn.	[3] The firm makes process inn. MPS=0	[4] The firm makes process inn. MPS=1	[5] The firm makes product inn. MPS=0	[6] The firm makes product inn. MPS=1
Only MPS	0.012	0.003				
	(0.012)	(0.011)				
(β_2) Only EPS	0.077***	0.052*				
	(0.025)	(0.028)				
(β_3) MLPS	0.076**	0.088***				
	(0.029)	(0.032)				
EPS (instrumented)			4.395***	2.761*	3.152***	2.801*
			(0.248)	(1.698)	(0.880)	(1.519)
H_0: $\beta_3 - \beta_2 = 0$ [p-value]	[0.972]	[0.356]				
Individual-based PRP	-0.049*	-0.011	-1.534***	-0.905	-0.036***	-0.917*
	(0.025)	(0.027)	(0.112)	(0.579)	(0.322)	(0.526)
AR(1)	0.177***	0.223***	0.209***	0.576***	0.558***	0.566**
	(0.009)	(0.008)	(0.101)	(0.164)	(0.156)	(0.156)
Other firm-level controls	YES	YES	YES	YES	YES	YES
Sector and region dummies	YES	YES	YES	YES	YES	YES
EES-INAPP waves	2010/15	2010/15	2010/15	2010/15	2010/15	2010/15
# of obs.	7369	7368	4244	3171	4242	3172
Estimation	LOGIT	LOGIT	IV-LOGIT	IV-LOGIT	IV-LOGIT	IV-LOGIT
			First-stage		First-stage	
II-level agree.s in 2006 (sector avg.)			0.241***	0.233***	0.256***	0.249***
			(0.066)	(0.067)	(0.066)	(0.067)

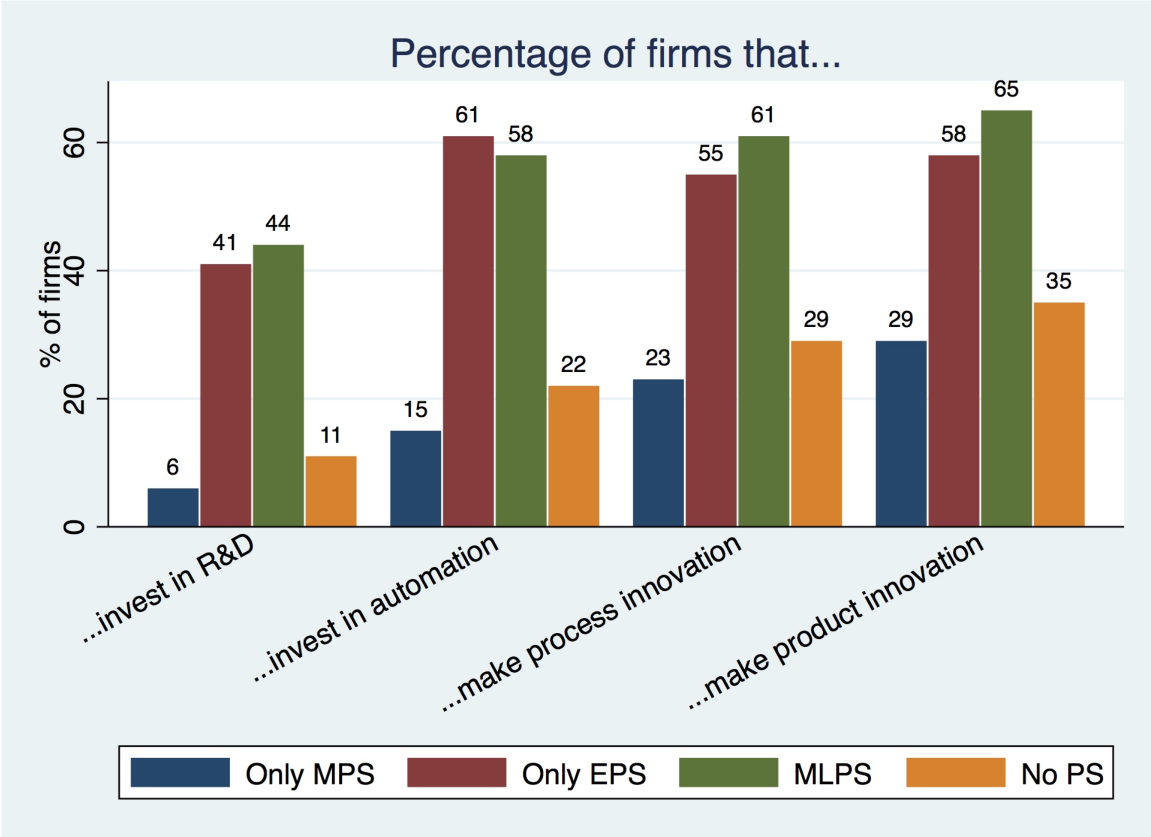
Statistical significance: * =10%, ** =5%, *** =1%. The entries are marginal effects. Standard errors are in parentheses. The dependent variable is a dummy for the firm making any between product and process innovation. Variables measuring only MPS, only EPS, MPLS, MPS and EPS (instrumented) are 1-wave lagged. The control for individual-based PRP is 1-wave lagged. Other firm-level controls (1-wave lagged) include: rate of voluntary separations, share of the workforce with tertiary education, share of the workforce aged 50+ years, the CEO is male, the CEO has tertiary education, the CEO is aged 50+ years, the controlling owner is a family or an individual, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, total revenues, years since incorporation. Only active companies are included (firms in bankruptcy or financial distress are excluded).

Table 11: Mechanisms: PS and training activities.

	[1] The firm makes training	[2] The firm makes training	[3] The firm makes training	[4] The firm makes training	[5] The firm makes any inn.
MPS	-0.014	-0.012	-0.013	-0.012	0.013
	(0.012)	(0.012)	(0.012)	(0.012)	(0.015)
EPS	0.088***	0.081**	0.083***	0.074**	0.023
	(0.032)	(0.032)	(0.032)	(0.032)	(0.050)
In-firm training					0.151***
					(0.013)
MPS × In-firm training					0.001
					(0.020)
EPS × In-firm training					0.015
					(0.055)
Investments in R&D	0.105***	NO	NO	0.048**	NO
	(0.018)			(0.019)	
Investments in automation	NO	0.098***	NO	0.068***	NO
		(0.012)		(0.013)	
Innovation over 2007-2009	NO	NO	0.116***	0.103***	NO
			(0.010)	(0.011)	
Other firm-level controls	YES	YES	YES	YES	YES
Sector and region dummies	YES	YES	YES	YES	YES
EES-INAPP waves	2010/15	2010/15	2010/15	2010/15	2010/15
# of obs.	7347	7347	7379	7347	7379
Estimation	LOGIT	LOGIT	LOGIT	LOGIT	LOGIT

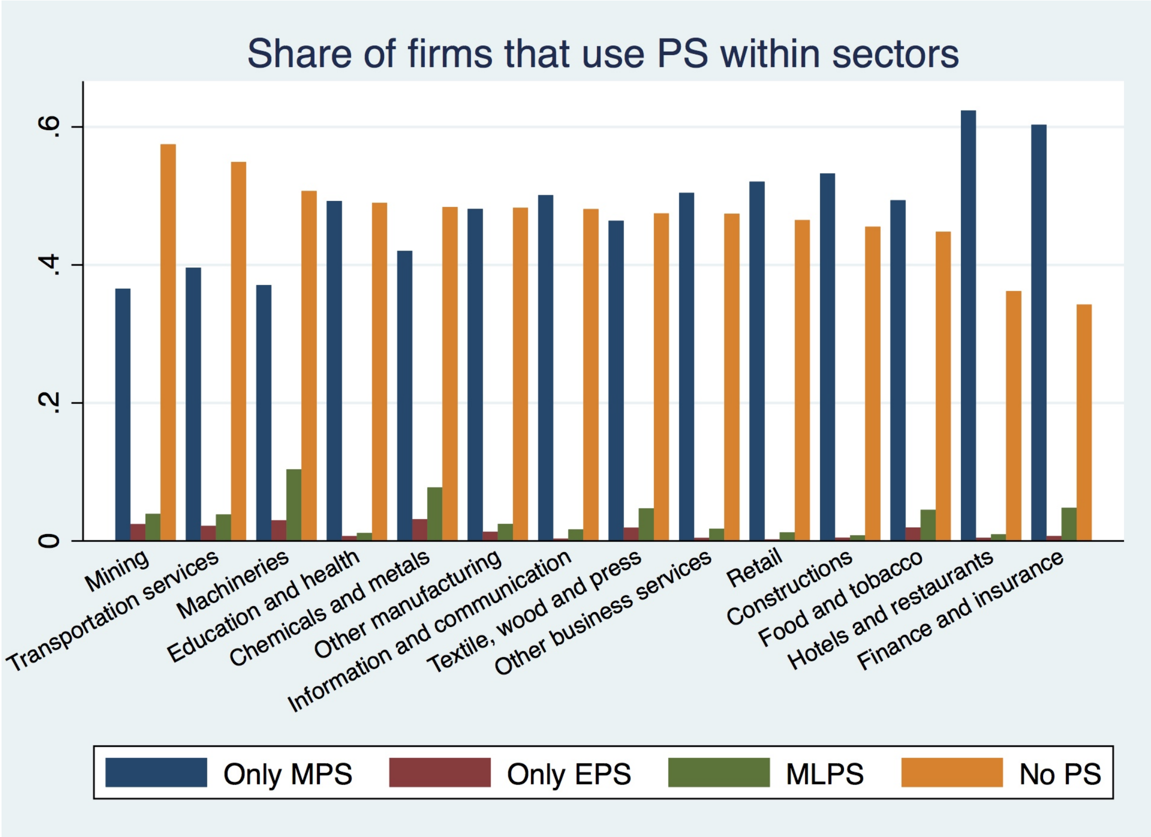
Statistical significance: * =10%, ** =5%, *** =1%. The entries are marginal effects. Standard errors are in parentheses. The dependent variable is a dummy for the firm making training activity. Both MPS and EPS are 1-wave lagged. Controls for individual-based PRP, investments in R&D and investments in automation are 1-wave lagged. Other firm-level controls (1-wave lagged) include: rate of voluntary separations, share of the workforce with tertiary education, share of the workforce aged 50+ years, the CEO is male, the CEO has tertiary education, the CEO is aged 50+ years, the controlling owner is a family or an individual, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, total revenues, years since incorporation, individual-based PRP. Only active companies are included (firms in bankruptcy or financial distress are excluded).

Figure 1: Innovative activity of firms, by PS policy.



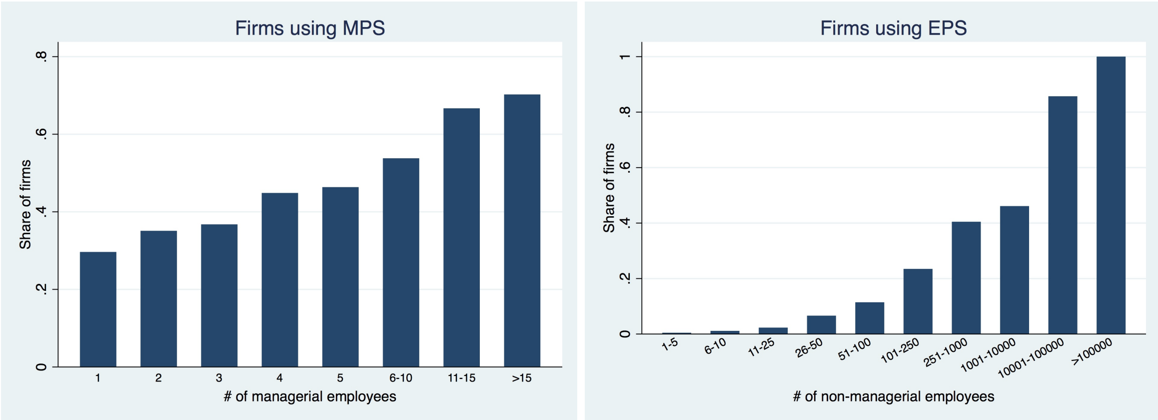
Descriptive statistics are obtained over the pooled sample covering the 2010 and 2015 waves of the EES-INAPP data. The size of the pooled sample is 54550 observations (10306 firms are followed longitudinally across the two waves, amounting to 20612 panel observations; the remaining 33938 observations are cross-sectional). Legend: only MPS = PS is used only at the managerial layer (executives, including the CEO, and/or non-executive managers), only EPS = PS is used only at the non-managerial layer (non-managerial supervisors, white-collars, and/or blue-collars), MLPS = PS is used at both layers, no PS = PS is not used an any layer.

Figure 2: PS policy of firms, by sector.



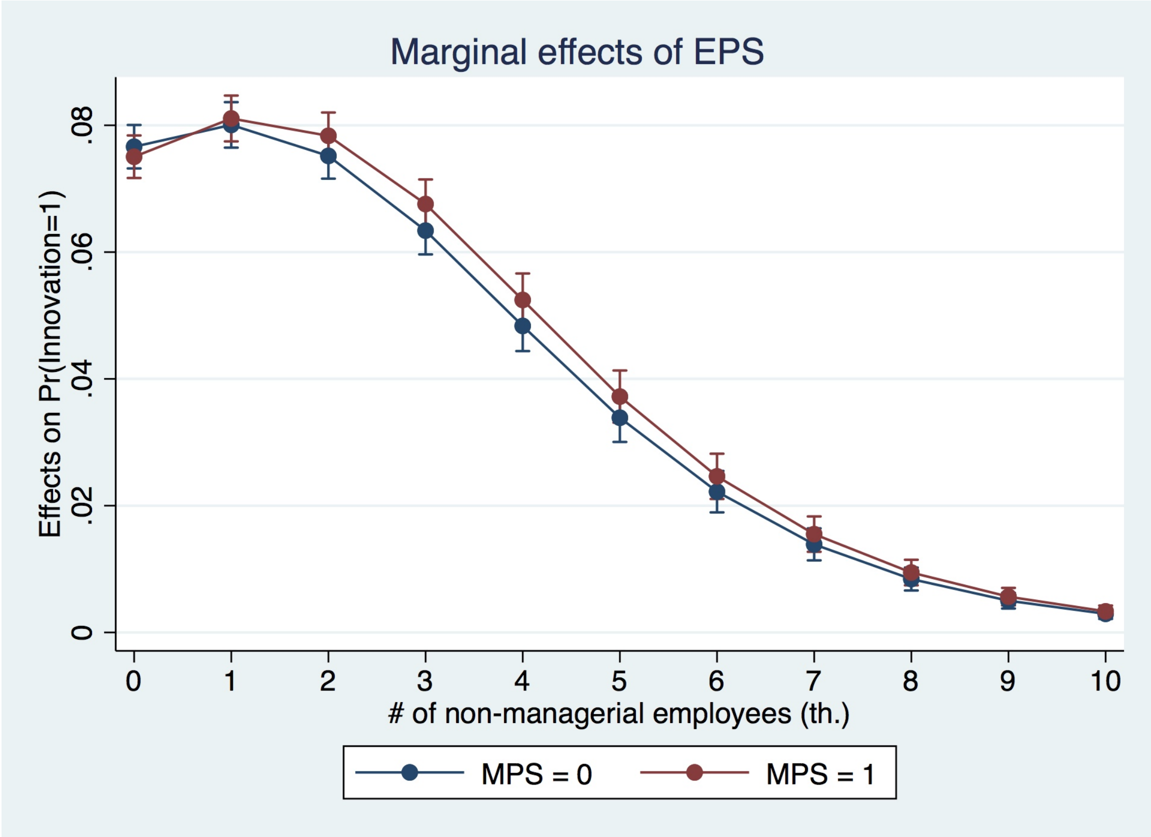
Descriptive statistics are obtained over the pooled sample covering the 2010 and 2015 waves of the EES-INAPP data. The size of the pooled sample is 54550 observations (10306 firms are followed longitudinally across the two waves, amounting to 20612 panel observations; the remaining 33938 observations are cross-sectional).

Figure 3: PS policy of firms, by size-class.



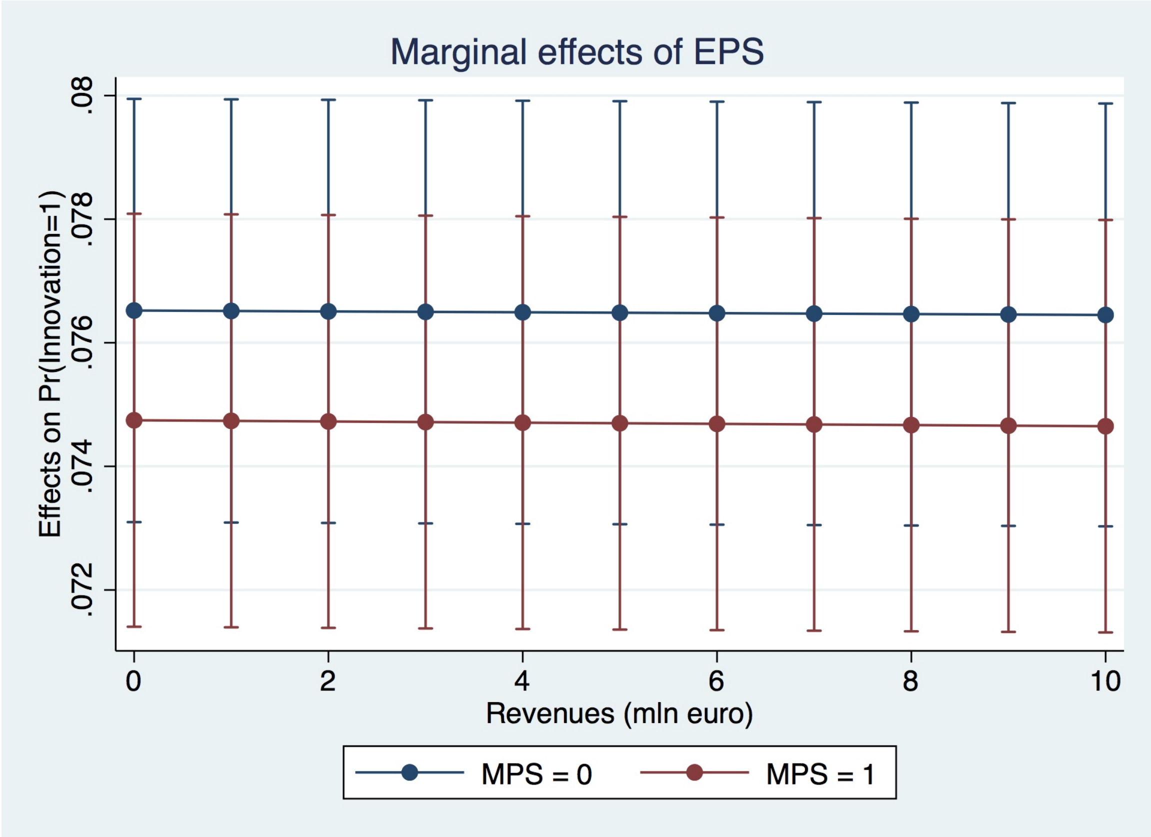
Descriptive statistics are obtained over the pooled sample covering the 2010 and 2015 waves of the EES-INAPP data. The size of the pooled sample is 54550 observations (10306 firms are followed longitudinally across the two waves, amounting to 20612 panel observations; the remaining 33938 observations are cross-sectional).

Figure 4: Marginal effects of EPS, conditional to MPS and number of non-managers.



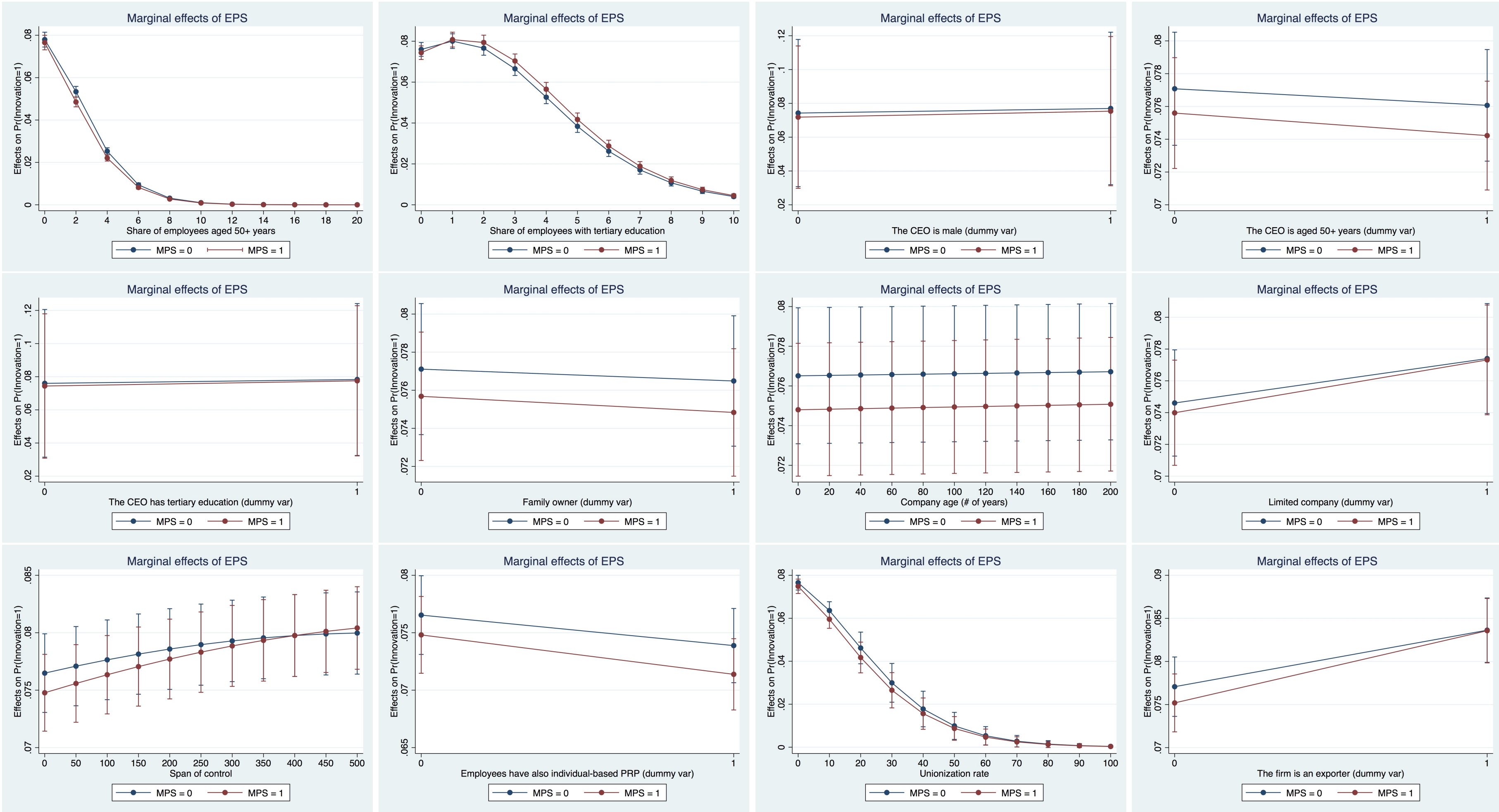
Conditional marginal effects of EPS on innovation are obtained by estimating our baseline logit model, as specified in column [2] of Table 4. The full set of controls is included, covering individual-based PRP, rate of voluntary separations, share of the workforce with tertiary education, share of the workforce aged 50+ years, the CEO is male, the CEO has tertiary education, the CEO is aged 50+ years, the controlling owner is a family or an individual, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, total revenues, years since incorporation, and sector and region dummies. All the controls are 1-wave lagged as well as EPS and MPS variables. Only active companies are included (firms in bankruptcy or financial distress are excluded). Number of observations: 7051; EES-INAPP waves: 2010/15.

Figure 5: Marginal effects of EPS, conditional to MPS and total revenues.



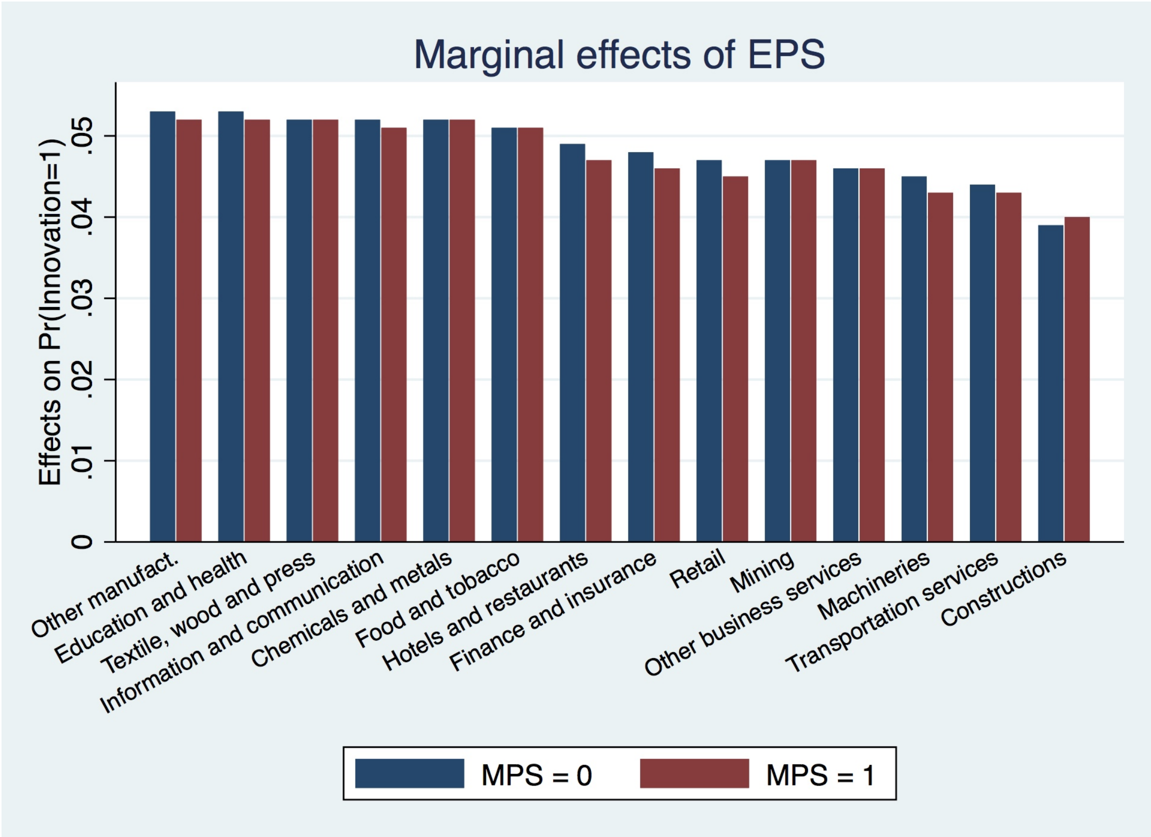
Conditional marginal effects of EPS on innovation are obtained by estimating our baseline logit model, as specified in column [2] of Table 4. The full set of controls is included, covering individual-based PRP, rate of voluntary separations, share of the workforce with tertiary education, share of the workforce aged 50+ years, the CEO is male, the CEO has tertiary education, the CEO is aged 50+ years, the controlling owner is a family or an individual, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, total revenues, years since incorporation, and sector and region dummies. All the controls are 1-wave lagged as well as EPS and MPS variables. Only active companies are included (firms in bankruptcy or financial distress are excluded). Number of observations: 7051; EES-INAPP waves: 2010/15.

Figure 6: Marginal effects of EPS, conditional to MPS and other firm's characteristics.



Conditional marginal effects of EPS on innovation are obtained by estimating our baseline logit model, as specified in column [2] of Table 4. The full set of controls is included, covering individual-based PRP, rate of voluntary separations, share of the workforce with tertiary education, share of the workforce aged 50+ years, the CEO is male, the CEO has tertiary education, the CEO is aged 50+ years, the controlling owner is a family or an individual, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, total revenues, years since incorporation, and sector and region dummies. All the controls are 1-wave lagged as well as EPS and MPS variables. Only active companies are included (firms in bankruptcy or financial distress are excluded). Number of observations: 7051; EES-INAPP waves: 2010/15.

Figure 7: Marginal effects of EPS, conditional to MPS and sector of activity.



Conditional marginal effects of EPS on innovation are obtained by estimating our baseline logit model, as specified in column [2] of Table 4. The full set of controls is included, covering individual-based PRP, rate of voluntary separations, share of the workforce with tertiary education, share of the workforce aged 50+ years, the CEO is male, the CEO has tertiary education, the CEO is aged 50+ years, the controlling owner is a family or an individual, the firm is a limited liability company, span of control, the firm belongs to a group, the firm is an exporter, total number of employees, total revenues, years since incorporation, and sector and region dummies. All the controls are 1-wave lagged as well as EPS and MPS variables. Only active companies are included (firms in bankruptcy or financial distress are excluded). Number of observations: 7051; EES-INAPP waves: 2010/15.

Multi-Layer Profit Sharing and Innovation

– supplementary material –

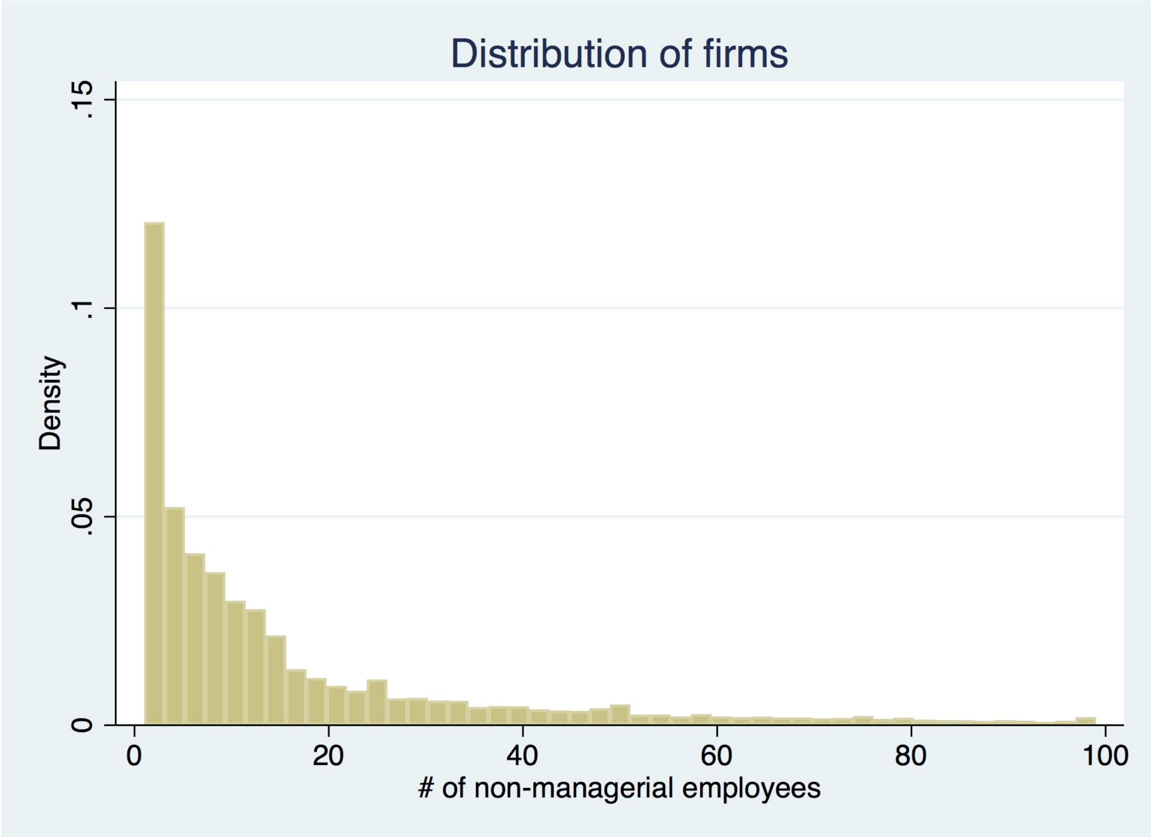
(for online publication)

Table 12: Adoption of multi-layer PS, longitudinal changes.

	UNCONDITIONAL CHANGE RATES				
	(a) Not used both in 2009 and 2014	(b) Not used in 2009 and used in 2014	(c) Used in 2009 and not used in 2014	(d) Used both in 2009 and 2014	(a)+(b) + (c)+(d)
MPS	34.34%	23.48%	12.30%	29.88%	100%
EPS	92.84%	1.02%	4.01%	2.13%	100%
MLPS	95.60%	1.96%	1.43%	1.01%	100%
	CONDITIONAL CHANGE RATES				
	(e) Share of firms not using PS in 2009 that don't use it in 2014	(f) Share of firms not using PS in 2009 that use it in 2014	(g) Share of firms using PS in 2009 that don't use it in 2014	(h) Share of firms using PS in 2009 that use it in 2014	(e)+(f) and (g)+(h)
PS: MPS	59.39%	40.61%	29.15%	70.85%	100%
PS: EPS	98.91%	1.08%	65.35%	34.65%	100%
PS: MLPS	97.99%	2.01%	58.61%	41.39%	100%

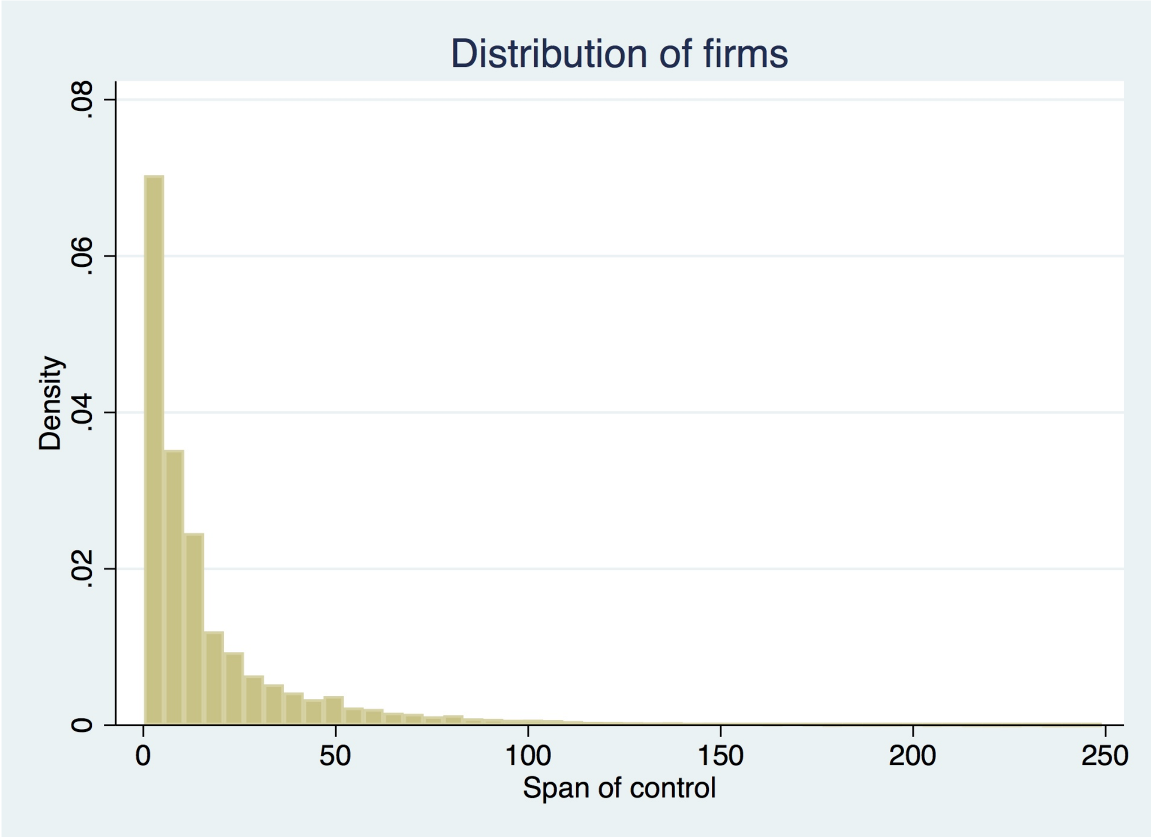
Change rates in the use of PS between 2009 and 2014 are obtained by using the longitudinal EES-INAPP sample, covered by the 2010 and 2015 EES-INAPP waves. The size of the panel sample is 10306 firms, amounting to 20612 panel observations (change rates reported in this Table are obtained after cleaning the data for missing PS information).

Figure 8: Distribution of firms, by size.



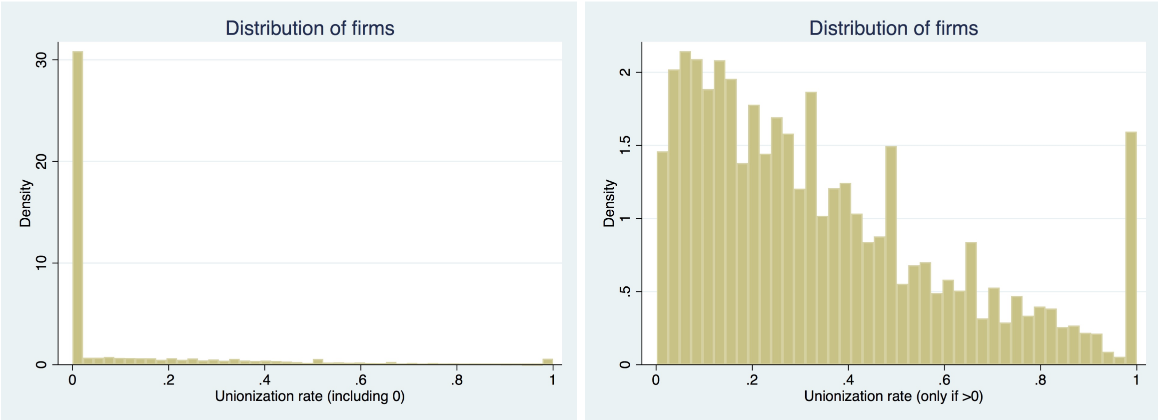
The histogram is obtained over the pooled sample covering the 2010 and 2015 waves of the EES-INAPP data. The size of the pooled sample is 54550 observations (10306 firms are followed longitudinally across the two waves, amounting to 20612 panel observations; the remaining 33938 observations are cross-sectional). This Figure helps understanding why the 1/N problem, which is showed in our estimation to be significant only for firms with more than 20000 employees, is unlikely to be an issue for most Italian firms, as argued in Section 6 of the paper.

Figure 9: Distribution of firms, by span of control.



The histogram is obtained over the pooled sample covering the 2010 and 2015 waves of the EES-INAPP data. The size of the pooled sample is 54550 observations (10306 firms are followed longitudinally across the two waves, amounting to 20612 panel observations; the remaining 33938 observations are cross-sectional). This Figure shows that the relevant range of the span of control is between 0 and 100, this is why in Section 5 of the paper we report the conditional effects of PS on innovation with respect to values of the span of control not higher than 500.

Figure 10: Distribution of firms, by unionization rate.

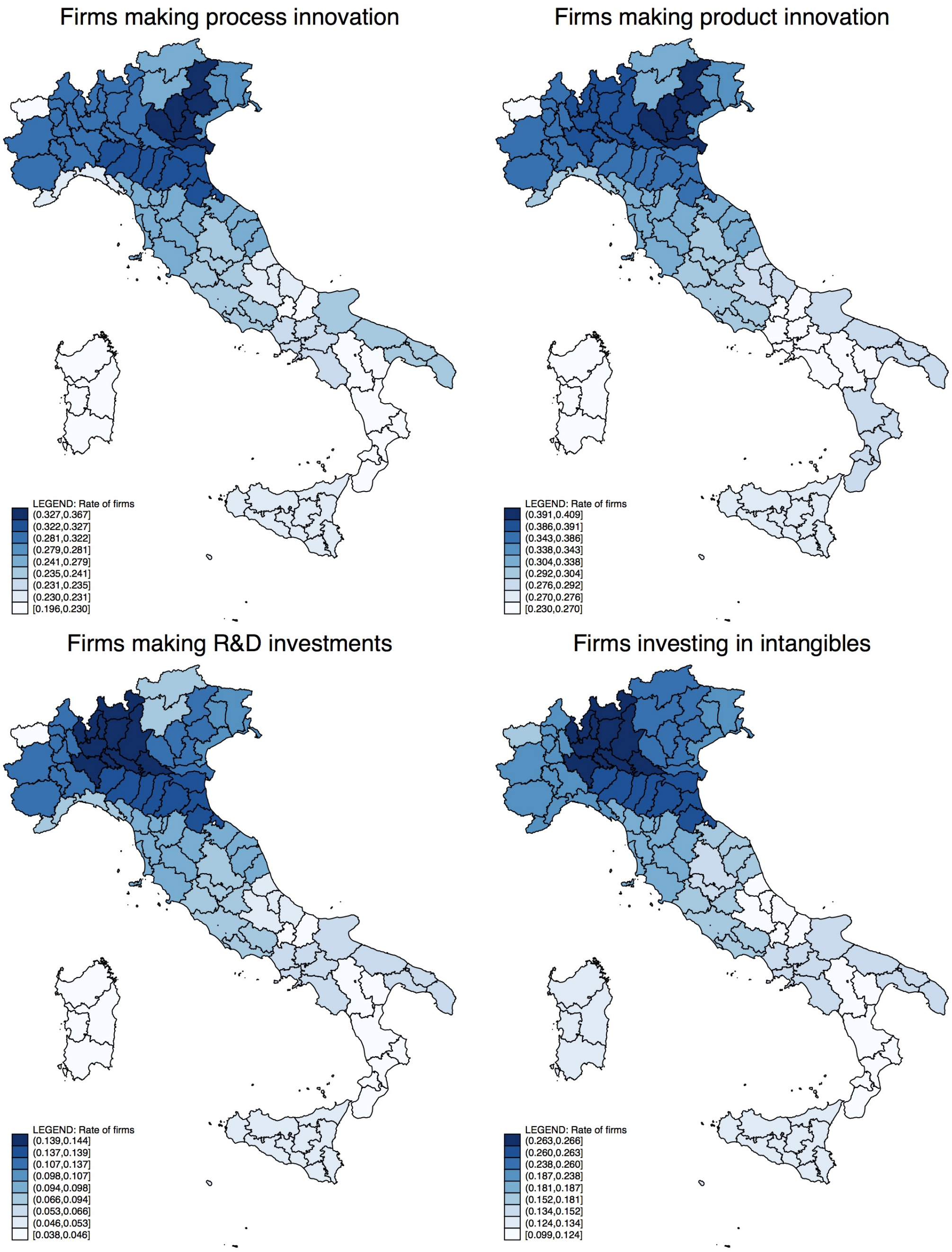


Descriptive statistics are obtained over the pooled sample covering the 2010 and 2015 waves of the EES-INAPP data. The size of the pooled sample is 54550 observations (10306 firms are followed longitudinally across the two waves, amounting to 20612 panel observations; the remaining 33938 observations are cross-sectional).

Figure 11: PS policy of firms, by a selection of firm's characteristics.

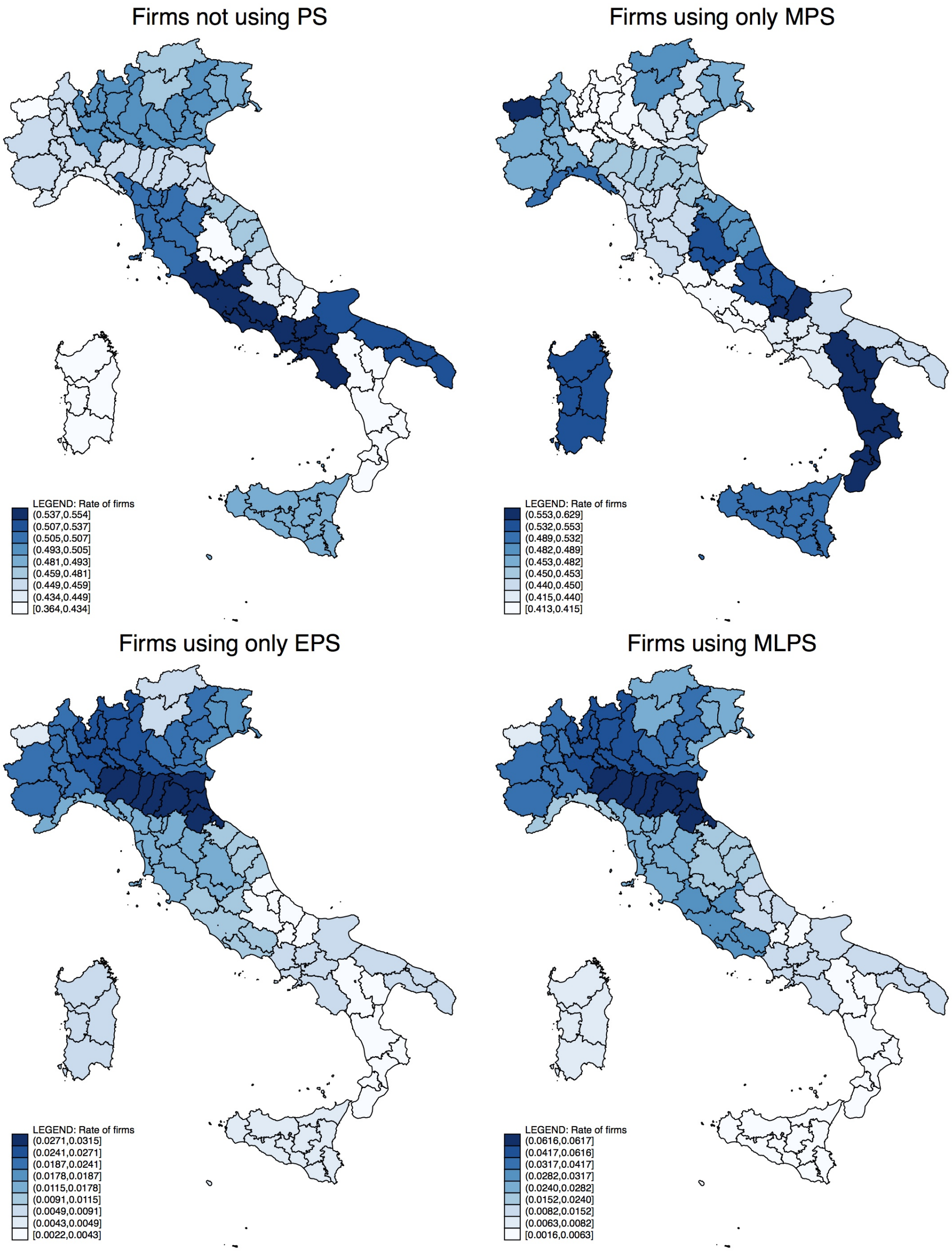
Descriptive statistics are obtained over the pooled sample covering the 2010 and 2015 waves of the EES-INAPP data. The size of the pooled sample is 54550 observations (10306 firms are followed longitudinally across the two waves, amounting to 20612 panel observations; the remaining 33938 observations are cross-sectional).

Figure 12: Geographical distribution of firms, by innovation activity.



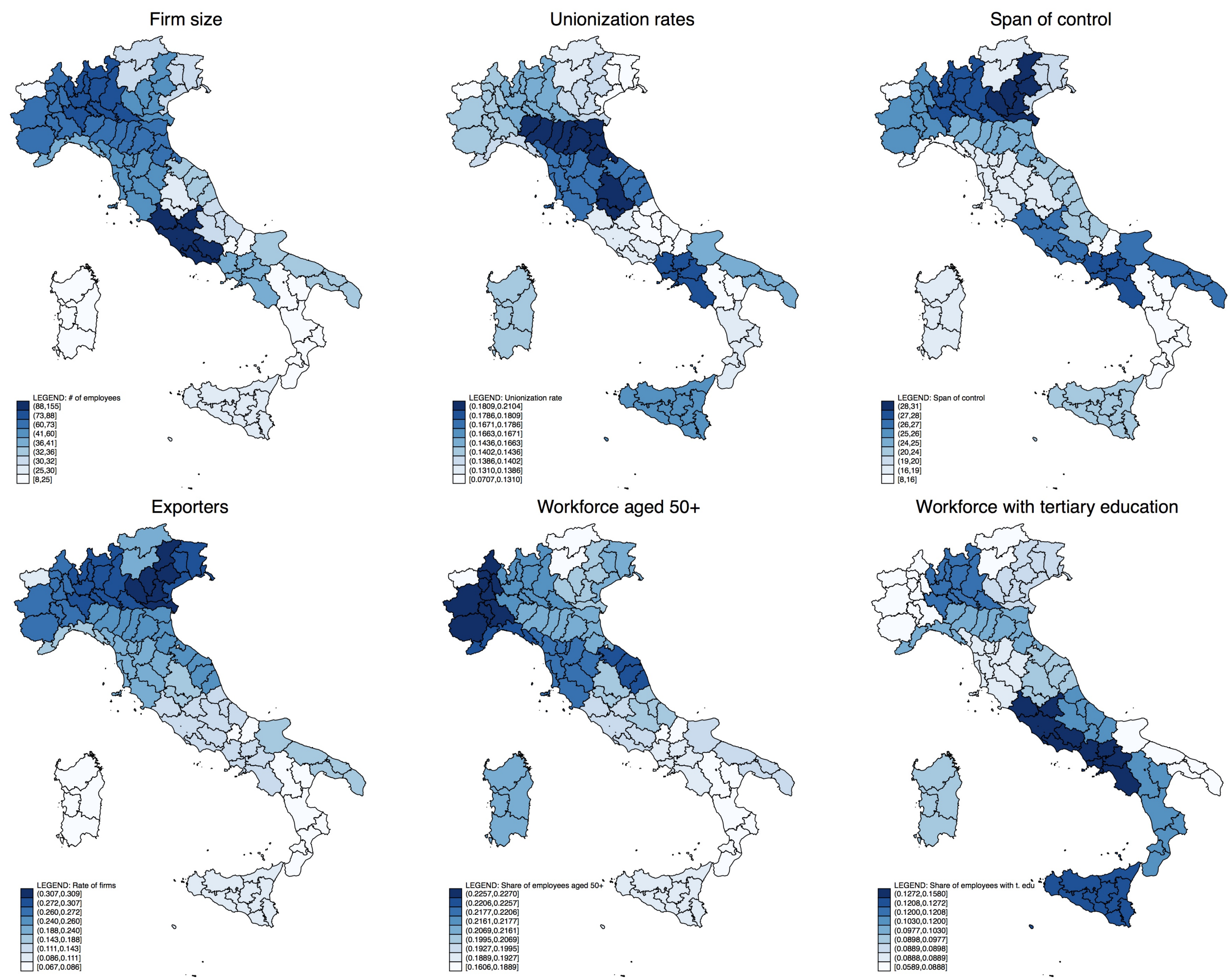
Geographical descriptive statistics are obtained as regional averages over the 2010 and 2015 waves of the EES-INAPP data (pooled sample of 54550 observations).

Figure 13: Geographical distribution of firms, by PS policy.



Geographical descriptive statistics are obtained as regional averages over the 2010 and 2015 waves of the EES-INAPP data (pooled sample of 54550 observations).

Figure 14: Geographical distribution of firms, by mediating characteristics.



Geographical descriptive statistics are obtained as regional averages over the 2010 and 2015 waves of the EES-INAPP data (pooled sample of 54550 observations).