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PROFIT SHARING AND INNOVATION ACROSS ORGANIZATIONAL LAYERS

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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 organizational 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 12 percentage points. The difference between managerial and non-managerial PS effects appears wider for process, arguably incremental innovation. 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.

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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 organizational layer it is used at. Since PS is typically based on short-run indicators of firm profits (essentially, this is one of the main differences between PS and 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

¹Kruse *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).

²To 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 still in the firm 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 12 percentage points. 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.

A possible channel behind the positive association between PS for non-managers and innovation relates to the improved employee behaviour at the workplace under contractual PS

due to increased effort, peer-pressure and greater collaboration among co-workers, particularly for innovations that are most strongly influenced by the work of non-managers, such as continuous bottom-up improvements of the production process as opposed to discrete product innovation at the top. Related to this, we show that the effects of PS for non-managers are relatively stronger for process innovation than for product innovation. We also show that non-managerial PS is associated to the adoption of complementary upskilling practices that may be instrumental to incremental process 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 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 by means of standard 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

³Nikiforakis *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.

⁴A 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)).

⁵A 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.

on whether PS also influences long-run measures of performance, such as innovation, and, if yes, how. Moreover, the vast majority of studies 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 when the size of the workforce increases. 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 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 between

⁶Incidentally, 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).

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 typically do it through 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. At the same time, given that the employees with a same job in a same firm are generally subject to a same labour contract, when PS applies at a given layer, it will cover the employees at that layer all together.

Most commonly, 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 meets some negotiated performance target, then a cash bonus is paid in addition to the baseline wage. When the target is not reached, wages are paid according to the I-level contract and negative adjustments are not allowed (i.e. the so-called "favorability principle" applies). While some PS schemes are directly based on profits, operating income or revenues ("*premio di redditività*"), some others are based different performance indicators, including efficiency indicators ("*premio di produttività*").

In Italy, cash bonuses paid under non-managerial PS (EPS) plans are eligible for a special tax regime granting some fiscal benefits. A pre-requisite for obtaining these tax reliefs is that

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

the EPS plan is registered in a repository at the Ministry of Labour and Social Policy. This repository provides a useful source of information to learn what are the characterizing aspects of EPS plans in Italy. As for 2019, about 14000 EPS plans were registered. Looking at these data, it emerges that firm-level EPS plans are more common among larger firms (15% of the registered firm-level EPS plans are adopted by firms below 15 employees and 26% of them is among firms above 250 employees) with respect to territorial-level EPS plans (about 61% of them is adopted by firms below 15 employees and only 10% by those above 250 employees). About 77% of EPS plans is adopted by firms in North Italy, 15% in Centre Italy and 8% in the South and the main islands. In terms of sectoral distribution, EPS plans are far more common in manufacturing firms (54% of the total) than in retail (about 8%) and other services (e.g., 6% are in professional activities, 4% in insurance and financial services, 3% in services related to information and communication). The amount of the bonus paid at the end of the year does not show dramatic variability across firms and sectors, but some important differences can be observed. On average, the bonus is around €1477, with a higher local average in South Italy (€1869) and Centre Italy (€1832) than in the North (€1373). Bonuses paid under EPS plans at a firm-level on average are around €1650, while the average bonus paid under EPS at a territorial-level is €710. In both cases, the bonus tends to be larger in larger firms (on average, the bonus is €1208 for firms below 15 employees and €1744 for those above 250 employees). Firms in service sectors pay larger bonuses (around €2000) than manufacturing firms (€1316 on average). Interestingly, EPS bonuses can be converted in the supply of welfare services by the firm (e.g., a private health insurance, reimbursement of education expenses for family members or flexible agreements for the work life balance) or in other so-called “fringe benefits” (e.g., meal tickets or a company car), if allowed by the associated II-level agreement. About 57% of all EPS plans allow for this conversion (which does not mean that the bonus is actually converted at the end of the year): this equals to around 1.695.602 workers potentially involved (76% of the workers covered by registered EPS plans). EPS plans that include the possibility of converting the bonus in welfare benefits are more common in North Italy (58% of EPS plans in the North are convertible) and in the Centre (56%) than in the South (where only 48% of EPS plans can be converted), are more diffused among large firms (about 28% of these convertible contracts are in firms above 250 employees) and are generally associated to a higher bonus (€1514 on average).

On the other side, large scale information on the specific attributes of MPS plans in Italy is rather scant. In the years covered by our study, bonuses paid under MPS schemes were eligible

for tax benefits only for managers with a gross wage below €50000 and for bonuses below €3000. This has made the special tax regime for MPS not attractive, with the result that MPS plans generally have been not registered for fiscal benefits purposes. While this has the consequence that there are not comprehensive sources of data on the actual implementation of MPS, it also implicitly suggests that cash bonuses paid under MPS contracts are most often above €3000, which means they are at least twice as high as the average bonus paid to non-managers under EPS. Available information about actual examples of MPS suggests that MPS bonuses touch €10000 very often, and in many cases reach much higher values.⁸ Moreover, about 4% of firms using PS for executive managers integrate PS with some forms of equity compensation and stock options, whilst this is much rarer for non-executives (and non-managers). As for EPS, also MPS bonuses can be converted in welfare or fringe benefits, but descriptive statistics on the diffusion of this practice are not available. Finally, managerial bonuses under PS often include also an additional variable component tied to the manager's individual performance. This introduces some variability in the actual gross bonuses paid to different managers at the end of the year in a same firm. At the opposite, most typically EPS bonuses are equally distributed across non-managers.

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. 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

⁸The fact that nominal wages are on average higher for managers than for non-managers makes the difference between MPS and EPS bonuses lower in real terms. Istat (2019) reports that the average net monthly salary for managers is €4518, while it is €2633 for non-managerial supervisors, €1677 for white-collars and €1470 for blue-collars.

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 . 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 instrumental to innovation. 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 .⁹

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 $\bar{\pi}$, a share α_i of the extra-output $\Delta\pi \equiv \pi^j - \bar{\pi}$ 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 $\pi^j > \bar{\pi}$, 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 $\pi^S > \bar{\pi}$ and $\pi^D = \bar{\pi}$.

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

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

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:

$$\delta_i < \frac{\mathbb{E}_i[p^S]\Delta\pi\alpha_i - c_i^S}{c_i^S} \equiv \bar{\delta}_i \quad (2)$$

Condition (2) is weaker (and the likelihood of an innovative undertaking higher) when, all

⁹To 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.

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 voluntarily 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).¹⁰ The present value (ω_{Mt1}) of the outside option for the manager is:

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

Suppose that $\delta_i < \bar{\delta}_i \forall i$ (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 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.:

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

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

¹⁰That managers can rely on outside options whilst bargaining with the firm is a common feature of incomplete contracts models in the theory of the firm (e.g., [De Meza and Lockwood \(1998\)](#)).

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 has 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.¹¹ 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.

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

¹¹The ability of the managers to do so may depend on various factors, including the span of control over non-managers.

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.¹²

[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.¹³

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.¹⁴ PS at the non-managerial layer (EPS) is used much 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

¹²This notion of innovation encompasses both patentable and unpatented innovations (e.g. trade secrets).

¹³Our PS measure, as obtained from the EES-INAPP survey, conflates both the types of PS mentioned in Section 2 (i.e. “*premio di redditività*” and “*premio di produttività*”). Relatedly, we are aware that not all PS is created equal, with PS for managers and non-managers possibly differing in a number of relevant details (Kato and Kauhanen, 2018), in particular the amount of the bonus paid at the end of the year, which we fail to observe in the EES-INAPP data.

¹⁴The 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.

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 voluntarily 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:

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

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:

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

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

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.¹⁵

¹⁵Since 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.

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 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 $p\text{-value} = 0.5196$ ($H_0: \rho_{inn}^{PS_change} = 0$).¹⁶

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, all else being equal.

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

¹⁶ 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.

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.¹⁷

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 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 2004-2006.¹⁸

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

¹⁷[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.

¹⁸Unfortunately, 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.

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., [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_{wage}^{MPS} and ρ_{wage}^{EPS} between the use of MPS and EPS, respectively, and average wages. We find $\rho_{wage}^{MPS} = 0.0007$, with $p\text{-value} = 0.9287$ ($H_0: \rho_{wage}^{MPS} = 0$), and $\rho_{wage}^{EPS} = 0.0005$, with $p\text{-value} = 0.9491$ ($H_0: \rho_{wage}^{EPS} = 0$). 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.¹⁹

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.

¹⁹Clearly, 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 tackle this possibility below, by employing finer definitions of managerial and non-managerial layers in our baseline estimation analysis.

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 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 0.055 (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 specifica-

tions 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.

In terms of economic significance, our baseline estimated EPS parameter seems to be economically meaningful. Given that the average probability of a firm's making innovation in our sample is 0.38, a marginal increase of this probability by 8.2 percentage points means that the average innovation probability under EPS shifts to around 0.46. Such an effect is neither trivial nor implausibly large, in comparison with previous estimates. In particular, [Aerts *et al.* \(2015\)](#), for a sample of German firms, find a statistically significant effect of PS on product innovation of about 10 percentage points.

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.²⁰

[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 $PS = \text{MPS}, \text{EPS}$. 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.

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

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

where Φ denotes the logistic cumulative density function and $h(\mathbf{M}_{f,w})$ is the specification

²⁰Related 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.

including all the covariates in $\mathbf{M}_{f,w}$.²¹ 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.²²

[insert Table 6 about here]

The results are presented in Table 6. ATT estimates obtained with Radius Matching, Kernel Matching, and Stratification Matching 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.

5.4 Additional results

5.4.1 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

²¹Vector $\mathbf{M}_{f,w}$ 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.

²²See [Becker and Ichino \(2002\)](#) for details on these matching methods.

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:

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

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 $H_0: \beta_3 - \beta_2 = 0$.

Moreover, 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:

$$\text{Innovation}_{f,w} = \beta_0 + \beta_1 \text{MPS}_{f,w-1} + \beta_2 \text{EPS}_{f,w-1} + \beta_3 \text{MPS}_{f,w-1} \times \text{EPS}_{f,w-1} + \mathbf{bX}_{f,w-1} + \text{sector FE}_{f,w} + \text{region FE}_{f,w} + \varepsilon_{f,w} \quad (10)$$

where, differently from Equation (9), the marginal effect of the interaction term $\text{MPS} \times \text{EPS}$ has to be read as the effect of coupling MPS with EPS with respect to using only MPS or only EPS.

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 [1] and column [2], the χ^2 -test of equality of parameters (namely, β_2 and β_3 of Equation (9)) has been run and the results are displayed. Columns from [3] to [6] report the results obtained through the standard interaction model described in Equation (10), where controls for R&D investments, investments in automation and past innovation performance are added one by one.

[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 from [3] to [6], we report the results of the standard interaction model with and without controls for past technological investments and innovation outcomes over 2007-2009. Coherently with the results reported in columns [1] and [2], 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.²³

5.4.2 Disentangling PS effects on process and product innovation

One possible interpretation of the contrasting effects of EPS and MPS relates to the prevailing characteristics of innovation in our sample of Italian firms. While some innovations come from the top of the firm where managers work in collaboration with a small team of R&D staff, some others arise from the bottom, i.e. at the grassroots level where non-managerial employees participate in innovation-oriented activities aimed at generating incremental bottom-up improvements. It could be that much of innovation in our data is continuous improvement at the grassroots rather than discrete innovation at the top. As a result, EPS may matter more for innovation than MPS, because bottom-up innovations are more common among Italian

²³We verified that these findings remain qualitatively similar in an instrumental variable (IV) framework, where EPS is instrumented by using the region-sector average share of firms adhering to II-level agreements in 2006. In the IV model, we find that EPS is associated with a positive and significant parameter, which is however larger than in the baseline model, casting doubt on the validity of the instrument. Given that we already performed a PSM, the IV results are not reported in the paper (but they are available upon request). Unfortunately, our data do not provide other useful variables that can be used as instruments.

firms and more responsive to the incentive effects activated by EPS. Since innovation at the grassroots is most likely to result in process innovation as opposed to product innovation, by disentangling the two types of innovation we may shed some light on this possibility.

Relatedly, it is plausible that continuous improvement, such as innovation activities for small incremental bottom-up process innovation promoted by EPS, may yield fruit more quickly than top-down discrete innovation promoted by MPS. Moreover, it may require a shorter gestation period for EPS to foster process innovation. Hence, should this interpretation be valid, we may observe stronger EPS effects in the short-run for process innovation than for product, arguably top-down innovation.

The EES-INAPP data allow disentangling process and product innovation. Hence, we can run Equation (5) considering process and product innovation activities as two alternative dependent variables. We run two model versions. In one, we include our baseline 1-wave lagged EPS and MPS dummies. In the other, EPS and MPS are observed in the same wave as the dependent variable. The latter specification helps us exploring the simultaneous effects of PS on process and product innovation. The results are reported in Table 8.

[insert Table 8 about here]

We find that EPS has a positive and significant effect on both process and product innovation across all the model specifications. Since the estimated effects are marginal, their magnitude can be directly compared between models, when the underlying sample of firms is the same. Hence, we can see that the effect of 1-wave lagged EPS on process innovation (column [1]) is slightly higher than for product innovation (column [2]) and that this difference in magnitude is larger when simultaneous effects are considered (columns [3]-[4]). Possible reverse causality might introduce a bias in the estimates when PS and innovation outcomes are observed in the same wave. Yet, the fact that the difference in magnitude between lagged and simultaneous EPS effects increases relatively more for process innovation than for product innovation may suggest that the type of innovation most strongly promoted by EPS is the one resulting in faster process improvements as opposed to new products. It is consistent with this interpretation the slightly significant negative sign of the simultaneous MPS effect on process innovation (column [3]), which might indicate that under PS managers may prefer to sacrifice small incremental improvements to the benefit of possibly more rewarding product innovation over the long-run.

5.4.3 Size of the workforce and the “1/N problem”

One major factor weakening PS effects on productivity is the possibility of 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

$$\Pr(\text{Innovation}_{f,w} = 1) = \frac{e^{\beta x}}{1 + e^{\beta x}} \quad (11)$$

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

the conditional marginal effects of EPS as

$$\frac{\partial \Pr(\text{Innovation}_{f,w} = 1)}{\partial \text{EPS}_{f,w-1}} = \frac{e^{\beta x}}{(1 + e^{\beta x})^2} \frac{\partial(\beta x)}{\partial \text{EPS}_{f,w-1}}$$

at $[\text{MPS}_{f,w-1} = (0 \ 1) | \# \text{ of non-managerial employees}_{f,w-1}, E(\mathbf{X}_{f,w-1})]$ (12)

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 percentage points 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

$$\frac{\partial \Pr(\text{Innovation}_{f,w} = 1)}{\partial \text{EPS}_{f,w-1}} = \frac{e^{\beta x}}{(1 + e^{\beta x})^2} \frac{\partial(\beta x)}{\partial \text{EPS}_{f,w-1}}$$

at $[\text{MPS}_{f,w-1} = (0 \ 1) | \text{Total revenues}_{f,w-1}, E(\mathbf{X}_{f,w-1})]$ (13)

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.

5.4.4 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

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

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 firms with more educated employees rely on top-down discrete innovation (most likely, product innovation) rather than bottom-up continuous improvement of the production process. If EPS promotes relatively more incremental improvements at the grassroots level, then it is not surprising that EPS effects are milder in firms with high-educated labour force dealing mainly with product innovation at the top. This interpretation is consistent with the observed distribution of employees with tertiary education across firms making process and product innovation. In our data, we find that the share of employees with tertiary education is systematically higher among firms making only product innovation (13.4%) with respect to

those making only process innovation (8.7%).

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 non-innovative 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, the EPS effect on innovation is about 8 percentage points when the unionization rate is below 1%, but they decrease rapidly as unionization increases. A possible reason behind this finding is that unionization picks up the firm size effect; however, in our data the pairwise correlation coefficient between unionization and firm size (as measured by the number of employees) is very low, namely 0.0012 with p -value = 0.8528. Alternatively, it could be that unions may be introducing alternative mechanisms for the employees to negotiate on wages and to share-in innovation revenues (as suggested by previous empirical literature based on Italian data, e.g. Origo (2009) and Lucifora and Origo (2015)), but unfortunately data limitation prevents us from exploring

this possibility further.²⁴

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. One alternative interpretation is that firms with exposure to international markets may learn about various high-performance work practices and introduce them, and some of them are complementary to EPS. Consistently with this latter possibility, in our data we observe that about 53.2% of exporting firms report to have conducted worker training activities (including workshops, outdoor training, coaching, counselling and training on the job) in the year preceding the survey, whilst only 25.8% of firms report such activities among non-exporters.

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.

5.4.5 Complementarities between PS and upskilling practices

As we have argued, one possible interpretation of the contrasting effects of EPS and MPS is that much of innovation in our sample of Italian firms is incremental improvement at the grassroots rather than more radical top-down innovation. In particular, this interpretation is consistent with the larger effect of EPS on the probability of making process innovation relatively to product innovation, showed in Table 8. A mechanism that may drive the association between EPS and such incremental, typically process innovation is that EPS facilitates the adoption of employee upskilling programs as well as other complementary human resource management practices (HRMPs) which in their turn may improve the ability of the firm to innovate.²⁵

²⁴Another strand of literature has showed that there are contexts in which unions might serve as a vehicle to make PS more effective for those firms that do introduce PS (Doucouliagos *et al.*, 2019).

²⁵Previous research found that upskilling is most essential to innovation (Bauernschuster *et al.*, 2009; Dostie, 2017). Related to this, Acemoglu (1997) showed that workers are more willing to invest in their skills and

The richness of information provided by the EES-INAPP data allows us to explore empirically this possible channel. We focus on upskilling activities conducted through practices of various forms. We take advantage of both the 2010 and the 2015 EES-INAPP wave and use the information on whether the firm has conducted (i) formal classroom-based courses, (ii) in-firm workshops, (iii) outdoor training, (iv) coaching and counselling, and (v) other on-the-job learning initiatives. We run two simple empirical exercises. First, we measure the empirical association between the adoption of PS plans and any form of upskilling activities. If PS favours upskilling activities, then the relationship between PS and these activities should be positive. Specifically, we run a logit model where the dependent variable is a dummy equal to 1 when the firm has conducted any upskilling practice in the year preceding the survey and 0 otherwise 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, on the right-hand-side, we consider a set of dummies capturing the adoption of the five upskilling practices above mentioned one by one. If EPS influences innovation by facilitating the adoption of upskilling practices that improve the firm's probability to innovate, then the magnitude of the estimated parameter measuring EPS effects on innovation should be reduced when the adoption of upskilling practices is controlled for.

The results are collected in Table 9. In column [1], the dependent variable is the dummy for the adoption of any upskilling practice and we study how it is influenced by EPS. In columns [2]-[6], the dependent variable is the innovation dummy and we study how EPS effects on innovation change with the inclusion of the dummies for the various upskilling practices with respect to the baseline EPS parameter as reported in column [1] of Table 4.

[insert Table 9 about here]

In column [1] of Table 9, we observe that EPS is positively associated with the adoption of upskilling practices, while MPS is associated to a statistically insignificant effect. In columns [2]-[6], we find that the inclusion of any upskilling dummy reduces EPS effects with respect to the baseline estimate by about 29% or more (i.e. from 0.082 to 0.058 or less). Moreover, some of the upskilling practices here considered (namely, in-firm workshops, outdoor training, and other on-the-job learning initiatives) have a direct significant effect on innovation. These findings are consistent with the idea that non-managerial PS may induce higher innovation probability

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.

by facilitating the adoption of complementary upskilling practices that are instrumental to innovation (e.g. because they favour the development of firm-specific human capital).

Clearly, also other HRMPs may play a role in this context. For example, [Jones *et al.* \(2017\)](#) show that profit sharing may be complementary to practices of employee involvement (such as employee board representation, joint consultation committees, quality circles, self-managed teams, job rotation, suggestion schemes, and job satisfaction surveys), which in turn reduce workers' voluntary exits, thus retaining firm-specific human capital. [Jones *et al.* \(2010\)](#) find that teamwork practices may reinforce the effect of group-incentive pay on workers' efficiency and productivity. [Kato and Morishima \(2002\)](#) find that representative participation may facilitate trust in management and reduce managerial moral hazard, especially when combined with financial participation. Taken together, this literature suggests that it might be rational for firms to complement PS with HRMPs that promote worker participation and improve the workplace climate. Unfortunately, our data do not allow us to control for the adoption of HRMPs of this type.²⁶ If these complementary HRMPs are used along with EPS but not with MPS, and at the same time they are beneficial to innovation (because they influence innovation directly or because they improve EPS effects on innovation), our analysis may suffer from an omitted variable problem, as additional HRMPs variables would arguably pick up some of the EPS effects estimated in our regressions. Therefore, the EPS parameters obtained in our analysis may be upward biased and should be interpreted as an upper bound of the true EPS effect.

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, despite the fact that in Italy cash bonuses paid under MPS are generally at least twice as high as those paid to non-managers. Our results help documenting how PS may have differential effects on team-based measures of corporate performance, such as innovation, depending on the organizational layer 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. Moreover, by unveiling that EPS

²⁶Related to this, we only control for the unionization rate (which is the most common institutional channel of worker participation in Italy) and the rate of voluntary separation (which may partly reflect the quality of the workplace climate). In the descriptive statistics collected in Table 3 we showed that firms adopting EPS are more unionized and exhibit lower voluntary separation rates.

effects are relatively stronger for process innovation than for product innovation, our estimates can also be interpreted as suggesting that the type of innovation most strongly promoted by EPS is the one resulting in process improvements as opposed to new products. Since it could be that much of innovation in our sample of Italian firms is continuous improvement at the grassroots level rather than discrete innovation at the top, PS for managers may appear as less relevant in our analysis because of the type of innovation Italian firms deal with the most. Relatedly, an important caveat is that, given data availability, we did not use a continuous measure of innovation capturing innovation value. It is possible that MPS may not yield fruit as often as EPL but, when it does, the payoff is much greater than EPS. Unfortunately, we could not explore this possibility.

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, and medium-high span of control 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 the impact of EPS on innovation is weaker in more unionized firms. Could unionization be channeling some of the effect of firm size? Previous international evidence on the relationship between PS and unionization 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. The relationship between unions and PS, therefore, seems to 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 under PS, be it in the form of increased individual effort, stronger peer-pressure or more effective teamwork. Yet, a cleaner identification of causality requires unambiguously exogenous shocks in the use of PS, which we could not observe with our data. It is also likely that PS schemes are used as part of larger systems of performance-improving HRMPs and that the effects of PS on innovation are reinforced by the use of such practices. Related to this, we showed in particular that non-managerial PS is associated to the adoption of complementary upskilling practices that are instrumental to innovation, including in-firm workshops, outdoor training, and other on-the-job learning initiatives. However, data limitation prevented us from conducting a more refined analysis of the full set of possible complementarities between PS and HRMPs highlighted by the previous literature (e.g. [Jones *et al.* \(2017\)](#)). 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.

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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]	[2]	[3]	[4]	[5]	[6]
	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.
MPS	0.008 (0.012)	0.008 (0.012)	0.011 (0.012)	0.011 (0.012)	-0.014 (0.022)	0.012 (0.022)
EPS	0.082*** (0.027)	0.061** (0.027)	0.058** (0.027)	0.055** (0.021)	0.086** (0.043)	0.112** (0.053)
Individual-based PRP	-0.034 (0.031)	-0.044 (0.031)	-0.040 (0.031)	-0.049* (0.029)	-0.025 (0.055)	-0.017 (0.066)
Investments in R&D	NO	0.165*** (0.017)	NO	NO	NO	NO
Investments in automation	NO	NO	0.108*** (0.012)	NO	NO	NO
AR(1)	NO	NO	NO	0.215*** (0.009)	NO	NO
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]	[2]	[3]	[4]	[5]
	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.	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 (0.053)	-0.042 (0.053)	-0.033 (0.012)	-0.037 (0.051)
EPS (white/blue collars + non-managerial supervisors)		0.087*** (0.028)	0.067** (0.029)	0.063** (0.029)	0.056** (0.028)
CEO's pay based on PS	0.010 (0.013)	0.010 (0.013)	0.009 (0.013)	0.011 (0.013)	0.013 (0.012)
CEO's pay based on shares/stock options	0.006 (0.075)	0.006 (0.075)	0.011 (0.074)	0.019 (0.074)	0.018 (0.073)
CEO's pay based on PS and shares/stock options	-0.008 (0.050)	-0.005 (0.050)	-0.004 (0.050)	-0.001 (0.050)	-0.002 (0.049)
Individual-based PRP	-0.037 (0.031)	-0.037 (0.031)	-0.047 (0.032)	-0.042 (0.031)	-0.048 (0.030)
Investments in R&D	NO	NO	0.164*** (0.017)	NO	NO
Investments in automation	NO	NO	NO	0.105*** (0.012)	NO
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 (0.026)	0.015 (0.026)	0.016 (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** (0.052)	0.111** (0.057)	0.114** (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 multi-layer PS on any innovation.

	[1]	[2]	[3]	[4]	[5]	[6]
	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.	THE FIRM MAKES ANY INN.
Only MPS	0.005 (0.012)	0.009 (0.012)				
(β_2) Only EPS	0.077** (0.031)	0.053* (0.030)				
(β_3) MLPS	0.102*** (0.037)	0.066* (0.036)				
MPS			0.007 (0.012)	0.007 (0.012)	0.010 (0.012)	0.012 (0.012)
EPS			0.077** (0.032)	0.057** (0.033)	0.052* (0.032)	0.052* (0.026)
MPS \times EPS			0.013 (0.047)	0.011 (0.047)	0.015 (0.047)	-0.003 (0.045)
$H_0: \beta_3 - \beta_2 = 0$ [p -value]	[0.577]	[0.750]				
Individual-based PRP	-0.038 (0.031)	-0.050* (0.029)	-0.035 (0.031)	-0.045 (0.031)	-0.041 (0.032)	-0.046 (0.030)
Investments in R&D	NO	NO	NO	0.165*** (0.017)	NO	NO
Investments in automation	NO	NO	NO	NO	0.108*** (0.012)	NO
AR(1)	NO	0.212*** (0.009)	NO	NO	NO	0.215*** (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
# of obs.	7379	7379	7051	7018	7018	7051
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. Variables measuring only MPS, only EPS, MPLS, MPS and EPS (and their interaction) 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 PS on process and product innovation.

	[1]	[2]	[3]	[4]
	THE FIRM MAKES PROCESS INN.	THE FIRM MAKES PRODUCT INN.	THE FIRM MAKES PROCESS INN.	THE FIRM MAKES PRODUCT INN.
MPS	0.014 (0.011)	0.007 (0.011)		
EPS	0.056** (0.022)	0.041* (0.024)		
MPS (simultaneous effect)			-0.019* (0.010)	-0.001 (0.011)
EPS (simultaneous effect)			0.103*** (0.027)	0.078*** (0.030)
Individual-based PRP	-0.048* (0.026)	-0.014 (0.028)	-0.042 (0.025)	-0.012 (0.027)
Investments in R&D	0.059*** (0.015)	0.097*** (0.016)	0.060*** (0.015)	0.097*** (0.016)
Investments in automation	0.032*** (0.012)	0.040*** (0.012)	0.032*** (0.012)	0.040*** (0.012)
AR(1)	0.168*** (0.009)	0.211*** (0.009)	0.168*** (0.009)	0.211*** (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.	7005	7004	7005	7004
Estimation	LOGIT	LOGIT	LOGIT	LOGIT

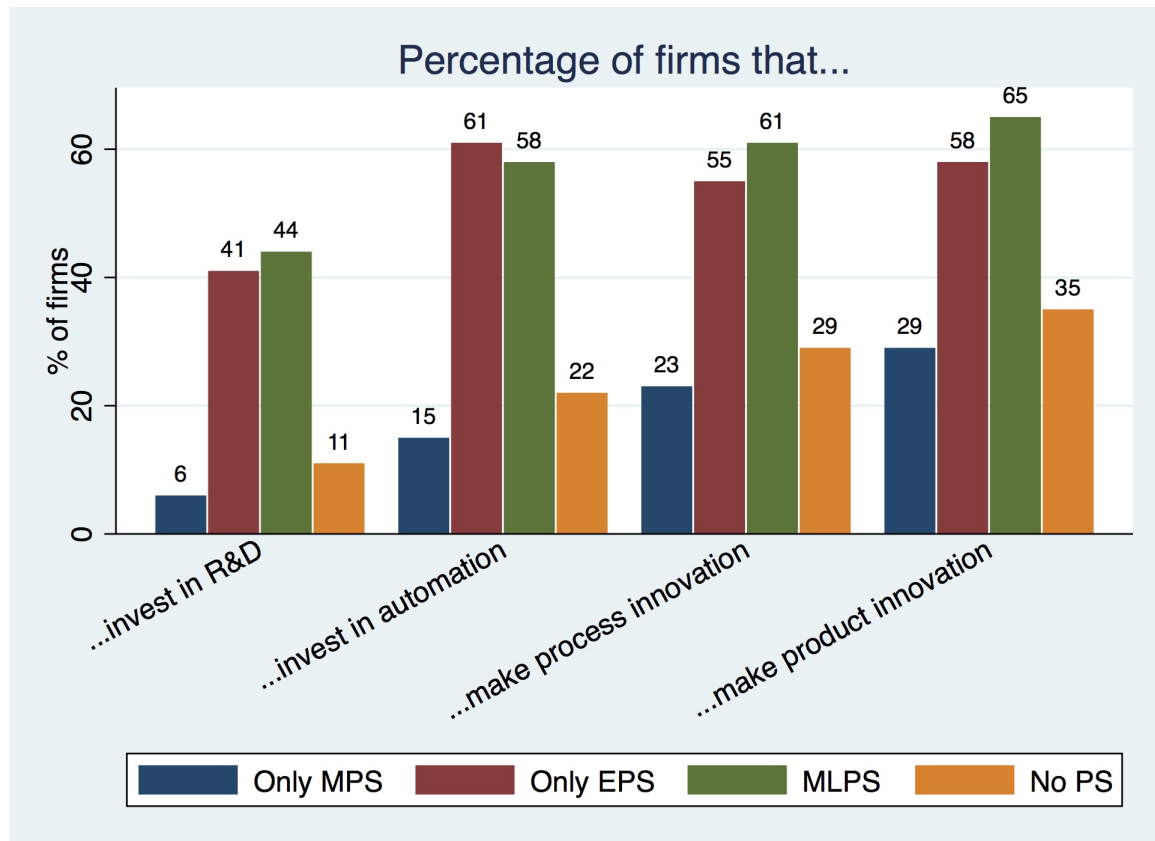
Statistical significance: * =10%, ** =5%, *** =1%. The entries are marginal effects. Standard errors are in parentheses. The dependent variable is a dummy for the firm making either product or process innovation. Both MPS and EPS are 1-wave lagged if not otherwise specified. Simultaneous effects of MPS and EPS are obtained by using MPS and EPS variables from the same wave as the dependent variable. 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: PS and upskilling practices.

	[1] THE FIRM MAKES ANY UPSKILLING PRACTICE	[2] THE FIRM MAKES ANY INNOVATION	[3] THE FIRM MAKES ANY INNOVATION	[4] THE FIRM MAKES ANY INNOVATION	[5] THE FIRM MAKES ANY INNOVATION	[6] THE FIRM MAKES ANY INNOVATION
MPS	-0.012 (0.012)	-0.009 (0.019)	-0.010 (0.019)	-0.011 (0.019)	-0.010 (0.019)	-0.011 (0.019)
EPS	0.074** (0.032)	0.056* (0.033)	0.051* (0.033)	0.056* (0.033)	0.058* (0.033)	0.053* (0.033)
Classroom courses		0.016 (0.024)				
In-firm workshops			0.057*** (0.021)			
Outdoor training				0.062* (0.034)		
Coaching and counselling					0.023 (0.038)	
On-the-job learning						0.047** (0.022)
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.	7347	2918	2918	2918	2918	2918
Estimation	LOGIT	LOGIT	LOGIT	LOGIT	LOGIT	LOGIT

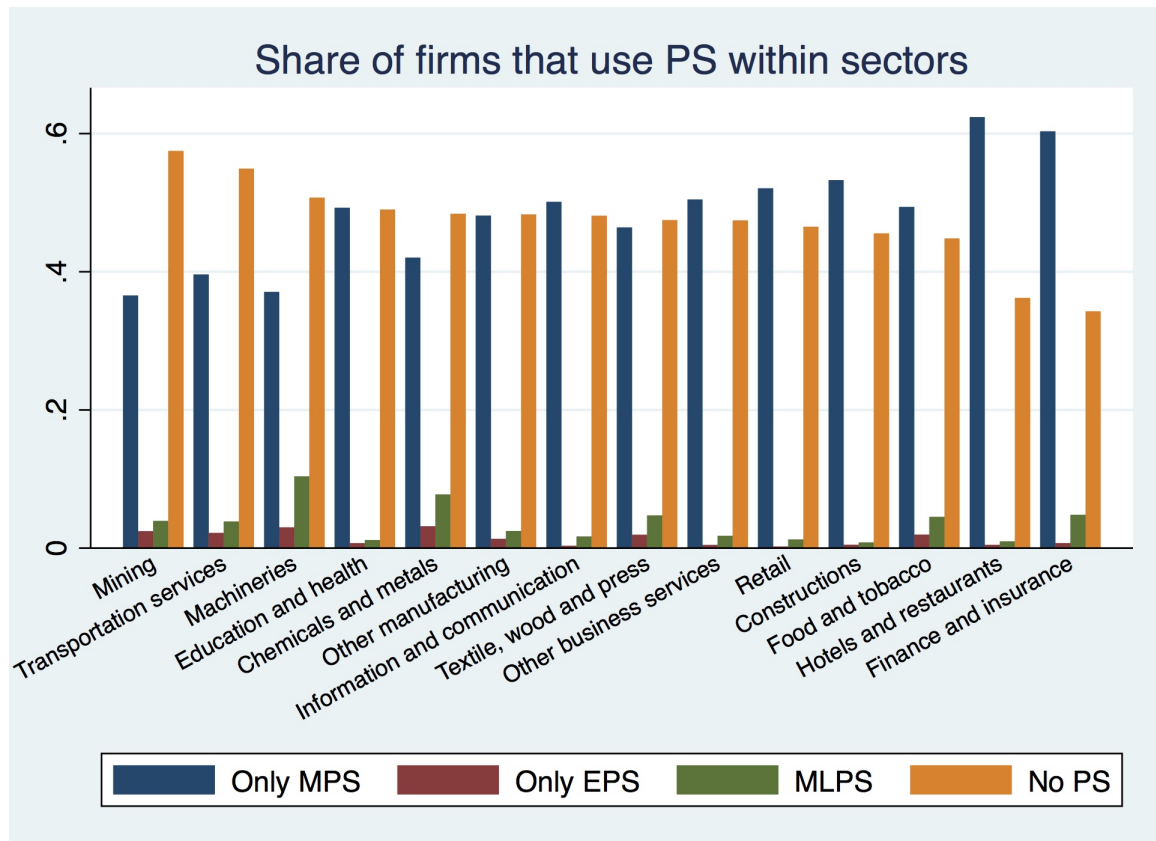
Statistical significance: * =10%, ** =5%, *** =1%. The entries are marginal effects. Standard errors are in parentheses. The dependent variable is a dummy for the firm making training activity. Both MPS and EPS are 1-wave lagged. Firm-level controls (1-wave lagged) include: individual-based PRP, investments in R&D, investments in automation, past innovation dummy, 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.



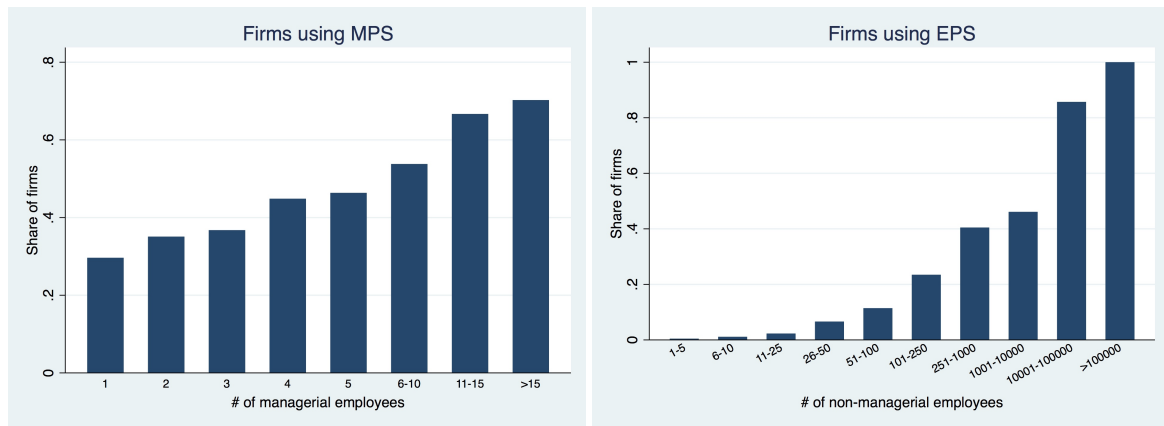
Descriptive statistics are obtained over the pooled sample covering the 2010 and 2015 waves of the EES-INAPP data. The size of the pooled sample is 54550 observations (10306 firms are followed longitudinally across the two waves, amounting to 20612 panel observations; the remaining 33938 observations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

Figure 2: PS policy of firms, by sector.



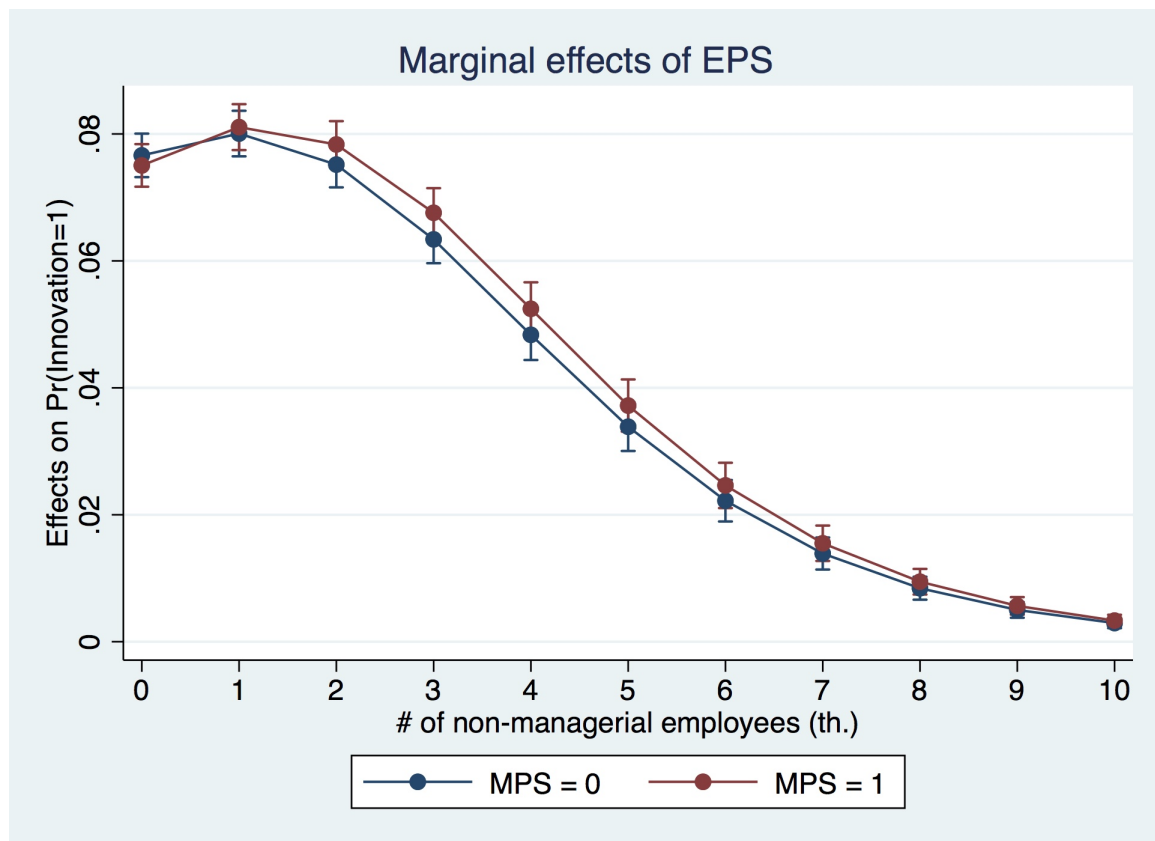
Descriptive statistics are obtained over the pooled sample covering the 2010 and 2015 waves of the EES-INAPP data. The size of the pooled sample is 54550 observations (10306 firms are followed longitudinally across the two waves, amounting to 20612 panel observations; the remaining 33938 observations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

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



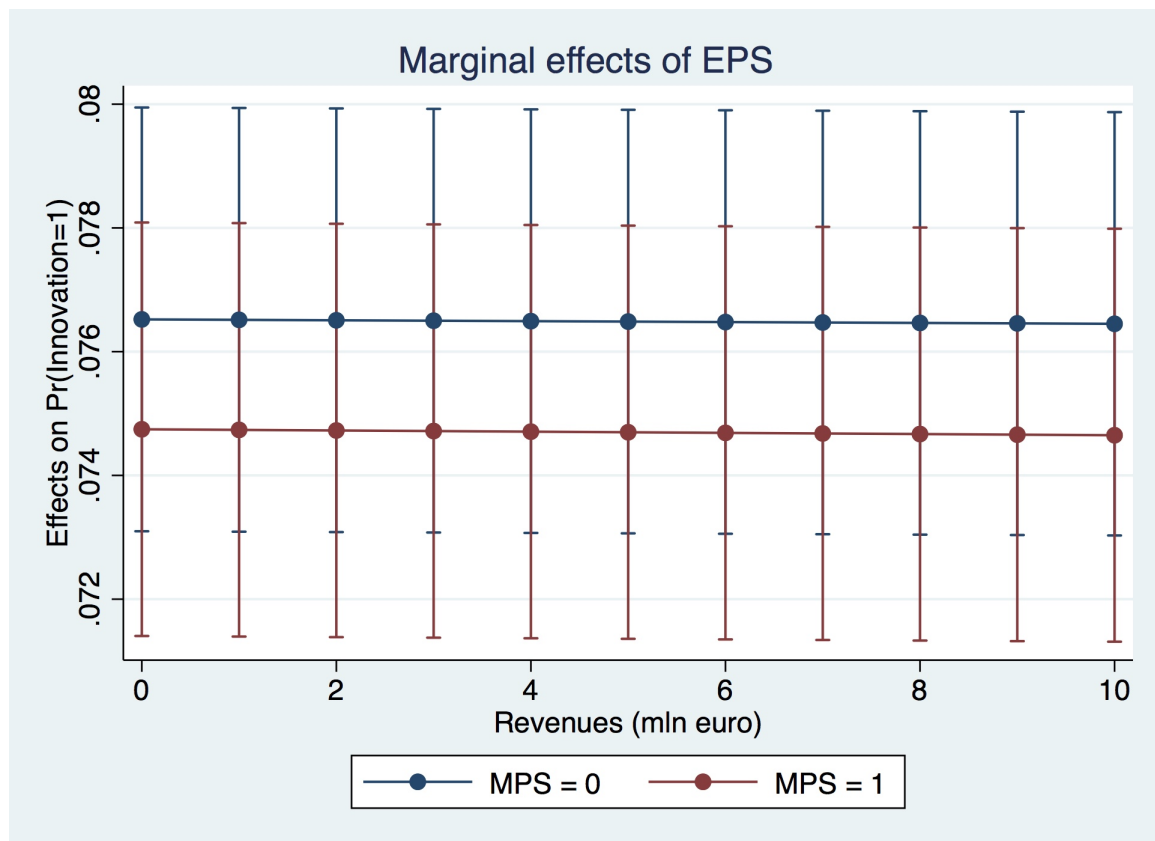
Descriptive statistics are obtained over the pooled sample covering the 2010 and 2015 waves of the EES-INAPP data. The size of the pooled sample is 54550 observations (10306 firms are followed longitudinally across the two waves, amounting to 20612 panel observations; the remaining 33938 observations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

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



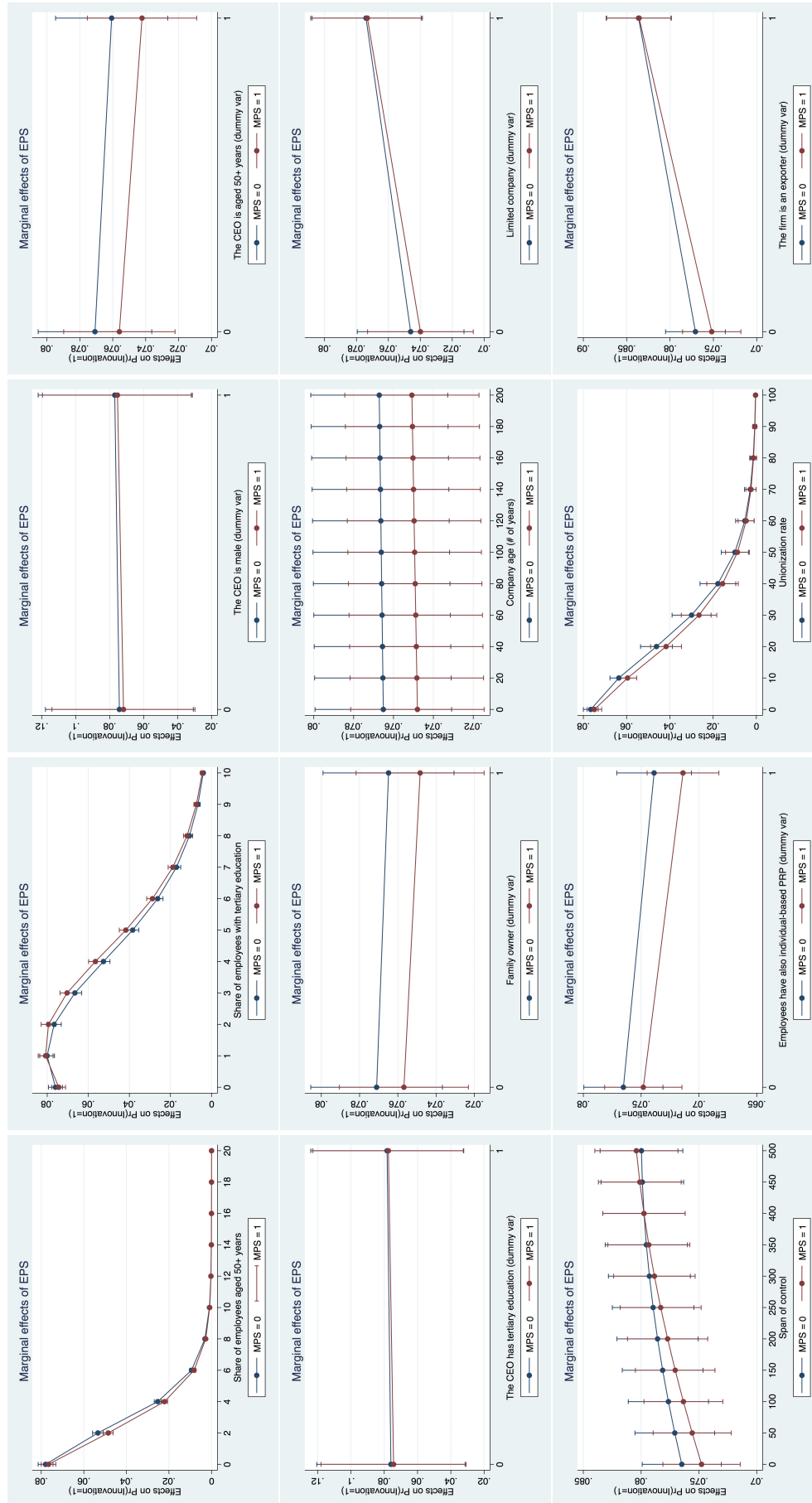
Conditional marginal effects of EPS on innovation are obtained by estimating our baseline logit model, as specified in column [2] of Table 4. The full set of controls is included, covering individual-based PRP, rate of voluntary separations, share of the workforce with tertiary education, share of the 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.



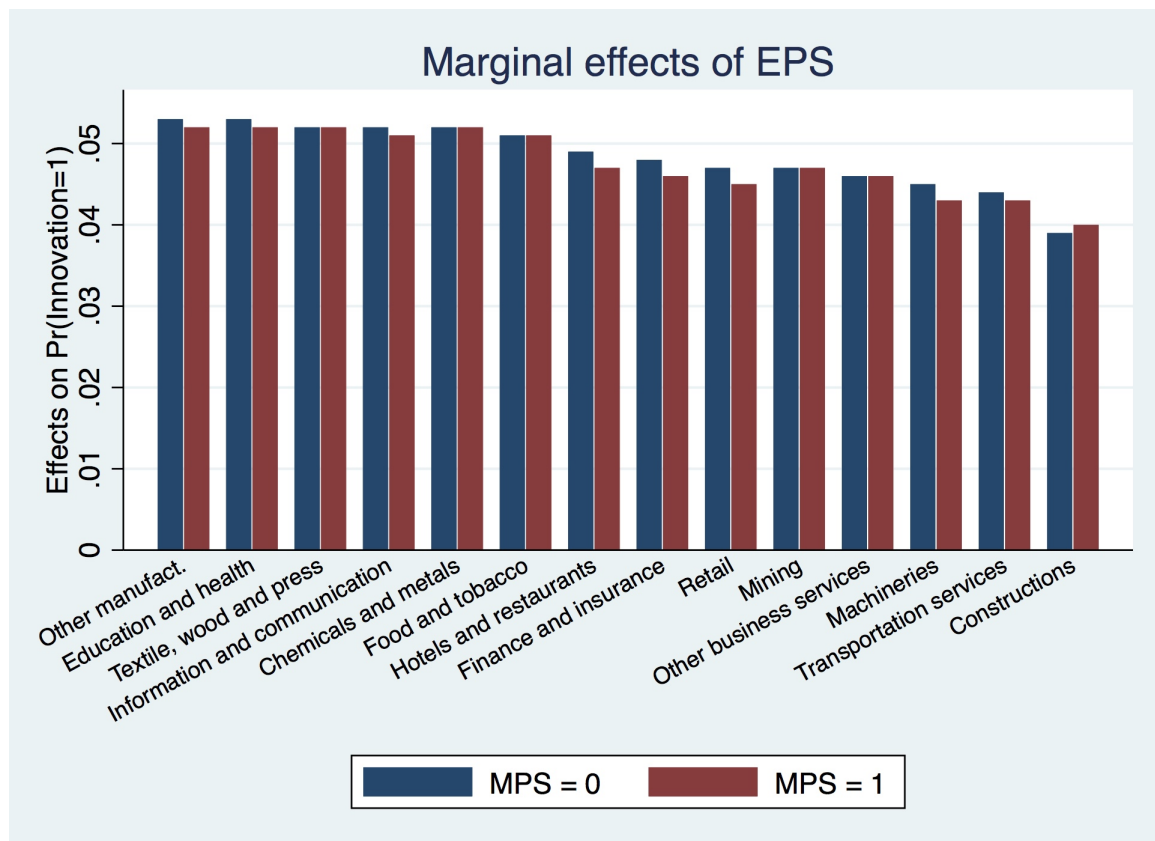
Conditional marginal effects of EPS on innovation are obtained by estimating our baseline logit model, as specified in column [2] of Table 4. The full set of controls is included, covering individual-based PRP, rate of voluntary separations, share of the workforce with tertiary education, share of the 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.