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Employer-Employee Profit-Sharing and the Incentives to Innovate when the Dismissal Regulation Matters

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Abstract

We develop a simple incomplete-contract model of the relationship between worker participation to revenue sharing and innovation performance of firms, under firing regimes with different stringency. Stronger worker participation to profits is shown to increase innovation probability when employer-side hold-up is prevented by stringent layoff regulation and the human capital matters significantly. Vice-versa, under a strict layoff regulation, when the financial capital is relatively more important, the effects of worker participation devices may be reduced or inverted. Our results may help in understanding why there is no one-size-fits-all optimal strategy in the design of worker financial participation mechanisms for knowledge-intensive productions.

Keywords: profit-sharing, dismissal regulation, hold-up, innovation.
JEL classification: J54, K31, O31

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1 Introduction

The way employee ownership and worker participation to corporate profits may contribute to the production of technological innovations has garnered increasing attention over the last decades, due to the growing importance of finding performance-improving solutions for knowledge-intensive organizations. A long standing empirical literature has analyzed how worker financial participation and ownership may influence a firm's performance from various perspectives, since the early study of Smith (1994) on worker cooperatives and innovation quality to more recent contributions on group incentive performance related pay and employee financial participation schemes. In particular, a strand of study has focused on profit-sharing devices (Jones and Kato, 1995; Doucouliagos, 1995; Jones *et al.*, 2010; Bryson *et al.*, 2012; Aerts *et al.*, 2015) and on the complementarities between employee involvement and financial participation (Jones *et al.*, 2017) in traditional shareholder-owned firms, generally pointing to a positive effect of employee ownership and financial participation practices on productivity and product quality. Very recently, Kato and Kauhanen (2018) showed that employee financial participation schemes (e.g. profit/gain-sharing, employee stock ownership and stock options) are more potent in boosting enterprise productivity than individual incentive devices that link pay to individual performance.

This literature has largely improved our understanding of the productivity effects of group incentive pay mechanisms, such as worker ownership and profit-sharing, emphasizing the role of self-enforcing cooperative mechanisms. At the same time, however, it has overlooked the role played by labour regulatory frameworks (including dismissal regulations and firing restrictions), which may be of great relevance especially when financial participation instruments are adopted within a standard (and still most common) employee-employer relationship.

When the employer is credibly committed not to extract rents from innovative employees, the worker may contribute to the production of technological innovation in several ways. Typically, workers may increase their cognitive effort necessary to acquire and elaborate new information, to understand firm-specific technical problems and to learn firm-specific technologies and organizational schemes, may exchange information on possibilities to improve the production process and products with the management, may improve collaborative relationships with colleagues in order to develop new ideas, and may undertake firm-specific learning aimed at developing specialized human capital. The contribution of workers in driving product innovation has risen over time. For example, Bond *et al.* (2005) report that at least 60% of R&D budgets typically consist of the wages and salaries of highly qualified scientists and engineers. This motivates to think harder about which institutional devices may improve commitment in the firm and the expectation of workers to actually participate in gain-sharing, once the innovation revenues are realized.

In this paper, we try to contribute to this issue in an incomplete contracts Grossman-Hart-Moore framework (Grossman and Hart, 1986; Hart and Moore, 1990), by focusing on profit-sharing as a possible trigger for employee-driven innovation and by developing a simple theoretical model that incorporates both positive and negative effects of worker financial participation on innovation incentives for firms, under alternative firing regimes which differ in terms of stringency. The underpinnings of this model are based on Aghion and Tirole (1994). They analyze the basic contractual relationship between employees and a financier in an innovative firm. They posit that the exact nature of the innovation is ill-defined ex-ante and that the parties involved cannot contract for delivery of a specific innovation. Based on the allocation of property rights on any forthcoming innovation, Aghion and Tirole distinguish an integrated case, in which the financier owns and freely uses the innovation, from a non-integrated case, in which the employees own the innovation and, once the innovation is made, bargain with the financier over the license fee. The model of Aghion and Tirole shows that giving property rights to the employees is optimal when it is more important to encourage the employee's effort to discover than to boost the employer's financial investment in the research. In addition to this Grossman and Hart-like conclusion, we account for the possibility that negligible firing costs leave a hold-up power to the shareholder even if he does not own the innovation, and show that, in this case, any sharing rule contracted upon ex-ante is irrelevant. The main result of our model is that dismissal regulations have an impact on whether worker financial participation increases innovation, also depending on the relative relevance of the human capital with respect to the financial or physical capital.

While this paper mainly aims at shedding light on the possible positive and negative effects of employee financial participation mechanisms on innovative productions in regulated labour markets, it also contributes to a recent literature on employment protection and innovation (Acharya *et al.*, 2013, 2014; Griffith and Macartney, 2014; Belloc, 2018). In particular, our result that employment protection laws may act as a substitute of commitment and restore the incentive-compatibility of shared-ownership, with a positive effect on innovation being larger in human capital intensive environments, provides a theoretical complement to the empirical findings of Acharya *et al.* (2014), Griffith and Macartney (2014) and Belloc (2018). Acharya *et al.* (2014) used U.S. data to show that wrongful discharge laws (i.e., laws that protect employees against unjust dismissal) spur patenting activity in high innovation-intensive industries, by limiting employers' ability to hold-up employees after the innovation is successful. Griffith and Macartney (2014) studied the patenting behaviour of a sample of multinational firms and found that the optimal level of investment in incremental innovation increases in countries with stronger layoff regulations. Belloc (2018) exploited cross-country variations of labour laws and found that stronger employee representation laws in the presence of stricter firing restrictions are associated with higher innovation rates, particularly in those sectors where the human capital contribution to production is higher. We add to this empirical literature, by introducing a unified theoretical framework for studying the joint effects of financial participation schemes and dismissal regulation on innovation.

In doing so, we also provide a contribution with respect to the theoretical model presented in Acharya *et al.* (2014), which shows that an increase in the strictness of the dismissal regulation unambiguously increases the probability of innovation, by improving the bargaining power of workers and their effort at the workplace. We improve on this in two main directions. First, we model both human and financial efforts as inputs in the innovation process. This leads us to have an ambiguous overall effect of stricter firing restrictions on innovation, which depends on the relative contribution of human and financial capital to the success of the innovative project. In Acharya *et al.* (2014), the effort exerted by the employee is the only input to the innovation process. Second, we cross firing costs with an exogenously determined profit-sharing rule, and study optimal decisions over both working and financial efforts as determined by a combination of the dismissal regulation and the profit-sharing rule, while in Acharya *et al.* (2014) the employee's effort only depends on the dismissal regulation.

From a policy perspective, our analysis may thus provide useful insights in the debate on the deregulation of dismissals. In actual facts, OECD countries show some substantial heterogeneity in the way layoffs are regulated, with the at-will employment system of Anglo-Saxon economies being perceived as a sort of benchmark model by several European countries currently undertaking labour market reforms. In particular, the OECD indicator of the strictness of employment protection against individual and collective discharge of workers with a regular contract shows that the U.S., the U.K. and Ireland have relatively weaker legislations, while Italy, France and some other Southern and Central European countries are among the most stringent systems in terms of the legal instruments for protecting workers against dismissal (OECD, 2018). Related to this, our analysis may allow for more granular policy prescriptions with respect to previous literature (e.g., Acharya *et al.* (2014)), by suggesting that there is no one-size-fits-all optimal design of financial participation devices, under cross-country heterogeneity of employment protection and cross-sector heterogeneity in human capital intensity, and therefore that a simple transplantation of a successful ownership model from a country/sector environment to another may cause incentives distortions.

The remaining of the paper is organized as follows. In Section 2, we develop our baseline model of employee financial participation effects on innovation in a one-game framework. In Section 3, we discuss on the compatibility of our baseline model with the Shapiro-Stiglitz efficiency wage model, and extend our exercise to a context with increasing utility of effort, endogenous profit-sharing rule and multiple interactions (i.e., repeated labour contracts between an entrepreneur and his employees). Section 4 concludes.

2 A simple model of profit-sharing effects on innovation

A stylised firm is composed of a worker (w) and a shareholder-entrepreneur (s). Both the worker and the shareholder are concerned with the production of a technological innovation with a market value equal to Ψ (with $\Psi > 0$), which they split ex-post in a quota α to the worker and $1-\alpha$ to the shareholder (with $\alpha \in [0, \frac{1}{2}]$). If $\alpha = 0$, profit rights are entirely allocated to the shareholder (shareholder-profit rights case); if $\alpha = \frac{1}{2}$ profit rights are jointly assigned to the shareholder and the worker (joint-profit rights case). The profit-sharing rule α is given since the beginning of the employment relationship and it is incomplete (in the sense of Grossman and Hart (1986) and Hart and Moore (1990)).[1] Thus, it can be enforced by a third party only within the labour contract and, if the labour relationship ceases (for example, because the worker is fired) before the innovation revenues are distributed, the profits remain entirely in the firm (even if $\alpha > 0$) and the worker cannot claim them by taking the employer to court. Both parties can contribute to the innovation process with, respectively, working effort ($\eta_w(\alpha, \tilde{\Psi}_w) \in [0, \overline{\eta}_w]$) and financial effort ($\varphi_s(\alpha, \tilde{\Psi}_s) \in [0, \overline{\varphi}_s]$), where $\tilde{\Psi}$ (with $\tilde{\Psi} > 0$) is the expected value of the innovation. The financial effort encompasses both the investment in physical assets and the finance of firm-specific training for the development of human capital. Let us assume that the worker and the shareholder have the same expectation on Ψ (i.e. $\tilde{\Psi}_w = \tilde{\Psi}_s = \tilde{\Psi}$). Both $\eta_w(\alpha, \tilde{\Psi})$ and $\varphi_s(\alpha, \tilde{\Psi})$ are strictly convex and increasing in the share of Ψ they expect to get at the end of the production process, i.e. respectively α and $1-\alpha$. The working effort is verifiable and contractible only up to the level $\underline{\eta}_w$ (with $\underline{\eta}_w > 0$), while effort exterted above $\underline{\eta}_w$ is not verifiable and so cannot be part of an explicit contractual agreement. The working effort has an upper limit $\overline{\eta}_w$, due to physical constraints. On the other hand, the financial effort of the shareholder is constrained between 0 and a level $\overline{\varphi}_s$ due to financial constraints. Assume further that φ_s is sunk and not contractible, i.e. the worker cannot force the shareholder to contribute finance to the firm, and that the worker cannot raise finance on the capital market. The success of the innovation process is uncertain and is described by the probability function $\varrho(\eta_w(\alpha, \tilde{\Psi}), \varphi_s(\alpha, \tilde{\Psi}))$, that is increasing

[1] We assume the sharing rule α being exogenously given in the model (for example, it can be assumed to be due to a corporate charter or bylaw).

in $\{\eta_w(\alpha, \tilde{\Psi}), \varphi_s(\alpha, \tilde{\Psi})\}$. Let us also assume that the technology has a separable form (this is not crucial for the argument) as follows: $\varrho(\eta_w(\alpha, \tilde{\Psi}), \varphi_s(\alpha, \tilde{\Psi})) = \zeta(\eta_w) \cdot \xi(\varphi_s)$, where $\zeta(\eta_w)$ and $\xi(\varphi_s)$ are functions relating innovation outcomes to working and financial efforts respectively. This latter property means that financial effort and worker effort are complementary. We simplify the model by assuming that the firm is composed by only one worker and one shareholder, thereby ignoring possible free-riding among multiple employees and shareholders.[2]

We consider the labour relationship between the worker and the shareholder being subject to a labour regulation according to which employment is at-will (i.e., the employee can be dismissed by the shareholder for any reason and without warning) and some costs (χ) must be paid by the shareholder when terminating the labour contract. In particular, firing costs may have a monetary or non-monetary nature and have the form of a tax (i.e., payments that are not received by the worker).[3]

As for the timing, we consider a three-period setting. In t_1, both the worker and the shareholder take their investment decisions. In t_2, the production process takes place and the output is realized. In t_3, the shareholder collects the revenues, pays the employee and gets the residual profits. We further assume that the distributions of $\varphi_s(\alpha, \tilde{\Psi})$, $\eta_w(\alpha, \tilde{\Psi})$ and $\varrho(\eta_w(\alpha, \tilde{\Psi}), \varphi_s(\alpha, \tilde{\Psi}))$ are common knowledge; both parties, thus, can take their optimal investment decisions ex-ante, in t_1, by backward induction, including the hold-up decision of the shareholder.

In order to analyze the effects of different worker financial participation regimes, we examine separately the case in which dismissal laws impose significant costs on firing decisions, therefore locking parties into a bilateral relationship until payoffs are paid, from the situation in which labour laws make employee dismissal costless for the shareholder, so that the latter can threaten to fire (i.e. hold-up) the worker after the output is produced without the worker having received his share of the innovation revenues (the worker receives only a baseline fixed compensation). Phrased differently, firing allows the shareholder to appropriate the full value of the innovation in exchange for paying the

[2]An extension in the form of a nested model, with complementary investments made by multiple workers (and/or multiple shareholders) and sub-sharing of profits among workers (and/or shareholders), would only increase the complexity of the analysis without changing our conclusions substantially.

[3]This is different from the way firing costs are modeled in Acharya *et al.* (2014), where the cost of firing is a penalty that the firm may be ordered to pay to the wrongfully dismissed employee, if the employee wins the lawsuit, with the penalty being proportional to the value of the project.

worker a fixed wage.

2.1 Prohibitively costly firing

Assume first that, having hired a worker, it is prohibitively costly to fire him, i.e. to hold him up (we will specify the threshold level of firing costs more precisely later). In this environment, the investment decisions of both the worker and the shareholder and the probability of innovating depend crucially on the profit-sharing scheme adopted by the firm.

2.1.1 Shareholder-profit rights (SPR) case

If no profit rights are given to the employee, then the shareholder retains all of the revenues, i.e. $\alpha = 0$. In this case, the worker has no incentive to exert any additional effort above $\underline{\eta}_w$ and gets a baseline fixed compensation ω_w (with $\underline{\eta}_w \leq \omega_w < \frac{1}{2}\tilde{\Psi}$), while the shareholder acts in order to solve the problem:

$$\max_{\varphi_s} \quad \pi_s = \varrho(\underline{\eta}_w, \varphi_s(\tilde{\Psi})) \cdot \tilde{\Psi} - \varphi_s - \omega_w \tag{1}$$

and chooses a level of financial effort equal to $\varphi_s^*(\tilde{\Psi})$. Final payoffs v_w^{SPR} and π_s^{SPR} of, respectively, the worker and the shareholder will be:

$$v_w^{SPR} = \omega_w - \underline{\eta}_w \tag{2}$$

and

$$\pi_s^{SPR} = \varrho(\underline{\eta}_w, \varphi_s^*(\tilde{\Psi})) \cdot \Psi - \varphi_s^*(\tilde{\Psi}) - \omega_w. \tag{3}$$

The probability of observing a successful innovation in this case is $\varrho(\underline{\eta}_w, \varphi_s^*(\tilde{\Psi}))$.

2.1.2 Joint-profit rights (JPR) case

With joint-profit rights, the two parties jointly hold some rights over the innovation revenues. To keep the problem simple, let us assume that the worker and the shareholder are assigned an equal right to revenue sharing, so that $\alpha = \frac{1}{2}$.

In this case, the worker will solve the problem:

$$\max_{\eta_w} \quad \upsilon_w = \frac{\varrho(\eta_w(\frac{1}{2}\tilde{\Psi}), \varphi_s(\frac{1}{2}\tilde{\Psi})) \cdot \tilde{\Psi}}{2} - \eta_w, \tag{4}$$

will choose a level of working effort equal to $\eta_w^{**}(\frac{1}{2}\tilde{\Psi})$ and will obtain a payoff equal to:

$$\upsilon_w^{JPR} = \frac{\varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^{**}(\frac{1}{2}\tilde{\Psi})) \cdot \Psi}{2} - \eta_w^{**}(\frac{1}{2}\tilde{\Psi}) \tag{5}$$

where $\eta_w^{**}(\frac{1}{2}\tilde{\Psi}) > \underline{\eta}_w$.[4] On the other hand, the shareholder solves:

$$\max_{\varphi_s} \quad \pi_s = \frac{\varrho(\eta_w(\frac{1}{2}\tilde{\Psi}), \varphi_s(\frac{1}{2}\tilde{\Psi})) \cdot \tilde{\Psi}}{2} - \varphi_s, \tag{6}$$

chooses $\varphi_s^{**}(\frac{1}{2}\tilde{\Psi})$ and gets:

$$\pi_s^{JPR} = \frac{\varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^{**}(\frac{1}{2}\tilde{\Psi})) \cdot \Psi}{2} - \varphi_s^{**}(\frac{1}{2}\tilde{\Psi}) \tag{7}$$

where $\varphi_s^{**}(\frac{1}{2}\tilde{\Psi}) < \varphi_s^{*}(\tilde{\Psi})$.

Here, the probability of observing a successful innovation is $\varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^{**}(\frac{1}{2}\tilde{\Psi}))$.

The threshold level of firing costs. We can now obtain the threshold level of firing costs as follows. Suppose that, in a joint-profit rights scheme, the shareholder chooses a hold-up strategy in order to appropriate the full value of the innovation after the worker has exerted $\eta_w(\frac{1}{2}\tilde{\Psi})$ level of effort. In

[4] The extent to which $\eta_w^{**}(\frac{1}{2}\tilde{\Psi})$ is greater than $\underline{\eta}_w$ depends also on possible shirking.

this case, the shareholder, in t_1, solves the problem:

$$\max_{\varphi_s} \quad \pi_s = \varrho(\eta_w(\frac{1}{2}\tilde{\Psi}), \varphi_s(\tilde{\Psi})) \cdot \tilde{\Psi} - \varphi_s - \omega_w - \chi,$$

exerts a financial effort equal to $\varphi_s^*(\tilde{\Psi})$ and obtains:

$$\pi_s^\delta = \varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^*(\tilde{\Psi})) \cdot \Psi - \varphi_s^*(\tilde{\Psi}) - \omega_w - \chi;$$

while, if he did not hold-up, he would have obtained π_s^{JPR}. Hold-up, therefore, is certainly prevented if

$$\chi > \varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^*(\tilde{\Psi})) \cdot \Psi - \varphi_s^*(\tilde{\Psi}) - \omega_w - \pi_s^{JPR}. \tag{8}$$

Indeed, because $\eta_w^{**}(\frac{1}{2}\tilde{\Psi})$ is the maximum effort the worker may exert, if this is still not enough to increase the expected value of the innovation to the point where the expected benefit of appropriation exceeds the cost χ, nothing will. However, the inverse of condition (8) does not mean that hold-up is always ex-ante profitable, because, if the worker anticipates that he will get only the baseline compensation, he will only exert $\underline{\eta}_w$, and, if $\varrho(\underline{\eta}_w, \varphi_s^*(\tilde{\Psi})) \cdot \Psi - \varphi_s^*(\tilde{\Psi}) - \omega_w - \pi_s^{JPR} < \chi < \varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^*(\tilde{\Psi})) \cdot \Psi - \varphi_s^*(\tilde{\Psi}) - \omega_w - \pi_s^{JPR}$, for the shareholder it is still convenient not to hold the worker up. Thus, in conclusion, the sufficient condition for firing to be ex-ante unprofitable is

$$\chi > \varrho(\underline{\eta}_w, \varphi_s^*(\tilde{\Psi})) \cdot \Psi - \varphi_s^*(\tilde{\Psi}) - \omega_w - \pi_s^{JPR}, \tag{9}$$

that is

$$\chi > \pi_s^{SPR} - \pi_s^{JPR}, \tag{10}$$

which is weaker than condition (8).[5]

[5]Notice that, if condition (10) holds and, therefore, the worker is able to anticipate that the shareholder is not going

Notice that, in order to keep the problem tractable, we are assuming that both the worker and the shareholder are able to observe the level of the firing costs and the distribution of the human and financial effort (as function of α and $\tilde{\Psi}$) and that of $\varrho(\eta_w(\alpha, \tilde{\Psi}), \varphi_s(\alpha, \tilde{\Psi}))$. So, the two players can take their optimal investment decisions ex-ante, by backward induction, as in traditional Grossman-Hart-Moore models. In particular, given his information set, the worker is always able to anticipate whether to play hold-up is profitable for the shareholder and he can take his optimal investment decision, in t_1, accordingly (i.e., in choosing his effort, the worker does not simply take into account the likelihood that the shareholder will hold him up, but he can fully anticipate that event). As a result, in this framework, both contracting parties have a strictly dominant strategy.

2.2 Costless firing

If the employee dismissal is costless for the shareholder (i.e. $\chi < \pi_s^{SPR} - \pi_s^{JPR}$), the latter will find it profitable to hold the worker up after the output is produced, i.e. the shareholder will refuse to make payments above the contractible level ω_w and will retain all of the innovation revenues Ψ. In this environment, even if $\alpha > 0$, the worker has no incentive to exert any additional effort above $\underline{\eta}_w$, to the extent he anticipates the opportunistic behaviour of the shareholder. The shareholder, on the other hand, will solve the problem:

$$\max_{\varphi_s} \quad \pi_s = \varrho(\underline{\eta}_w, \varphi_s(\tilde{\Psi})) \cdot \tilde{\Psi} - \varphi_s - \omega_w \tag{11}$$

and will choose a level of financial effort equal to $\varphi_s^*(\tilde{\Psi})$, giving rise to a probability of innovation equal to $\varrho(\underline{\eta}_w, \varphi_s^*(\tilde{\Psi}))$ (that is the same of the shareholder-profit rights case under prohibitively costly firing).

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to play hold-up, he will decide his optimal level of effort by comparing the two alternative payoffs $\frac{\varrho(\underline{\eta}_w, \varphi_s^{**}(\frac{1}{2}\tilde{\Psi}))\cdot\Psi}{2} - \underline{\eta}_w$ and $\frac{\varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^{**}(\frac{1}{2}\tilde{\Psi}))\cdot\Psi}{2} - \eta_w^{**}(\frac{1}{2}\tilde{\Psi})$. Assuming that the incremental value of the innovation is, for the worker, higher than the incremental cost of effort, we will have that $\frac{\varrho(\underline{\eta}_w, \varphi_s^{**}(\frac{1}{2}\tilde{\Psi}))\cdot\Psi}{2} - \underline{\eta}_w < \frac{\varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^{**}(\frac{1}{2}\tilde{\Psi}))\cdot\Psi}{2} - \eta_w^{**}(\frac{1}{2}\tilde{\Psi})$ and so that the worker, under condition (10), will always choose $\varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi})$ level of effort. As a consequence, in the joint-profit rights scheme, if condition (10) holds, the probability of observing a successful innovation is $\varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^{**}(\frac{1}{2}\tilde{\Psi}))$, as mentioned in the text.

We summarize these results in Table 1 (while alternative cases are discontinuous and well defined in the Table, they may partially overlap in reality).

[insert Table 1 about here]

To the extent that the explicit form of the two components of ϱ (i.e. $\zeta(\eta_w)$ and $\xi(\varphi_s)$) is unknown, the model fails to uniquely predict whether the probability of innovation is relatively higher where $\alpha > 0$ and firing is prohibitively costly. The model suggests that, under dismissal laws imposing costly firing, stronger worker financial participation increases the probability of a firm's innovating only when the working effort is relatively more important to the success of the innovation process than the financial effort, that is, formally, when

$$|\partial\zeta(\eta_w)/\partial\alpha| > |\partial\xi(\varphi_s)/\partial\alpha|. \tag{12}$$

3 Additional results and discussion

3.1 Compatibility with the Shapiro-Stiglitz efficiency wage model

One of the main results of our model is that, under costless firing (precisely, if $\chi < \pi_s^{SPR} - \pi_s^{JPR}$), the worker gets a baseline fixed compensation ω_w (with $\underline{\eta}_w \leq \omega_w < \frac{1}{2}\tilde{\Psi}$). In this case, the worker has no incentive to undertake additional effort above the contractible level $\underline{\eta}_w$. One may wonder whether this is compatible with the Shapiro-Stiglitz model of efficiency wages (Shapiro and Stiglitz, 1984).

In the Shapiro-Stiglitz model, workers can choose their level of effort and it is costly for firms to determine how much effort workers are exerting. To induce workers not to shirk, firms pay above-market wages, so that job loss imposes a penalty. Hence, wages above some contractible threshold provide incentives for employee effort conditional on employment.

A key difference between our framework and the Shapiro-Stiglitz model is that we allow for the possibility that ex-ante agreements on pay above minimum contractible levels and on revenue sharing are not respected, while in the Shapiro-Stiglitz model agreed payments are always enforceable by third parties. Under full enforceability of payments, our results can be easily re-framed into the Shapiro-Stiglitz model. Let us assume, as in Shapiro and Stiglitz (1984), that firing is costless. Moreover, assume that ω_w equals the market-clearing wage level and denote with ω_s the efficiency wage *à la* Shapiro and Stiglitz (with $\omega_s > \omega_w$). Suppose that a wage equal to ω_s induces the worker to exert some privately optimal effort $\eta^*_{ws} > \underline{\eta}_w$. Recalling that $\frac{\varrho(\eta^{**}_w(\frac{1}{2}\tilde{\Psi}),\varphi^{**}_s(\frac{1}{2}\tilde{\Psi}))\cdot\Psi}{2}$ is the monetary pay of the worker under joint-profit rights and costly firing, we have two possible scenarios:

- if $\omega_s < \frac{\varrho(\eta^{**}_w(\frac{1}{2}\tilde{\Psi}),\varphi^{**}_s(\frac{1}{2}\tilde{\Psi}))\cdot\Psi}{2}$, our main results do not change substantially, as the optimal level of working effort continues to be higher under joint-profit rights and costly firing (although the difference between maximum effort and minimum (i.e. under fix wage) effort will be reduced, that is $\eta^{**}_w - \eta^*_{ws} < \eta^{**}_w - \underline{\eta}_w$);
- if $\omega_s \geq \frac{\varrho(\eta^{**}_w(\frac{1}{2}\tilde{\Psi}),\varphi^{**}_s(\frac{1}{2}\tilde{\Psi}))\cdot\Psi}{2}$, then an efficiency wage may perfectly substitute for dismissal restrictions (or even outperform them), in terms of innovative working effort effects (i.e. $\eta^{**}_w \leq \eta^*_{ws}$); however, in this case, the employer will be accepting to give a larger quota of the extra-profits to the worker than his own share, which is not very realistic.

Clearly, if payments are distributed after the innovation revenues are collected by the employer and after firing decisions are made, and if any payment above ω_w is not enforceable by third parties outside the labour contract, efficiency wage effects disappear and, in the absence of dismissal costs, workers' effort reduces to $\underline{\eta}_w$, because of the hold-up power of the employer. In this case, the promise of efficiency wages paid by firms would not make any difference, while only layoffs restrictions may matter, as shown in our baseline model version.[6]

3.2 Increasing utility from working effort

Our model lays heavily on the assumption that the working effort has a negative effect on worker utility. Even if this is probably true in most jobs, it may be interesting to show how our model conclusions would change for some types of creative work (like in science or arts), where worker

[6]The mechanisms of firing taxes as a substitute for commitment in a model with Shapiro-Stiglitz efficiency wages are explored, from a welfare perspective, by Fella (2000).

utility is increasing in the working effort.

Here, we still assume that higher pay induces greater human effort, but consider effort as a positive input in the worker utility function (in this exercise, financial effort continues to enter the shareholder utility function with a negative sign).

With increasing utility from working effort, the worker will always exert $\overline{\eta}_w$, both with shareholder-profit rights and with joint-profit rights, and under both costless and costly firing. In any case, the optimal level of human effort maximizing the worker's payoff is $\overline{\eta}_w$, with the shareholder having no reasons to pay wages above ω_w.

On the other side, the problem of the shareholder changes with respect to our baseline model version:

• with shareholder-profit rights (both with costless and costly firing), the shareholder maximizes $\pi_s = \varrho(\overline{\eta}_w, \varphi_s(\tilde{\Psi})) \cdot \tilde{\Psi} - \varphi_s - \omega_w$ and chooses a level of financial effort equal to $\varphi_s^+(\tilde{\Psi})$;

• with joint-profit rights (both with costless and costly firing), the shareholder maximizes $\pi_s = \frac{\varrho(\overline{\eta}_w, \varphi_s(\frac{1}{2}\tilde{\Psi})) \cdot \tilde{\Psi}}{2} - \varphi_s$, and chooses a level of financial effort equal to $\varphi_s^{++}(\frac{1}{2}\tilde{\Psi})$.

It is easy to observe that, here, the probability of a succesfull innovation will be strictly higher in the SPR scheme (i.e., $\zeta(\overline{\eta}_w) \cdot \xi(\varphi_s^+(\tilde{\Psi}))$) than in the JPR scheme (i.e., $\zeta(\overline{\eta}_w) \cdot \xi(\varphi_s^{++}(\frac{1}{2}\tilde{\Psi}))$), given that $\varphi_s^+(\tilde{\Psi}) > \varphi_s^{++}(\frac{1}{2}\tilde{\Psi})$ and the working effort being fix at $\overline{\eta}_w$. Dismissal costs do not matter in this case.

3.3 Endogenous profit-sharing rule

Throughout the analysis, we assumed that the profit-sharing rule α is given ex-ante, i.e. before the labour relation starts. We now allow for the possibility that the employer and the worker bargain over the level of α and, in particular, consider the case in which a given profit-sharing scheme results from a given dismissal regulation regime. Where layoffs constraints are relatively stricter, employees are more likely to have stronger bargaining power on revenue-sharing (because they can negotiate over profit-sharing and salaries without the threat of being dismissed due to the negotiation), while, with zero discharge costs, they tend to be more disciplined to accept the remuneration scheme preferred by the employer.

Assume that:[7]

$$\alpha(\chi) = \begin{cases} 0 & \text{if} \quad \chi < \pi_s^{SPR} - \pi_s^{JPR} \\ \frac{1}{2} & \text{if} \quad \chi \geq \pi_s^{SPR} - \pi_s^{JPR}. \end{cases} \tag{13}$$

Under this assumption, our model reduces to a two-case problem, with "shareholder-profit rights and costless dismissal" and "joint-profit rights and costly dismissal" being the only two possible cases. In particular, we will have that:

- with shareholder-profit rights and costless firing, the worker exerts $\underline{\eta}_w$ level of effort, while the shareholder maximizes $\pi_s = \varrho(\underline{\eta}_w, \varphi_s(\tilde{\Psi})) \cdot \tilde{\Psi} - \varphi_s - \omega_w$ and chooses a level $\varphi_s^*(\tilde{\Psi})$ of financial effort;
- with joint-profit rights and costly firing, the worker maximizes $\upsilon_w = \frac{\varrho(\eta_w(\frac{1}{2}\tilde{\Psi}), \varphi_s(\frac{1}{2}\tilde{\Psi})) \cdot \tilde{\Psi}}{2} - \eta_w$ and chooses $\eta_w^{**}(\frac{1}{2}\tilde{\Psi})$ level of effort, and the shareholder maximizes $\pi_s = \frac{\varrho(\eta_w(\frac{1}{2}\tilde{\Psi}), \varphi_s(\frac{1}{2}\tilde{\Psi})) \cdot \tilde{\Psi}}{2} - \varphi_s$ and chooses $\varphi_s^{**}(\frac{1}{2}\tilde{\Psi})$ of financial effort.

In the first case (i.e., with costless firing), the probability of observing a successful innovation is $\zeta(\underline{\eta}_w) \cdot \xi(\varphi_s^*(\tilde{\Psi}))$, while, in the second case (i.e., with costly firing), it is $\zeta(\eta_w^{**}(\frac{1}{2}\tilde{\Psi})) \cdot \xi(\varphi_s^{**}(\frac{1}{2}\tilde{\Psi}))$. Again, as in our basic model version, the probability of a firm's innovating will be higher under costly firing only when the working effort is relatively more important to the success of the innovation process than the financial effort (i.e., when condition (12) holds).

Less common is an institutional context in which dismissal regulation and gain-sharing devices are substitutes. This possibility may hold where the two dimensions are both perceived as mechanisms for protecting workers' interests and, as such, are used as alternative legal instruments by worker-friendly labour policy makers. In this scenario, we would have that $\alpha(\chi) = 0$ with $\chi \geq \pi_s^{SPR} - \pi_s^{JPR}$ and $\alpha = \frac{1}{2}$ with $\chi < \pi_s^{SPR} - \pi_s^{JPR}$.

Only one outcome would emerge from this situation, with the worker exerting $\underline{\eta}_w$ level of effort and the shareholder maximizing $\pi_s = \varrho(\underline{\eta}_w, \varphi_s(\tilde{\Psi})) \cdot \tilde{\Psi} - \varphi_s - \omega_w$ and choosing a level $\varphi_s^*(\tilde{\Psi})$ of financial effort. The probability of successful innovation, here, is $\zeta(\underline{\eta}_w) \cdot \xi(\varphi_s^*(\tilde{\Psi}))$ under both costless and costly

[7] While α may be continuous in firing costs, here we assume a binary sharing-rule, for simplicity. Yet, the intuition is preserved.

firing.

3.4 Repeated interactions

In our baseline model, the shareholder-profit rights and the joint-profit rights cases are identified based on the rights of the workers to participate to the revenue sharing. This may be obtained with direct mechanisms, such as profit-sharing schemes or stock-ownership plans, but also indirectly by means of codetermination rules and union activity, which enable the workers to Nash-bargain with employers over wages and gain distribution. This additional institutional mechanisms, based on repeated negotiations between the employer and worker representatives, introduce the issue of reputational concerns in the model. In particular, employee representation structures may act as an information vehicle across different sequential labour interactions, thereby enabling the contracting parties to build inter-temporal commitment. Here, we propose a model extension in a repeated multi-game setting with worker learning effects (driven by an employee representation structure, such as a trade union). While this extension introduces much more reality in our framework (in particular, making it closer to the actual dynamics of European labour relationships, where union-driven reputation mechanisms matter significantly),[8] the theoretical conclusions will be shown not to change crucially with respect to our baseline one-game model.

Let us assume that the worker and the shareholder interact in a repeated-game framework, where each one-game interaction may lead to a successful innovation. Suppose also that, if the worker is subject to an opportunistic action by the shareholder (i.e., the shareholder retains the full value of the realized innovation even if both parties agreed on splitting it evenly), the worker quits, while future employees participating in a relationship with the opportunistic shareholder will exert an effort level equal to $\underline{\eta}_w$ as they can learn that the employer is an opportunist player thanks to the presence of an employee representation structure. The possibility to have repeated games, therefore, influences the threshold level of dismissal costs that makes a hold-up strategy utility-increasing for the shareholder.

[8] In a related paper focused on the common law exceptions to the employment-at-will doctrine, Acharya *et al.* (2014) model the employer-employee interaction in an innovative process without considering possible union-driven reputation issues, which are less relevant in the U.S. labour market environment.

We next propose a simple extension of our model under a two-time repeated game setting, and then show a more general result with multi-time repeated games.

Let us study, first, the scenario under prohibitively costly firing (i.e., dismissal costs are above a certain critical level, that we will derive more precisely below).

In the shareholder-profit rights case, α is equal to 0, the shareholder retains all of the innovation revenues and the worker has no incentive to exert any additional effort above $\underline{\eta}_w$ in the first game. In particular, if $\underline{\eta}_w \leq \omega_w < \frac{1}{2}\tilde{\Psi}$ in the first game, then the labour relationship continues also in the second game; in this case, in both games, the worker exerts $\underline{\eta}_w$ level of effort and the shareholder gets:

$$\pi_s^{SPR} = \varrho(\underline{\eta}_w, \varphi_s^*(\tilde{\Psi})) \cdot \Psi - \varphi_s^*(\tilde{\Psi}) - \omega_w. \tag{14}$$

Thus, the result of each game is the same as in the one-game framework of our baseline theoretical model.

In the joint-profit rights case, the outcome of the interaction may change. If the shareholder does not play hold-up in the first game, then in both games the worker and the shareholder get respectively:

$$\upsilon_w^{JPR} = \frac{\varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^{**}(\frac{1}{2}\tilde{\Psi})) \cdot \Psi}{2} - \eta_w^{**}(\frac{1}{2}\tilde{\Psi}) \quad \text{and} \quad \pi_s^{JPR} = \frac{\varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^{**}(\frac{1}{2}\tilde{\Psi})) \cdot \Psi}{2} - \varphi_s^{**}(\frac{1}{2}\tilde{\Psi}). \tag{15}$$

Suppose, now, that the firing costs are lower than a certain critical threshold (which we will specify below) and that the shareholder plays hold-up in the first game. If the worker knows the level of firing costs and is able to anticipate that he will be paid only a baseline wage, he will exert $\underline{\eta}_w$ level of effort. In this case, the shareholder gets:

$$\pi_s^{\beta} = \varrho(\underline{\eta}_w, \varphi_s^*(\tilde{\Psi})) \cdot \Psi - \varphi_s^*(\tilde{\Psi}) - \omega_w - \chi, \tag{16}$$

that is

$$\pi_s^{\beta} = \pi_s^{SPR} - \chi \tag{17}$$

in the first game, and

$$\pi_s^{SPR} = \varrho(\underline{\eta}_w, \varphi_s^*(\tilde{\Psi})) \cdot \Psi - \varphi_s^*(\tilde{\Psi}) - \omega_w \tag{18}$$

in the second game (as substitute workers will exert only $\underline{\eta}_w$ in the second game after previous employees being subject to hold-up in the first one). As a consequence, in the first labour interaction, the shareholder is prevented from violating the ex-ante agreement if

$$\pi_s^{\beta} + \pi_s^{SPR} < 2\pi_s^{JPR} \tag{19}$$

that is, more specifically:

$$\chi > 2(\pi_s^{SPR} - \pi_s^{JPR}). \tag{20}$$

Recall that, in a one-game framework, hold-up is prevented if $\chi > \pi_s^{SPR} - \pi_s^{JPR}$. Thus, in a two-game setting, the critical level of dismissal costs preventing hold-up is increased with respect to the one-game interaction if $\pi_s^{SPR} > \pi_s^{JPR}$, while it is reduced if $\pi_s^{SPR} < \pi_s^{JPR}$. In words, if the working effort is relatively more important to the success of the innovation process than the financial effort (i.e. $|\partial\zeta(\eta_w)/\partial\alpha| > |\partial\xi(\varphi_s)/\partial\alpha|$) hold-up is more likely to be prevented in the two-game framework, χ being equal.

If condition (20) is violated, dismissal costs are relatively low and firing can be considered costless. In this case, the shareholder maximizes his utility according to equation (11) and the worker exerts a $\underline{\eta}_w$ level of effort, in both games. As a result, in the two-game framework with costless firing, final payoffs and innovation probabilities will be the same as in the one-game model version.

In a more general multi-game time setting, finally, condition (20) will be:

$$\chi > [\pi_s^{SPR} + (\pi_s^{SPR})/(1+i)^n] - [\pi_s^{JPR} + (\pi_s^{JPR})/(1+i)^n] \tag{21}$$

with i being the discount rate.

Again, the theoretical framework suggests that, under dismissal laws imposing costly firing, worker participation may or may not increase the probability of a firm's innovating, and whether a given level of dismissal costs is high enough to determine a positive influence of participatory mechanisms on innovation depends on the relative relevance of the human capital with respect to the financial or physical capital.

4 Conclusions

This paper develops a simple model to study efforts towards an uncertain innovation by each of an entrepreneur-shareholder and his employee under four conditions: when the shareholder gets the full value of the realized innovation versus splitting it evenly with the worker, crossed by whether firing the worker (and appropriating the full value of the innovation) is costless versus costly firing for the shareholder. The motivation for the exercise is to think harder about why innovation might sometimes increase or decrease with employee profit-sharing, depending on the labour protection environment.

Although it being a very simplified framework, the model shows that worker financial participation mechanisms may exert effects on innovation with a different prevailing sign. In particular, stronger worker profit rights increase the innovation probability when the strictness of the layoff regulation prevents the shareholder from holding the employee up and the relative importance of the human capital in the production process is higher than that of the financial capital. Vice-versa, under a strict layoff regulation, when the financial capital is relatively more important, the effects of profit sharing mechanisms may be reduced or inverted.

A limit of our simple model is that labour-biased profit sharing schemes (i.e., according to our notation, cases for which $\alpha > \frac{1}{2}$) are left outside the analysis. Moreover, we did not consider the possibility of an endogenous sorting of heterogeneous workers among types of firm depending of the adopted participation mechanisms. Keeping in mind these caveats, our analysis may help in understanding why, in the presence of substantial contract incompleteness, there is no one-size-fits-all optimal strategy in the design of worker participation mechanisms for knowledge-intensive productions and why the effectiveness of policy initiatives (and the accuracy of empirical investigations) in this area may benefit from specific adjustments both at a country (or any other relevant labour law layer) and sectoral level.

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Table 1: Innovation probabilities under alternative scenarios.

	Shareholder-profit rights (SPR) ($\alpha = 0$)	Joint-profit rights (JPR) ($\alpha = \frac{1}{2}$)
Firing is prohibitively costly (strict dismissal regulation)	$\zeta(\underline{\eta}_w) \cdot \xi(\varphi_s^*(\tilde{\Psi}))$	$\zeta(\eta_w^{**}(\frac{1}{2}\tilde{\Psi})) \cdot \xi(\varphi_s^{**}(\frac{1}{2}\tilde{\Psi}))$
Firing is costless (weak dismissal regulation)	$\zeta(\underline{\eta}_w) \cdot \xi(\varphi_s^*(\tilde{\Psi}))$	$\zeta(\underline{\eta}_w) \cdot \xi(\varphi_s^*(\tilde{\Psi}))$