NOTA DI LAVORO

4.2016

Employee Representation Legislations and Innovation

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Economic Theory
Series Editor: Carlo Carraro

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Summary

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Keywords: Employee Representation Law, Innovation, Panel data

JEL Classification: K31, O31, P51

This paper was partially written during my visit to the Centre for Business Research at the University of Cambridge (UK), at the invitation of Simon Deakin, whose hospitality I acknowledge with gratefulness. I wish to thank the participants to the 2015 International Law & Economics Workshop organized by Tel Aviv University, Toronto Law School and University of Siena (held at AgCom, Rome), to the 2015 Annual AIEL Conference (Cagliari) and to the IdEP Research Seminar held at USI (28th October 2015, Lugano) for their helpful suggestions, in particular Mario Padula, Raphael Parchet, Ariel Porat, Anthony Niblett, Massimo D'Antoni, Massimiliano Vatiero, Marcello Puca, Francesca Affortunato, Giovanni Sulis and Bruno Caprettini. I gratefully acknowledge financial support from the University of Chieti-Pescara - Department of Economic Studies. Usual disclaimers apply.

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Abstract

We analyse how countries' innovation outcomes are affected by national legislations of worker participation to corporate governance. We develop a model of employee representation laws (ERL) and innovation in the presence of incomplete labour contracts and predict heterogeneous ERL effects across different systems of dismissal regulation. We then perform a panel regression analysis, exploiting 2-digit panel data for 21 manufacturing sectors of USA, UK, India, France and Germany, over the 1977-2005 period. We find that ERL effects on aggregate innovation output are positive, statistically significant and higher in magnitude where national labour laws impose significant firing costs to the firm with respect to institutional settings in which firing costs are low or absent. These results are robust to possible technology selection dynamics, endogeneity and institutional changes in the legal system of patent protection. We also estimate ERL effects on innovation conditional on firing costs at an industry level and show that the impact of ERL is relatively larger in those sectors where the human capital contribution to production is higher. Our results have relevant implications for the optimal design of employee representation legislations.

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1 Introduction

In recent years, the relationship between labour law and innovation has been the focus of an increasing attention by empirical economists. Existing studies so far have examined this relationship looking at a complex bundle of legal norms commonly referred to as employment protection legislation (EPL), which mainly relates to dismissal restrictions and to the availability of temporary contracts. Among others, Acharya *et al.* (2013; 2014) show that country innovation outcomes are fostered by stringent laws governing dismissal of employees. In a similar vein, Griffith and Macartney (2014) find that firms perform more innovation in high-EPL countries, in particular in incremental innovation sectors.

Surprisingly, in this literature the specific role played by the employee representation legislation (hereafter ERL), that is the sphere of labour law concerning the worker rights to participate in business management, has received very little attention (a notable exception is the study of Kraft *et al.* (2011), focused on the 1976 German Co-determination Act). The consequence is that policy concerns on the optimal design of employee representation regulation still wait for conclusive answers. The aim of this paper is to try to fill this gap.

Legislations of worker participation to corporate governance – by which a direct voice in management is given to the employee along with some control over the allocation of final returns – are institutional devices that contribute to shape the distribution of ownership rights among firm members. According to the ownership rights theory (Grossman and Hart, 1986; Hart and Moore, 1990), the allocation of ownership rights (i.e. the right to make residual management decisions and to claim the residual profits) is crucial to firm production activity, because it increases the incentives to invest by the owner whilst reducing those of the other investors who remain exposed to hold-up risks. Innovation productions, in particular, require two fundamental types of investors: emploeeys, who provide human capital, and shareholders, who contribute with financial capital. Using an incomplete contract framework, Aghion and Tirole (1994) show that, when the financial capital is more important to the success of the innovation program than the human capital, the probability of a firm innovating increases if ownership rights are assigned to the shareholder; when the marginal efficiency of the working effort is relatively higher, then ownership rights should be allocated to the workers.

A legislation of employee participation in the firm governance can thus have an impact on innovation output of firms as far as it influences the relative abilities of workers and shareholders to appropriate larger shares of the ex-post surplus. However, in a world of incomplete contracts, ERL alone is not sufficient to define the distribution of ownership rights between the employee and the shareholder if the latter has an ultimate right to fire the worker without the worker having received his share of the innovation revenues. Phrased differently, if – once a successful innovation has been produced – the shareholder can renegotiate ex-ante agreements in order to extract undue rents at the expenses of the worker by threatening dismissal, stronger ERL is unlikely to spur innovative effort by employees. Incentive effects of ERL on innovation, on the contrary, will be significant only provided that the shareholder cannot threaten to fire the worker after the innovation revenues are realized, i.e. where labour law imposes sufficiently high (monetary or non-monetary) costs of exit on the side of the employer.

The main objective of this paper is to provide empirical evidence on these effects, by employing an index of ERL conditional on firing costs in a cross-country econometric model of innovation production. To motivate our empirical strategy we develop a simple theoretical model that incorporates both positive and negative effects of employee representation laws on innovation incentives for firms. On the one hand, legislations promoting worker participation to corporate governance force the shareholder to negotiate with the employees on revenue sharing, thereby increasing the employee incentive to exert innovative effort, as long as the shareholder is prevented from violating ex-ante agreements by dismissal laws. On the other hand, stronger ERL combined with stricter dismissal regulation should reduce the shareholder incentive to contribute financial capital to the firm. The model suggests that, if on average the working effort is relatively more important than the financial effort to the success of innovation processes, we should observe a positive relationship between ERL and innovation output under a strict regulation of dismissal. We see this basic relationship in the cross-country association between ERL and innovation activity in Figure 1. Figure 1 shows the number of yearly successful business patent applications per-capita of a group of 5 countries, over the 1977-2005 period, plotted against ERL, where only country-year observations for which dismissal laws impose significant firing costs are considered.

[insert Figure 1 about here]

This aggregate picture may be masking many other effects. We run a panel regression model, exploiting 2-digit panel data for 21 manufacturing sectors of USA, UK, India, France and Germany, and show that this relationship is statistically robust to countries' innovative specialization heterogeneity, sectoral innovation time patterns, industry-specific time invariant unobservable factors and to controlling for *country* $\times$ *year* fixed effects, which absorb all variation at the country-year level, possibly due to other institutional changes, country-specific business cycles or any other country-level variable that correlates with ERL. We also show that our estimates are not driven by technology selection effects nor by endogeneity of labour laws. Our results, furthermore, are shown to be unaffected by the legal change in the international system of patent protection due to the 1994 Trade-Related Aspects of Intellectual Property Rights (TRIPs) Agreement. We identify a positive and statistically significant effect of ERL on innovation within industries in a country, where national labour laws impose significant firing costs to the firm.

Moreover, we estimate ERL effects on innovation conditional on firing costs at an industry level, by running a cross-country panel regression sector-by-sector. We find that – consistently with our theoretical prediction – ERL effects are relatively larger in those sectors where the employee effort has a greater impact on innovation outcomes, measured by means of the sectoral average of intangible assets per worker. By including the quality of management, information infrastructure, trade secrets, research and development and, more generally, a company's intellectual capital, intangible assets form the knowledge base of a firm and provide a measure of the human capital contribution to production. We find that the estimated effect of our index of ERL conditional on high firing costs in the pharmaceuticals industry (where the intangible capital per worker, on average, is 112.13 thousand euros) is 29.78 times that in the fabricated metals industry (where the intangible capital per worker is 13.76 thousand euros).

The contribution of this study is two-fold. First, we add to previous literature on labour laws and innovation (primarily Acharya *et al.* (2013; 2014) and Griffith and Macartney (2014)), providing the first attempt to measure the impact of employee representation legislations on technological innovation under different schemes of regulation of dismissal. Second, our results may complement very recent empirical research on the relationship between employee voice, hold-up and investments (among others, Card *et al.* (2014), Cardullo *et al.* (2015), Conti and Sulis (2015)). While extant studies (in particular, Conti and Sulis (2015)) show that union power has a negative effect on physical investments to a larger extent in sectors where sunk physical capital intensity is higher, symmetrically we find that laws protecting employee voice tend to stimulate worker innovative effort relatively more in human capital intensive industries.

The remaining of the paper proceeds as follows: section 2 summarizes the existing related studies; section 3 briefly describes how employee representation rights may be structured and implemented; section 4 presents a simple model of the relationship between ERL and innovation under different levels of firing costs; section 5 introduces the data used in empirical study and discusses the identification strategy; section 6 presents our estimation results, whose robustness is checked in section 7; section 8 concludes.

2 Previous literature

The empirical literature on the relationship between labour laws and innovation is rather scant. Two small bodies of studies can be identified.

A first one (Kraft *et al.*, 2011; Acharya *et al.*, 2013) explicitly refers to employee representation legislations, providing contrasting evidences. In particular, Kraft *et al.* (2011) propose an empirical study focused on the German Co-determination Act of 1976 ("MitbestG"), introducing full parity of labour representation on the supervisory board. Specifically, they compare the patenting activity of 148 German manufacturing firms observed in the years 1971-1976, before the introduction of the co-determination law, with their innovation performance over the period 1981-1990, after the law became effective. Their panel regression results show that co-determination has no negative impact on innovativeness, while, if anything at all, a positive effect can be estimated. More generally, Acharya *et al.* (2013) have analysed the relationship bewteen innovation and a set of labour laws indexes covering the regulation of dismissal, industrial action and a measure of employee representation (which includes the workers' right to collective bargaining, board membership and unionization). They use the labour laws data provided by Deakin *et al.* (2007) and patent data from the USPTO. They analyze the labour laws indexes separately and find that only dismissal laws significantly stimulate employees to engage in more successful innovative pursuits, while employee representation legislations have no effect.

We depart from these studies in two ways. First, we aim at providing more general results than Kraft *et al.* (2011), by exploiting cross-country data and using an ERL index based on a set of legal variables that account for the diversity across systems in the mechanisms providing workers with participation rights. Different countries may indeed adopt different legal mechanisms (such as collective bargaining versus co-determination) to reach the same level of protection of labour interests. Second, unlike Acharya *et al.* (2013), we consider possible interactions between ERL and dismissal laws, by estimating the ERL impact on innovation conditional on firing costs. The connection between different aspects of labour laws may indeed be crucial to properly measure ERL effects.

A second group of studies (Griffith and Macartney, 2014; Acharya *et al.*, 2014) focuses on discharge laws. Griffith and Macartney (2014) use an overall index of EPL, which is a weighted sum of a set of sub-indicators for regular and temporary contracts and collective dismissals, and innovation data from a sample of around 2200 multinational firms that filed one or more patents in the years 1997 to 2003. They find that EPL does not discourage multinational firms from carrying out innovation activity and may in fact spur incremental patenting activity. They also find that multinational firms do locate radical patenting activity disproportionately in low-EPL countries. Acharya *et al.* (2014)

exploit the staggered adoption of wrongful discharge laws (i.e. laws that protect employees against unjust dismissal) across US states in order to measure how these laws impact on firms' innovation performance and find that wrongful discharge laws do spur innovation and new firm creation. In both these last mentioned studies, representation laws are not analyzed.

It is worth mentioning that the empirical results of this second group of research partially contrasts with some previous theoretical works on dismissal costs and innovation, in particular Saint-Paul (2002) and Samaniego (2006). They posit some possible negative effects of more stringent dismissal laws and show, respectively, that higher firing costs stimulate improvements on existing (rather than new) products and that countries with high firing costs specialize in industries in which the rate of technical change is slower.

Finally, our analysis also adds to the long-standing literature on unionism, hold-up and quasi-rent sharing, which studies within-firm bargaining by considering the effect of union power and collective worker actions on the level of investment (Grout, 1984; Connolly *et al.*, 1986; Machin and Wadhwani, 1992; Denny and Nickell, 1992; Addison *et al.*, 2007; Card *et al.*, 2014; Cardullo *et al.*, 2015), including investments in firm-specific skills and training (Booth and Chatterji, 1998; Acemoglu and Pischke, 1999). More generally, our results may contribute to the discussion on employment protection and productivity (e.g., Autor *et al.* (2007), MacLeod and Nakavachara (2007) and Conti and Sulis (2015)). In particular, our sectoral estimates suggest that the extent to which employment legislations impact on productivity tends to depend on human capital intensity and that employee protection laws are likely to be more influential in more skill-intensive sectors.

3 Structure and implementation of employee representation rights

The law governing employee representation rights concerns those institutional devices that shape the worker participation to the corporate governance. Generally, they are structured into three levels pertaining to information, consultation and co-determination. Information rights relate to the employer duty to transmit data to employee representatives. Relevant information may include updates on significant financial and business events (e.g., yearly balance sheets, mergers and takeovers) or more general information on the progress of the company. Consultation rights imply a more significant involvement of workers, as they provide an opportunity for the employees to express an opinion on business matters, like significant changes to the company's business strategies and the introduction of new production technologies. Co-determination, finally, applies where the consent of the employees is a mandatory requirement for undertaking particular decisions. Co-determination rules provide workers with a direct role in the management of the company and may take different forms. In some countries, like the US and UK, the law does not provide for employee directors and no managerial role is given to employees. In some others, co-determination rules are stronger. In France, for instance, since the 1982 "lois Auroux", two members of the enterprise committee have the right to attend board meetings in private-sector companies, but without effective co-management powers. In Germany, co-determination has developed to a wider degree and the employees are given seats in a board of directors or in a supervisory board. According to the 1976 "MitbestG" law, in particular, the employees have the right to a 50% representation on the supervisory board in firms with at least 2000 employees.

Workers may implement their participation rights through two main types of representative organizations: trade unions and works councils. While trade unions are voluntary affiliations that represent the interests of their members and deal with the negotiation of collective labour agreements, works councils represent all employees in the company and generally have participation rights over operational issues at the company level. In both France and Germany the right to unionisation is protected by the Constitution. In Germany, however, employees are mainly represented by the works council ("Betriebsrat"), and the trade union density has been declining over the last decades (OECD, 2015). In the UK, the formation of trade unions is allowed and unions are considered as a matter of public interest, but many companies in which trade unions are absent do not have employee representation. In the US, differently, although the Constitution allows unions to be representatives of workers, the right to form trade unions is not recognised and trade unionism is not encouraged by the law.

The effective implementation of worker representation rights is also affected by the employer duties to bargain or to reach an agreement with unions, works councils or other organizations of employees. On this matter, again, significant differences emerge across national legislations, with Germany having no employer duty to bargain as such in its labour law (however, once collective agreements are reached, generally they are extended to third parties at the national or sectoral level), France having enacted a duty to bargain at workplace level in the 1982 "lois Auroux" (extension of sector-level collective agreements by legislation, moreover, is a practice of long standing in France, dating back to the law of 24.6.1936), and the UK and US laws supplying some employee legal duties to bargain, without providing for collective agreements extension to non-signatory workers or unions. Specifically, in the UK, the employer legal duty to recognise trade unions for the purposes of collective bargaining has been reintroduced from 2001 with the 1999 Employment Relations Act, while fair wages legislations providing for extension of collective agreements mostly ceased to have any effect from 1982. In the USA, employers have a duty to enter into collective bargaining with a certified bargaining agent under the National Labor Relations Act, but only a small percentage of the private sector workforce is currently affected by this obligation and no legal underpinning exists for agreement extension.

4 Theoretical background

In this section, we motivate our empirical study, by developing a simple theoretical model that incorporates both positive and negative effects of employee representation laws on innovation incentives for firms. 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 an 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.

A stylised firm is composed by 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 $\alpha = 0$, ownership rights are entirely allocated to the shareholder (shareholder-management case); if $\alpha = \frac{1}{2}$ ownership rights are jointly assigned to the shareholder and the worker (joint-management case). Both parties can contribute to the innovation process with, respectively, working effort ($\eta_w(\alpha, \tilde{\Psi}) \in [0, \overline{\eta}_w]$) and financial effort ($\varphi_s(\alpha, \tilde{\Psi}) \in [0, \overline{\varphi}_s]$), 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. To keep things simple, 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 partly, until 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 costraints. 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 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: $\varrho(\eta_w(\alpha, \tilde{\Psi}), \varphi_s(\alpha, \tilde{\Psi})) = \zeta(\eta_w) \cdot \xi(\varphi_s)$. This latter property means that financial effort and worker effort are complementary.

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. In t_3, the output is realized, the shareholder collects the revenues, pays the employee and gets the residual profits.

In order to properly analyze the effects of different worker representation regimes, we need to examine separately the case in which dismissal laws impose significant (monetary and non-monetary) 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.

Prohibitively costly firing.

Assume first that, having hired a worker, it is prohibitively costly to fire – i.e. to hold-up – him (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 worker capability to stipulate ex-ante agreements with the shareholder upon sharing the innovation revenues.

Shareholder-management case. If no voice in management is given to the employee by ERL and therefore the employer entirely holds the ownership rights on innovation, then the shareholder retains all of the revenues ($\alpha = 0$). 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 υ_w^{SM} and π_s^{SM} of, respectively, worker and shareholder will be:

$$\upsilon_w^{SM} = \omega_w - \underline{\eta}_w \tag{2}$$

and

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

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

Joint-management case. Under a labour regulation scheme imposing joint-management, the two parties jointly hold profit rights over the innovation revenues. If ERL is strong enough as to give workers and shareholders the same bargaining power, a Nash equilibrium on revenue sharing leads to $\alpha = \frac{1}{2}$.

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:

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

where $\eta_w^{**}(\frac{1}{2}\tilde{\Psi}) > \underline{\eta}_w$. 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:

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

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 shareholder is prevented from violating the ex-ante agreement to the extent that firing costs χ are greater than $\varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^{\delta}(\tilde{\Psi})) \cdot \Psi - \varphi_s^{\delta}(\tilde{\Psi}) - \omega_w - \pi_s^{JM}$, where φ_s^{δ} is the shareholder's optimal level of financial effort under a dishonest strategy.[1]

Costless firing.

If the employee dismissal is costless for the shareholder (i.e. $\chi < \varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^{\delta}(\tilde{\Psi})) \cdot \Psi - \varphi_s^{\delta}(\tilde{\Psi}) - \omega_w - \pi_s^{JM}$), the latter can hold-up the worker after the output is produced, i.e. the shareholder can refuse to make payments above the contractible level ω_w and can 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 behavior of the shareholder. The shareholder, on the other hand, will solve the problem:

$$\max_{\varphi_s} \quad \pi_s = \varrho(\underline{\eta}_w, \varphi_s(\tilde{\Psi})) \cdot \tilde{\Psi} - \varphi_s - \omega_w \tag{8}$$

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-management case under prohibitively costly firing).

We summarize these results in Table 1.

[insert Table 1 about here]

[1] If the shareholder chooses a dishonest strategy, he 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 $\varphi_s^{\delta}(\tilde{\Psi})$ and obtains:

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

while, if he had behaved honestly, he would have obtained π_s^{JM}. Therefore, hold-up is prevented if $\chi > \varrho(\eta_w^{**}(\frac{1}{2}\tilde{\Psi}), \varphi_s^{\delta}(\tilde{\Psi})) \cdot \Psi - \varphi_s^{\delta}(\tilde{\Psi}) - \omega_w - \pi_s^{JM}$.

To the extent that the explicit form of the two components of ϱ (i.e. $\zeta(\eta_w)$ and $\xi(\varphi_s)$) is unknown, it remains an empirical question as to whether the probability of innovation is relatively higher where $\alpha > 0$ and firing is prohibitively costly. The theoretical discussion only suggests that, under dismissal laws imposing costly firing, a binding worker participation regulation increases, on average, the probability of a firm's innovating when the working effort is relatively more important to the success of the innovation process than the financial effort, that is, formally, when $\frac{\partial\zeta(\eta_w)}{\partial\alpha} > -\frac{\partial\xi(\varphi_s)}{\partial\alpha}$.

5 Empirical strategy

The purpose of our empirical study is to estimate the effect of employment representation legislations on innovation activity under different schemes of dismissal law. To this aim, we conduct our econometric investigation by means of a cross-country-industry panel regression analysis, in which a sectoral measure of innovation output is allowed to react to ERL changes. We next describe the data and then present the identification strategy and the model specification.

5.1 Data

5.1.1 Measuring labour laws

As for labour regulation, we use the labour laws data provided by Deakin *et al.* (2007). The data cover UK, USA, Germany, France and India for the period 1970-2005. Although only five countries are considered, they represent significant national economies as three of them are "parent" systems, one is the world's largest economy, and the other is its largest democracy. The Deakin *et al.*'s legal coding is based one the "functional equivalents" concept. According to this approach, the relative importance of a given legal variable may differ across countries, while, on the other hand, different legal mechanisms (such as legal versus non-legal sources of norms) may play a functionally similar role in different systems. Consistently with the theory of functional equivalents, the Deakin *et al.*'s data encompass several aspects of labour institutions, by taking into account both positive law and self-regulatory mechanisms, including collective agreements, which may achieve the same effect as a rule of law in certain countries. Moreover, these data take into account differences between formally binding or mandatory laws and default rules.

In particular, in our analysis, we employ an indicator of ERL which measures the strength of employee representation as proxied by a set of 7 sub-indicators covering the right to form trade unions, the right to collective bargaining, the employer's duty to bargain with unions, the extension of collective agreements to third parties at the national or sectoral level, the regulation of closed shops entrance, the workers' right to nominate board level directors, and the legal power of co-decision making given to works council. See Figure 2 for a picture of the 7 sub-indicators' changes over time in the five countries considered. The overall ERL index is calculated as the average of these 7 sub-indicators and ranges from 0 (weaker regulation) to 1 (more stringent regulation). In our econometric analysis, we refer to the ERL index with $\lambda_{c,y}$ at a country-year level, c being the country and y the year.

[insert Figure 2 about here]

In order to measure ERL effects conditional on firing costs, we use also the Deakin *et al.*'s index of regulation of dismissal (referred to as $\chi_{c,y}$ in our empirical study), constructed by combining a set of variables on legally mandated notice period and redundancy compensation, minimum qualifying period of service for normal case of unjust dismissal, procedural constraints on dismissal, remedies for unjust dismissal, notification of dismissal, rules of redundancy selection and of priority in re-employment.[2]

5.1.2 Measuring innovation

We measure economy-wide innovation outcomes at a country-sector level by means of the yearly number of successful patent applications (business enterprise sector) to the European Patent Office (EPO). Patent applications filed at the EPO are an attractive measure of innovative activity because

[2]See Table 8 in Appendix A for a detailed description of the variables.

they provide information with administrative nature under well-defined rules that are independent of the location of the patent applicant. Patents data, moreover, have been widely used by related previous studies (Kraft *et al.*, 2011; Acharya *et al.*, 2013, 2014; Griffith and Macartney, 2014).

EPO data are available for a large sample of countries and industries starting from 1977. In our empirical study, we match EPO data with Deakin *et al.*'s labour laws data and obtain a final sample of five countries (UK, USA, Germany, France and India) over the 1977-2005 period and 21 two-digit manufacturing sectors. Our final innovation outcome variable is the standardized per-capita number of yearly manufacturing business patent applications (i.e. the one-year difference of total patent levels) measured at a country-sector-year level and denoted by $I_{c,m,y}$, with c being the country, m the sector and y the year.[3]

In Table 2, we report basic descriptive statistics of the labour law and innovation indicators.

[insert Table 2 about here]

5.2 Identification

The key idea of our theoretical discussion is that ERL effects on innovation output are conditional on the level of firing costs. Thus, if the working effort is more important to the success of the innovation process than the financial effort, the effect of ERL will be positive and significant only when firing costs are high. Under costless firing, the impact of ERL is expected to be low or insignificant. As the centerpiece of our identification strategy, this motivates the estimation of ERL effects by means of an explanatory variable that measures the strength of ERL conditionally on the level of the firing costs. Specifically, we first divide ordered $\chi_{c,y}$ values into subsets, according to $\chi_{c,y} \gtrless q_\tau$, where q_τ is τth quantile of $\chi_{c,y}$. In particular, we consider three subsets for which, respectively, $\chi_{c,y} \leq q_{25}$ (firing costs are low or absent), $q_{25} < \chi_{c,y} \leq q_{75}$ (firing costs are medium) and $\chi_{c,y} > q_{75}$ (firing costs are high). Then we construct three variables ($E_{c,y}^{\chi_{low}}$, $E_{c,y}^{\chi_{med}}$ and $E_{c,y}^{\chi_{high}}$), given by our ERL index $\lambda_{c,y}$

[3]See Table 10 in Appendix B for a description of the sectors considered in our empirical study.

conditional on $\chi_{c,y} \gtrless q_\tau$. In formal terms:

$$E_{c,y}^{\chi_{low}} \begin{cases} = \lambda_{c,y} & \text{if} \quad \chi_{c,y} \leq q_{25} \\ = 0 & \text{otherwise} \end{cases}$$

$$E_{c,y}^{\chi_{med}} \begin{cases} = \lambda_{c,y} & \text{if} \quad q_{25} < \chi_{c,y} \leq q_{75} \\ = 0 & \text{otherwise} \end{cases}$$

$$E_{c,y}^{\chi_{high}} \begin{cases} = \lambda_{c,y} & \text{if} \quad \chi_{c,y} > q_{75} \\ = 0 & \text{otherwise} \end{cases}$$

The three variables $E_{c,y}^{\chi_{low}}$, $E_{c,y}^{\chi_{med}}$ and $E_{c,y}^{\chi_{high}}$ ($E_{c,y}^{\chi_{low}}$ being the benchmark) will be employed as the main regressors of interest in our cross-country estimation analysis.

A second issue we must deal with is the very large number of country-level variables that may affect innovation while being correlated with ERL, many of which are unlikely to be observable or measurable. Examples include country business cycles, firm demography, quality of physical and institutional infrastructures, higher education levels and capital market development. The presence of unobservable time-varying country-level omitted variables correlated with changes in ERL may be a source of endogeneity and may confound our results. To address this endogeneity concern, we specify our regression model at a country-sector-year level so as to be able to include *country* $\times$ *year* fixed effects (i.e. a vector of interaction terms obtained by interacting country dummies with year dummies). These fixed effects absorb all variation at the country-year level and allow us to account for all sources of omitted variables for each country-year pair in our sample. While the country-sector-year level specification allows us to circumvent a source of possible endogeneity, it also introduces sectoral heterogeneity in the model. In our context, sectoral heterogeneity may be relevant to the extent that countries show a different propensity to innovate across sectors. As Acharya *et al.* (2014)

show, indeed, labour laws may have a relatively larger impact on innovation in industries that exhibit a greater propensity to innovate. We takle this issue, by measuring the one-year lagged sectoral innovative specialization of countries ($S_{c,m,y-1}$) and interacting it with our $E^{\chi_{low}}_{c,y-1}$, $E^{\chi_{med}}_{c,y-1}$ and $E^{\chi_{high}}_{c,y-1}$ variables. Specifically, $S_{c,m,y-1}$ is measured as the ratio between the country-sector-year innovation outcome and the total country-year innovation, as follows:

$$S_{c,m,y-1} = \frac{I_{c,m,y-1}}{\sum_{m=1}^{M} I_{c,m,y-1}},$$

where $S_{c,m,y-1}$ indicates the sectoral specialization level for country c and sector m in the year $y-1$, with $m = 1, ..., M$ and M denoting the number of sectors, and where $I_{c,m,y-1}$ is the country innovation outcome at a sector-year level. This variable is one-year lagged in order to avoid possible endogeneity. Sectors may be also characterized by industry-specific time invariant unobservable factors and by different time variant innovation patterns (possibly due to sector-specific technological shocks). We capture time variant sectoral innovation patterns by using a first-order autoregressive component, that is, $I_{c,m,y-1}$, and, finally, we introduce sectoral fixed effects in order to absorb time-constant sector-specific heterogeneity.

The final regression model we implement is:

$$I_{c,m,y} = \beta_0 + \beta_{SE^{\chi_{low}}} \cdot E^{\chi_{low}}_{c,y-1} \cdot S_{c,m,y-1} + \beta_{SE^{\chi_{med}}} \cdot E^{\chi_{med}}_{c,y-1} \cdot S_{c,m,y-1} + \beta_{SE^{\chi_{high}}} \cdot E^{\chi_{high}}_{c,y-1} \cdot S_{c,m,y-1} + \\ + \beta_1 \cdot S_{c,m,y-1} + \beta_2 \cdot I_{c,m,y-1} + \beta_m + \beta_{c,y} + \varepsilon_{c,m,y} \quad (9)$$

where β_0 is the model constant, β_m and $\beta_{c,y}$ are sector-specific and *country* $\times$ *year* fixed effects respectively, $\varepsilon_{c,m,y}$ are the residuals, and $\beta_{SE^{\chi_{med}}}$ and $\beta_{SE^{\chi_{high}}}$ ($E^{\chi_{low}}_{c,y}$ being the benchmark) are the parameters of interest. The three variables $E^{\chi_{low}}_{c,y-1}$, $E^{\chi_{med}}_{c,y-1}$ and $E^{\chi_{high}}_{c,y-1}$ are one-year lagged in order to avoid possible reverse causality. Note that our interaction terms ($E^{\chi_{low}}_{c,y-1} \cdot S_{c,m,y-1}$, $E^{\chi_{med}}_{c,y-1} \cdot S_{c,m,y-1}$ and $E^{\chi_{high}}_{c,y-1} \cdot S_{c,m,y-1}$) vary at a country-sector-year level like the dependent variable ($I_{c,m,y}$); consequently, the parameters of interest $\beta_{SE^{\chi_{med}}}$ and $\beta_{SE^{\chi_{high}}}$ are identified in the presence of *country* $\times$ *year* fixed effects.

6 Econometric results

6.1 Basic results

Basic results are collected in Table 3. In columns [1], [2] and [3] we report the estimation results of the model with our basic $E_{c,y}^{\chi_{low}}$, $E_{c,y}^{\chi_{med}}$ and $E_{c,y}^{\chi_{high}}$ variables, where we add progressively country, sector, and year fixed effects and the two $I_{c,m,y-1}$ and $S_{c,m,y-1}$ controls. In column [4] we report the results of our full regression model, with the interaction terms, both $I_{c,m,y-1}$ and $S_{c,m,y-1}$, sector and *country* $\times$ *year* fixed effects.

Consistently with our theoretical background, we find that ERL effects are positive and statistically significant when firing costs are high. In particular, according to column [4] of Table 3, one-point increase in $E_{c,y-1}^{\chi_{high}} \cdot S_{c,m,y-1}$ is associated to an increase in $I_{c,m,y}$ equal to 0.52 (and statistically significant at a 1% level) with respect to the benchmark ERL variable (which refers to the group of observations with $\chi_{c,y} \leq q_{25}$). Following our theoretical framework, we interpret this result, arguing that – on average – an increased ERL under high firing costs stimulates workers' motivation to a greater extent than it reduces the financial and physical capital contribution to innovation programs, and that this effect is relatively larger in industries that exhibit a greater share of patents within country.

In column [4], moreover, we find that the two control variables $S_{c,m,y-1}$ (the sectoral specialization regressor) and $I_{c,m,y-1}$ (the first-order autoregressive term) both have a positive and statistically significant impact on innovation outcomes. Nonetheless, they do not significantly absorb the estimated impact of ERL effects.[4]

[insert Table 3 about here]

6.2 Cross-sector human capital heterogeneity

If our theoretical intuition is correct, we should also observe a relatively greater impact of ERL in those sectors where the human capital is relatively more important. This is what we try to investigate in this sub-section, by exploiting the industry-level dimension of the patent data and estimating sectoral ERL effects in the presence of high firing costs.

Formally, we run the following cross-country panel regression sector-by-sector:

$$I_{c,m,y} = \delta_0 + \delta_{E^{\chi_{low}}} \cdot E^{\chi_{low}}_{c,y-1} + \delta_{E^{\chi_{med}}} \cdot E^{\chi_{med}}_{c,y-1} + \delta_{E^{\chi_{high}}} \cdot E^{\chi_{high}}_{c,y-1} + \delta_1 \cdot I_{c,m,y-1} + \delta_c + \delta_y + \varepsilon_{c,m,y} \tag{10}$$

and compare sectoral $\delta_{E^{\chi_{high}}}$ parameters with an industry-specific measure of the potential efficiency of the working effort. To this aim, we use data on intangible assets per worker. By including the quality of management, information infrastructure, trade secrets, research and development and, more generally, a company's intellectual capital, intangible assets form the knowledge base of a firm and provide a measure of the human capital contribution to production (Battisti *et al.*, 2015). In particular, we observe the sectoral average of intangible capital per worker (in thousand of euro), calculated as the sectoral average of the ratio $\frac{IK}{L}$ (with IK being the firm-level amount of intangible assets and L the firm-level number of employees, both obtained from balance sheet data of a sample of 45168 firms from UK, USA, India, France and Germany included in the ORBIS database (Bureau van Dijk, 2013)).

[4]In unreported estimations, we have also checked whether our results are driven by sectoral outlier values by means of a jackknife variance estimation procedure. The original sample is divided in M sub-samples, each of them excluding the observations of a different sector and where M is the number of sectors. The estimation of each model's parameter is computed M times, once for each sub-group. The final parameter estimates are then calculated as the average of the M parameters obtained in each regression round. The estimates from the jackknife procedure are substantially similar to those of our baseline model. The table of results is available upon request.

Estimation results are collected in Table 4 and Table 5.[5] We find that ERL effects are relatively larger in those sectors where the employee effort has a greater impact on innovation outcomes, as measured by means of the sectoral average of intangible assets per worker. As an example, notice that the estimated effect of our index of ERL conditional on high firing costs in the pharmaceuticals industry (where the intangible capital per worker is 112.13 thousand euro) is 29.78 times the effect of the same variable in the fabricated metals industry (where the intangible capital per worker is 13.76 thousand euro).

[insert Table 4 about here]

[insert Table 5 about here]

For the sake of semplicity, in Figure 3 we plot sectoral ERL effects versus sectoral intangible capital-to-employees ratios. It emerges a linear positive relationship, corresponding to a statistically significant positive correlation coefficient ($Corr(\delta_E, \frac{IK}{L}) = 0.797$ [p-value = 0.000]).

[insert Figure 3 about here]

7 Robustness of the results

7.1 Technology selection

It might be argued that the positive relationship between innovation outcomes and our index of ERL conditional on firing costs is spurious, to the extent that stronger ERL rules induce firms to substitute labour with capital by adopting more advanced capital-intensive technologies. If capital-

[5]Regressions are run for 20 manufacturing sectors separately, the group of other n.e.c. (not elsewhere classified) manufacturing activities being excluded.

intensive technologies are also more innovative, we may then observe a positive relationship between ERL and innovation, even if ERL has no direct impact on employees' motivation and working effort.[6]

In order to check whether such technology selection effect drives our findings, we run a modified version of our baseline model and estimate the impact of a ERL increase on innovation also controlling for physical capital deepening. We use two different measures of capital intensification: the ratio of gross fixed capital formation to value added ($\frac{\Delta PK}{VA}$) and the ratio of gross fixed capital formation to the number of employees ($\frac{\Delta PK}{L}$). Both measures are extracted from the STAN Database (OECD, 2015) and are provided as aggregate values at a sector-country-year level.[7]

Formally, the regression model takes now the following form:

$$\begin{aligned} I_{c,m,y} = \gamma_0 + \gamma_{SE^{\chi_{low}}} \cdot E^{\chi_{low}}_{c,y-1} \cdot S_{c,m,y-1} + \gamma_{SE^{\chi_{med}}} \cdot E^{\chi_{med}}_{c,y-1} \cdot S_{c,m,y-1} + \gamma_{SE^{\chi_{high}}} \cdot E^{\chi_{high}}_{c,y-1} \cdot S_{c,m,y-1} + \\ + \gamma_1 \cdot S_{c,m,y-1} + \gamma_2 \cdot I_{c,m,y-1} + \gamma_3 \cdot \left(\frac{\Delta PK}{VA}\right)_{c,m,y} + \gamma_4 \cdot \left(\frac{\Delta PK}{L}\right)_{c,m,y} + \gamma_m + \gamma_{c,y} + \varepsilon_{c,m,y} \end{aligned} \quad (11)$$

The results of this robustness check are presented in column [5] of Table 6. Analogously to our basic estimation, we find that ERL changes have a positive and statistically significant (at a 1% level) impact on innovation only when firing costs are high. Regression results from column [5] of Table 6 show this relationship controlling for possible technology selection effects as measured by $\frac{\Delta PK}{L}$ and $\frac{\Delta PK}{VA}$ respectively. Interestingly enough, while fixed capital formation per worker is associated to a statistically significant parameter, the fixed capital formation to value added ratio is uncorrelated with innovation.[8]

7.2 The TRIPs Agreement and legal change in patent protection

An additional concern on the robustness of our econometric results might be due to the change in the international patent protection system following the 1994 Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs), signed by 128 countries (including USA, UK, India, France

[6]The idea that labour regulations induce labour saving technical change is widespread in the literature. Among others, see the recent contribution of Alesina *et al.* (2015).

[7]See Table 9 in Appendix A for a detailed description of these additional variables.

[8]Notice, however, that in the following robustness checks the sign of the coefficient of $\frac{\Delta PK}{L}$ will show not to be robust.

and Germany) within the Marrakesh Agreement establishing the World Trade Organization, that has strengthened the international legal protection of intellectual property rights.

A number of studies, beginning with Scotchmer (1991) and Green and Scotchmer (1995), have stressed the possible negative effects of stronger patent protection in industries characterized by cumulative or sequential technological progress. In particular, the larger scope of patent claims after the TRIPs may have increased contracting costs on sub-pieces of proprietary knowledge for industries with very complex technologies (Mazzoleni and Nelson, 1998) consistently with the "tragedy of anti-commons problem" highlighted by Heller and Eisenberg (1998). If this change in the international patent protection system has induced countries to innovate relatively less in bottom-up innovation activities and relatively more in top-down systems, then it may have also affected the relationship between innovation, industry specific fixed-effects and labour laws as far as different degrees of flexibility in labour regulation may be better at supporting innovation in different types of sectors. In our econometric model, we therefore need to control for the TRIPs Agreement and to relax the assumption that sectoral fixed-effects are time invariant, allowing them to change after 1994. We next do so, by including a TRIPs dummy variable and a vector of interaction terms between the TRIPs dummy and sectoral dummies in our regression equation.

Formally, we estimate the following regression model with technology selection controls:

$$\begin{aligned} I_{c,m,y} = \psi_0 + \psi_{SE^{\chi_{low}}} \cdot E^{\chi_{low}}_{c,y-1} \cdot S_{c,m,y-1} + \psi_{SE^{\chi_{med}}} \cdot E^{\chi_{med}}_{c,y-1} \cdot S_{c,m,y-1} + \psi_{SE^{\chi_{high}}} \cdot E^{\chi_{high}}_{c,y-1} \cdot S_{c,m,y-1} + \\ + \psi_1 \cdot S_{c,m,y-1} + \psi_2 \cdot I_{c,m,y-1} + \psi_3 \cdot \left(\frac{\Delta PK}{VA}\right)_{c,m,y} + \psi_4 \cdot \left(\frac{\Delta PK}{L}\right)_{c,m,y} + \\ + \psi_T \cdot T_y + \sum_{m=1}^{M} \psi_m \times T_y + \psi_m + \psi_c + \varepsilon_{c,m,y} \end{aligned} \tag{12}$$

where T_y is a TRIPs dummy variable equal to 0 for $y \leq 1994$ and equal to 1 for $y > 1994$.

The results are presented in column [6] of Table 6. Again, our estimates are shown to be stable. Once the TRIPs dummy T_y and the vector of $\psi_m \times T_y$ interaction terms are included, ERL effects are shown positive and statistically significant where dismissal regulations are stricter (the low firing costs group of osbervations being the benchmark).

7.3 Endogeneity of labour laws

Account should also be taken of the extent to which labour laws may be implemented with the aim of affecting industrial performance and long-run firms' outcomes (such as innovation output), thus raising reverse causality concerns in our econometric analysis. While in our basic model specifications we use one-year lagged explanatory variables to circumvent possible endogeneity, here we further check the robustness of our findings by running an instrumental variable regression.

It is widely acknowledged that local political and institutional contexts are a main driver of labour law reforms (see, e.g., Botero *et al.* (2004) and Deakin *et al.* (2007)). This is documented by the modern comparative legal research (Roe, 2003) and the varieties of capitalism approach in the contemporary political science literature (Hall and Soskice, 2001). Accordingly, we use two instruments for our ERL variables: an index of governments' orientation with respect to economic policy and an index of institutional separation between ownership from control. Specifically, following Botero *et al.* (2004) and Fiori *et al.* (2012), we measure the political determinants of labour law by means of an indicator (called PO, in our econometric study) computed as the interaction between two sub-indicators measuring a government's political orientation (from conservative to socialist) and the total vote share of all government parties, at a country- and year-level; both these sub-indicators are extracted from the Database of Political Institutions (Beck *et al.*, 2001). On the other hand, we measure the institutional drivers of labour legislations through an index (called SP, in our analysis) of shareholder protection against directors, managers and other shareholders, at a country- and year-level, provided by Lele and Siems (2007); as Roe (2003) argues, the evolution of the worker rights to voice has been deeply influenced by the evolution of corporate law.

We run a two-stage instrumental variable (IV) procedure, in which our ERL indicators conditional on firing costs are regressed on $PO_{c,y-2}$, $SP_{c,y-2}$ and the included instruments, in the first stage, while $I_{c,m,y}$ is regressed on the instrumented ERL variables and the full set of controls, including both $\left(\frac{\Delta PK}{VA}\right)_{c,m,y}$ and $\left(\frac{\Delta PK}{L}\right)_{c,m,y}$, in the second stage. Formally:

I-STAGE: $E^{\chi_{low}}_{c,y-1}, E^{\chi_{med}}_{c,y-1}, E^{\chi_{high}}_{c,y-1} = \kappa_0 + \kappa_1 \cdot PO_{c,y-2} + \kappa_2 \cdot SP_{c,y-2} + \mathbf{k} \cdot \mathbf{X}_{c,m,y-1} + \epsilon_{c,m,y-1}$

II-STAGE: $$I_{c,m,y} = \nu_0 + \nu_{E^{\chi_{low}}} \cdot \widehat{E}^{\chi_{low}}_{c,y-1} + \nu_{E^{\chi_{med}}} \cdot \widehat{E}^{\chi_{med}}_{c,y-1} + \nu_{E^{\chi_{high}}} \cdot \widehat{E}^{\chi_{high}}_{c,y-1} + \nu_1 \cdot S_{c,m,y-1} + \nu_2 \cdot I_{c,m,y-1} + \\ + \nu_3 \cdot \left(\tfrac{\Delta PK}{VA}\right)_{c,m,y} + \nu_4 \cdot \left(\tfrac{\Delta PK}{L}\right)_{c,m,y} + \nu_m + \nu_c + \nu_y + \varepsilon_{c,m,y} \quad (13)$$

where $\mathbf{X}_{c,m,y}$ is the full vector of included instruments and $\mathbf{k}$ the corresponding vector of parameters.[9]

The IV results are presented in column [7] Table 6. Reassuringly, our results remain substantially unchanged. We find that the instrumented indicator of ERL effects conditional on high dismissal laws is associated to a positive and statistically significant (at a 1% level) parameter in the II-stage regression (ERL effects conditional on low dismissal laws being the benchmark). We can thus conclude that endogeneity, if present, does not drive our findings.

[insert Table 6 about here]

7.4 Model specification and cross-sector human capital mis-measurement

Finally, we have also checked whether our results are robust to a different identification strategy. We consider different versions of the following regression model:

$$I_{c,m,y} = \mu_0 + \mu_1 \cdot \lambda_{c,y-1} \cdot \chi_{c,y-1} \cdot HC_m + \mu_2 \cdot \lambda_{c,y-1} + \mu_3 \cdot \chi_{c,y-1} + \mu_4 \cdot HC_m + \mu_5 \cdot S_{c,m,y-1} + \mu_6 \cdot I_{c,m,y-1} + \\ + \mu_7 \cdot \left(\frac{\Delta PK}{VA}\right)_{c,m,y} + \mu_8 \cdot \left(\frac{\Delta PK}{L}\right)_{c,m,y} + \mu_m + \mu_{c,y}[+\mu_c + \mu_y] + \varepsilon_{c,m,y} \quad (13)$$

Here, we study complementarity effects between basic ERL and dismissal regulation indicators ($\lambda_{c,y-1}$ and $\chi_{c,y-1}$, respectively), by interacting them with a proxy of the human capital contribution to innovation (HC_m). A positive effect of the interaction term would indicate that an increase in both ERL and dismissal costs tends to have a stronger impact on innovation in more human capital intensive sectors and, therefore, that ERL effects conditional on dismissal regulations are disproportionately larger in industries where the marginal contribution of the working effort to production is higher. In

[9] Note that $\nu_{E^{\chi_{low}}} \cdot \widehat{E}^{\chi_{low}}_{c,y-1}$ is the benchmark category in the II-stage equation and it does not need to be instrumented in the I-stage. Consequently, we end up with two endogenous variables and two excluded instruments in the I-stage regression and the model is identified.

order to control for possible mis-measurement of the human capital, we measure HC_m by using both the sectoral average of the intangible assets to employees ratio ($\left(\frac{IK}{L}\right)_m$), obtained from elaboration of ORBIS firm-level data (Bureau van Dijk, 2013), and the sectoral level of average years of schooling in 1980 (CP_m), calculated by Ciccone and Papaioannu (2009) for the USA, properly re-classificated in order to match our sectoral data with the Ciccone and Papaioannou (2009)'s indicator. Results are presented in Table 7.

[insert Table 7 about here]

In Table 7, we show estimates from different model specifications. In column [1] and column [3], we include our interaction term considering $\left(\frac{IK}{L}\right)_m$ and CP_m, respectively, as proxies of the sectoral human capital intensity; we also include *country* × *year* fixed effects and sectoral fixed effects, thus $\lambda_{c,y-1}$, $\chi_{c,y-1}$ and HC_m cannot be included as separate regressors due to identification constraints. In columns [2] and [4], we use $\left(\frac{IK}{L}\right)_m$ and CP_m, respectively, as measures of human capital and include $\lambda_{c,y-1}$, $\chi_{c,y-1}$ and HC_m as separate regressors along with country and year fixed effects (*country* × *year* and sectoral fixed effects being excluded).

The parameter associated to the interaction term is always positive, statistically significant and stable across model specifications, both when the human capital is measured by means of $\left(\frac{IK}{L}\right)_m$ and when CP_m is used. Moreover, as Acharya *et al.* (2013), we find that dismissal regulation ($\chi_{c,y-1}$) has a positive and statistically significant effect on innovation, while the ERL index ($\lambda_{c,y-1}$), if considered as a separate regressor, has a positive and statistically insignificant parameter. This confirms that ERL effects are significant only provided that dismissal regulation is sufficiently strict.

8 Conclusions

In this paper, we have analysed how innovation outcomes of countries are influenced by employee representation laws. We developed a model of ERL and innovation in the presence of incomplete labour contracts and predicted heterogenous effects across different systems of regulation of dismissal. We then performed a panel cross-country regression analysis, exploiting 2-digit panel data for 21 manufacturing sectors of USA, UK, India, France and Germany, over the 1977-2005 period. Although the variables' construction strategy does not allow us to measure the economic magnitude of the regression parameters, our estimates show a positive and statistically significant effect of ERL on innovation within industries in a country, where national labour laws impose significant firing costs to the firm, so ruling out that an increase in ERL may depress aggregate patenting activity. Our results are suggestive and consistent with the Grossman-Hart-Moore–style model of Aghion and Tirole (1994).

We interpret our estimation findings, arguing that the working effort – on average – is more important than the financial effort to the success of innovation processes. Crucial to this intepretation is the legal coding strategy of the ERL index used in the econometric study. This index measures the strength of the employee representation rights from zero (i.e. the firm is fully shareholder-controlled) to a level imposing a joint-management scheme to the corporation's governance. Labour-controlled corporate structures, with shareholders having no voice in management, are outside the scope of the coding. This implies that our estimates nothing say on the relative relevance of working and financial effort effects for labour-biased management shemes (i.e., according to the notation of the model of section 4, power sharing cases for which $\alpha > \frac{1}{2}$). Given (and, perhaps, thanks to) this limitation, we are able to detect a positive and statistically significant impact of ERL improvements in all the manufacturing sectors considered, with some differences in magnitude across industries. ERL effects are shown relatively larger in those sectors where the employee effort is likely to have a greater impact on innovation outcomes, measured by means of the sectoral average of intangible assets per worker and by the sectoral average years of schooling. In particular, we find that an increase in employee representation rights is expected to spur innovation in sectors like chemicals and pharmaceuticals to a larger extent than in the transports, motor vehicles and fabricated metal products industries.

Our findings have relevant implications for the optimal design of employee representation legislations. While previous empirical studies have examined only the relationship between innovation and more general measures of labour laws – commonly referred to as employment protection legislation – (Griffith and Macartney, 2014) or have focused on different aspects of labour laws separately (Acharya *et al.*, 2013, 2014) or on a single country's experience (Kraft *et al.*, 2011), our study permits a more thoughtful and general evaluation of the innovation effects of possibile complementarities between ERL and dismissal regulation. The main policy implication of our findings is twofold. First, our estimates suggest that a more stringent employee representation legislation is likely to have – on average – a positive effect on the aggregate innovation performance, measured as a country's patenting activity. In light of the functional equivalents approach based on which the ERL data used in this paper are coded, this result leaves room for exploration and implementation of different policy strategies, consistently, in each country, with its own institutional pattern. Board membership codetermination, works councils' rights, the extension of collective agreements and the right to unionisation, among others, all are institutional devices for employee representation and participation at the governance level of the company. There is, therefore, no best practice or solution that can be transplanted, as such, from a country into another. Rather, functional continuity can be obtained also through formally diverse systems of ERL. Second, the change in magnitude of our estimated ERL effects conditionally on firing costs highlights that labour laws are likely to be interconnected. Labour regulation is indeed a complex system of normative spheres, and the effect of a policy intervention in one sphere may change dramatically depending on whether another policy activity has been undertaken in a related sphere. In our study, in particular, we have shown that only where dismissal law imposes significant firing costs on the employer ERL effects can be expected to reduce hold-up risks for the employees and to stimulate innovative working effort. This contributes to the debate on labour law reform currently taking place in Europe. While less stringent labour regulations may reduce adjustment costs and improve short-term efficiency (see, e.g., Botero *et al.* (2004), Autor *et al.* (2007), Bird and Knopf (2009)), their unintended consequences in the long run may include slower firm-specific human capital development and more sluggish technological progress.

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A Description of variables

[insert Table 8 about here]

[insert Table 9 about here]

B List of sectors considered in the empirical study

[insert Table 10 about here]

Table 1: Innovation probabilities under complementary labour laws.

	Shareholder-management ($\alpha = 0$)	Joint-management ($\alpha = \frac{1}{2}$)
Firing is prohibitively costly	$\zeta(\underline{\eta}_w) \cdot \xi(\varphi_s^*(\tilde{\Psi}))$	$\zeta(\eta_w^{**}(\frac{1}{2}\tilde{\Psi})) \cdot \xi(\varphi_s^{**}(\frac{1}{2}\tilde{\Psi}))$
Firing is costless	$\zeta(\underline{\eta}_w) \cdot \xi(\varphi_s^*(\tilde{\Psi}))$	$\zeta(\underline{\eta}_w) \cdot \xi(\varphi_s^*(\tilde{\Psi}))$

Table 2: Descriptive statistics of the main variables (1977-2005 averages).

	US	UK	DE	FR	IN
Deakin *et al.*'s (2007) ERL indicator	0.035	0.221	0.685	0.569	0.256
Deakin *et al.*'s (2007) dismissal law indicator	0.098	0.411	0.442	0.756	0.796
2-digit NACE	Per-capita number of yearly patents				
10-11	1.741	1.810	3.146	1.829	0.004
12	0.114	0.140	0.236	0.090	0.001
13	0.273	0.255	0.697	0.328	0.001
14-15	0.116	0.136	0.393	0.233	0.000
16	0.046	0.071	0.206	0.093	0.000
17	0.709	0.684	1.651	0.796	0.001
18	0.215	0.201	0.389	0.207	0.001
19	1.409	1.217	3.104	1.434	0.002
20	11.960	11.093	27.388	12.461	0.022
21	9.997	8.315	13.872	7.680	0.032
22	1.183	1.459	3.986	2.044	0.001
23	1.117	1.127	3.198	1.533	0.001
24	1.330	1.379	4.097	1.986	0.001
25	1.298	1.766	5.611	2.692	0.001
26	10.441	9.047	18.900	11.281	0.007
27	2.521	2.587	7.667	3.917	0.001
28	13.332	12.724	33.499	16.692	0.008
29	6.726	7.178	23.626	11.101	0.003
30	1.738	1.926	5.446	2.940	0.001
31	4.038	0.781	2.482	1.633	0.001
32	3.411	2.115	4.038	2.202	0.001

Table 3: Basic results.

	[1]	[2]	[3]	[4]
	DEP.VAR.: $I_{c,m,y}$	DEP.VAR.: $I_{c,m,y}$	DEP.VAR.: $I_{c,m,y}$	DEP.VAR.: $I_{c,m,y}$
$E^{\chi_{low}}_{c,y-1}$	benchmark	benchmark	benchmark	
$E^{\chi_{med}}_{c,y-1}$	0.867 (0.028)***	0.204 (0.625)	0.019 (0.056)	
$E^{\chi_{high}}_{c,y-1}$	2.165 (0.048)***	0.005 (0.000)***	0.001 (0.000)***	
$E^{\chi_{low}}_{c,y-1} \cdot S_{c,m,y-1}$				benchmark
$E^{\chi_{med}}_{c,y-1} \cdot S_{c,m,y-1}$				-0.045 (0.058)
$E^{\chi_{high}}_{c,y-1} \cdot S_{c,m,y-1}$				0.528 (0.120)***
$S_{c,m,y-1}$			0.086 (0.146)	0.302 (0.064)***
$I_{c,m,y-1}$			0.944 (0.016)***	0.924 (0.020)***
Constant	-0.161 (0.015)***	-0.050 (0.390)	0.047 (0.014)**	0.372 (0.081)***
Country FE	no	yes	yes	no
Year FE	no	yes	yes	no
Sector FE	no	yes	yes	yes
Country-year FE	no	no	no	yes
F	2316.91	4119.24	4876.89	6080.52
Prob > F	0.000	0.000	0.000	0.000
N. of years	29	29	29	29
N. of countries	5	5	5	5
N. of sectors	21	21	21	21
N. of obs.	2940	2940	2940	2940

Statistical significance: * =10%, ** =5%, *** =1%. Standard errors (in parenthesis) are heteroskedasticity robust.

Table 4: Sectoral effects [*panel-a*].

	[FB]	[TO]	[TE]	[WL]	[WO]	[PA]	[PR]	[CP]	[CH]	[PH]
	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$
$E^{\chi_{low}}_{c,y-1}$	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark
$E^{\chi_{med}}_{c,y-1}$	0.0360	0.0685	0.0377	0.0393	0.0175	0.0331	0.0224	0.00310	0.0374	0.0038
	(0.070)	(0.037)	(0.058)	(0.060)	(0.026)	(0.046)	(0.030)	(0.010)	(0.033)	(0.045)
$E^{\chi_{high}}_{c,y-1}$	0.0034	0.0041	0.0009	0.0003	0.0006	0.0008	0.0025	0.0022	0.0024	0.0047
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
$I_{c,m,y-1}$	0.935	0.787	0.917	0.942	0.875	0.928	0.937	0.845	0.902	0.973
	(0.017)***	(0.091)***	(0.016)***	(0.023)***	(0.033)***	(0.015)***	(0.010)***	(0.015)***	(0.010)***	(0.008)***
Constant	0.053	0.023	0.041	0.043	0.045	0.046	0.055	0.039	0.040	0.056
	(0.000)***	(0.015)	(0.025)	(0.026)	(0.011)**	(0.020)*	(0.013)**	(0.004)***	(0.014)**	(0.019)**
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N. of years	29	29	29	29	29	29	29	29	29	29
N. of countries	5	5	5	5	5	5	5	5	5	5
N. of obs.	140	140	140	140	140	140	140	140	140	140
$\frac{IK}{L}$ (sectoral avg.)	49.674	120.288	4.487	9.378	7.607	19.507	63.792	62.138	113.360	112.132

Legend: CH = chemicals, CP = coke and petroleum, FB = food and beverages, PA = paper, PH = pharmaceuticals, PR = printing, TE = textile, TO = tobacco, WL = wearing and leather, WO = wood. Statistical significance: * =10%, ** =5%, *** =1%. Standard errors (in parenthesis) are heteroskedasticity robust. $\frac{IK}{L}$ indicates the sectoral average of intangible capital per worker (in thousand of euro). $\frac{IK}{L}$ values are calculated at a sectoral level from balance sheet data of a sample of 45168 firms from UK, USA, India, France and Germany included in the ORBIS database (Bureau van Dijk, 2013).

Table 5: Sectoral effects [*panel-b*].

	[PL]	[NM]	[BM]	[FM]	[EO]	[EL]	[MA]	[MV]	[OT]	[FU]
	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$	DEP.VAR.: $I_{c,y}$
$E^{\chi_{low}}_{c,y-1}$	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark
$E^{\chi_{med}}_{c,y-1}$	0.0471	0.0160	0.0009	0.0104	-0.0022	-0.0018	-0.0009	0.0164	0.0173	0.0035
	(0.037)	(0.056)	(0.067)	(0.067)	(0.042)	(0.069)	(0.062)	(0.056)	(0.073)	(0.057)
$E^{\chi_{high}}_{c,y-1}$	0.0006	0.0008	0.0007	0.0001	0.0009	0.0005	0.0007	0.0004	0.0002	0.0002
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
$I_{c,m,y-1}$	0.929	0.914	0.903	0.959	0.967	0.982	0.954	0.982	0.953	0.924
	(0.018)***	(0.020)***	(0.025)***	(0.019)***	(0.007)***	(0.017)***	(0.015)***	(0.011)***	(0.019)***	(0.023)***
Constant	0.035	0.047	0.051	0.050	0.070	0.063	0.062	0.049	0.052	0.061
	(0.016)*	(0.024)	(0.029)	(0.029)	(0.018)**	(0.030)	(0.026)*	(0.024)	(0.031)	(0.024)*
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N. of years	29	29	29	29	29	29	29	29	29	29
N. of countries	5	5	5	5	5	5	5	5	5	5
N. of obs.	140	140	140	140	140	140	140	140	140	140
$\frac{IK}{L}$ (sectoral avg.)	21.699	73.388	27.491	13.760	67.293	53.147	14.599	24.874	30.916	7.006

Legend: BM = basic metals, CH = chemicals, EL = electrical products, FM = fabricated metals, FU = furniture, MA = machinery, MV = motor vehicles, NM = non-metallic minerals, OT = other transports, PL = plastic and rubber. Statistical significance: * =10%, ** =5%, *** =1%. Standard errors (in parenthesis) are heteroskedasticity robust. $\frac{IK}{L}$ indicates the sectoral average of intangible capital per worker (in thousand of euro). $\frac{IK}{L}$ values are calculated at a sectoral level from balance sheet data of a sample of 45168 firms from UK, USA, India, France and Germany included in the ORBIS database (Bureau van Dijk, 2013).

Table 6: Check of basic results' robustness.

	[5] Technology selection dep.var.: $I_{c,m,y}$	[6] TRIPs legal change dep.var.: $I_{c,m,y}$	[7] Endogeneity dep.var. (II-stage): $I_{c,m,y}$
$E^{\chi_{low}}_{c,y-1} \cdot S_{c,m,y-1}$	benchmark	benchmark	
$E^{\chi_{med}}_{c,y-1} \cdot S_{c,m,y-1}$	-0.045 (0.058)	0.012 (0.076)	
$E^{\chi_{high}}_{c,y-1} \cdot S_{c,m,y-1}$	0.528 (0.120)***	0.269 (0.108)**	
$\widehat{E}^{\chi_{low}}_{c,y-1}$			benchmark
$\widehat{E}^{\chi_{med}}_{c,y-1}$			-0.071 (0.125)
$\widehat{E}^{\chi_{high}}_{c,y-1}$			1.078 (0.416)***
$S_{c,m,y-1}$	0.302 (0.064)***	0.160 (0.069)**	0.024 (0.061)
$I_{c,m,y-1}$	0.924 (0.020)***	0.909 (0.007)***	1.013 (0.023)***
$\left(\frac{\Delta PK}{VA}\right)_{c,m,y}$	0.005 (0.006)	0.056 (0.044)	0.046 (0.202)
$\left(\frac{\Delta PK}{L}\right)_{c,m,y}$	0.106 (0.015)***	-0.031 (0.010)***	-0.093 (0.039)**
T_y		0.054 (0.035)	
$\sum_{m=1}^{M} \psi_m \times T_y$		included	
Constant	-0.025 (0.033)	0.263 (0.039)***	0.189 (0.192)
Country FE	no	yes	yes
Year FE	no	no	yes
Sector FE	yes	yes	yes
Country-year FE	yes	no	no
F	6080.52	6409.93	2897.56
Prob > F	0.000	0.000	0.000
N. of years	29	29	29
N. of countries	5	5	5
N. of sectors	21	21	21
N. of obs.	2940	2940	2835
Overidentification test	–	–	eq. exactly identified

Statistical significance: * =10%, ** =5%, *** =1%. Standard errors (in parenthesis) are heteroskedasticity robust.

Table 7: Check of sectoral ERL effects' robustness.

	[1] DEP.VAR.: $I_{c,m,y}$	[2] DEP.VAR.: $I_{c,m,y}$	[3] DEP.VAR.: $I_{c,m,y}$	[4] DEP.VAR.: $I_{c,m,y}$
$\lambda_{c,y-1} \cdot \chi_{c,y-1} \cdot \left(\frac{IK}{L}\right)_m$	0.001 (0.000)***	0.001 (0.000)***		
$\lambda_{c,y-1} \cdot \chi_{c,y-1} \cdot CP_m$			0.007 (0.001)***	0.002 (0.001)*
$\lambda_{c,y-1}$		0.007 (0.006)		0.006 (0.006)
$\chi_{c,y-1}$		0.059 (0.014)***		0.091 (0.031)***
$\left(\frac{IK}{L}\right)_m$		-0.000 (0.000)		
CP_m				-0.001 (0.003)
$S_{c,m,y-1}$	0.144 (0.037)***	0.039 (0.040)	0.109 (0.031)***	0.035 (0.027)
$I_{c,m,y-1}$	0.881 (0.022)***	0.936 (0.009)***	0.925 (0.019)***	0.946 (0.009)***
$\left(\frac{\Delta PK}{VA}\right)_{c,m,y}$	0.010 (0.007)	0.001 (0.002)	-0.000 (0.007)	0.000 (0.001)
$\left(\frac{\Delta PK}{L}\right)_{c,m,y}$	0.115 (0.014)***	-0.001 (0.002)	-0.001 (0.006)	-0.001 (0.002)
Constant	-0.079 (0.037)**	0.326 (0.015)***	-0.152 (0.079)*	0.348 (0.049)***
Country FE	no	yes	no	yes
Year FE	no	yes	no	yes
Sector FE	yes	no	yes	no
Country-year FE	yes	no	yes	no
F	5700.04	6314.93	6226.37	6326.17
Prob > F	0.000	0.000	0.000	0.000
N. of years	29	29	29	29
N. of countries	5	5	5	5
N. of sectors	21	21	21	21
N. of obs.	2800	2800	2940	2940

Statistical significance: * =10%, ** =5%, *** =1%. Standard errors (in parenthesis) are heteroskedasticity robust.

Table 8: Basic variables' description.

Variable	Description	Source of the data
$\lambda_{c,y}$	It measures the strength of employee representation, calculated as the average of 7 sub-indicators, each of them ranging from 0 (no protection) to 1 (max protection): [*i*] right to unionisation, [*ii*] right to collective bargaining, [*iii*] duty to bargain, [*iv*] extension of collective agreements, [*v*] closed shops, [*vi*] board membership, [*vii*] codetermination and consultation of workers. Standardized values.	Deakin *et al.* (2007)
$\chi_{c,y}$	It measures the regulation of dismissal, calculated as the average of 9 sub-indicators, each of them ranging from 0 (no protection) to 1 (max protection): [*i*] legally mandated notice period, [*ii*] legally mandated redundancy compensation, [*iii*] minimum qualifying period of service for normal case of unjust dismissal, [*iv*] law imposes procedural constraints on dismissal, [*v*] law imposes substantive constraints on dismissal, [*vi*] reinstatement normal remedy for unfair dismissal, [*vii*] notification of dismissal, [*viii*] redundancy selection, [*ix*] priority in re-employment. Standardized values.	Deakin *et al.* (2007)
$E_{c,y}^{\chi_{low}}$	$E_{c,y}^{\chi_{low}} = 0$ if $\chi_{c,y} > q_{25}$; $E_{c,y}^{\chi_{low}} = \lambda_{c,y}$ if $\chi_{c,y} \leq q_{25}$ (where q_{25} is the 25th quantile of $\chi_{c,y}$)	Author's own calculation on Deakin *et al.*'s (2007) data
$E_{c,y}^{\chi_{med}}$	$E_{c,y}^{\chi_{med}} = 0$ if $\chi_{c,y} \leq q_{25}$ or $\chi_{c,y} > q_{75}$; $E_{c,y}^{\chi_{med}} = \lambda_{c,y}$ if $q_{25} < \chi_{c,y} \leq q_{75}$ (where q_{25} and q_{75} are, respectively, the 25th and 75th quantiles of $\chi_{c,y}$)	Author's own calculation on Deakin *et al.*'s (2007) data
$E_{c,y}^{\chi_{high}}$	$E_{c,y}^{\chi_{high}} = 0$ if $\chi_{c,y} \leq q_{75}$; $E_{c,y}^{\chi_{high}} = \lambda_{c,y}$ if $\chi_{c,y} > q_{75}$ (where q_{75} is the 75th quantile of $\chi_{c,y}$)	Author's own calculation on Deakin *et al.*'s (2007) data
$I_{c,m,y}$	Standardized per-capita number of yearly successful patent applications filed at the EPO (business enterprise sector).	Eurostat (2014)
$S_{c,m,y-1}$	$S_{c,m,y-1} = I_{c,m,y-1} / \sum_{m=1}^{M} I_{c,m,y-1}$ (with $m = 1, ..., M$ and M denoting the number of sectors)	Author's own calculation on Eurostat's (2014) data

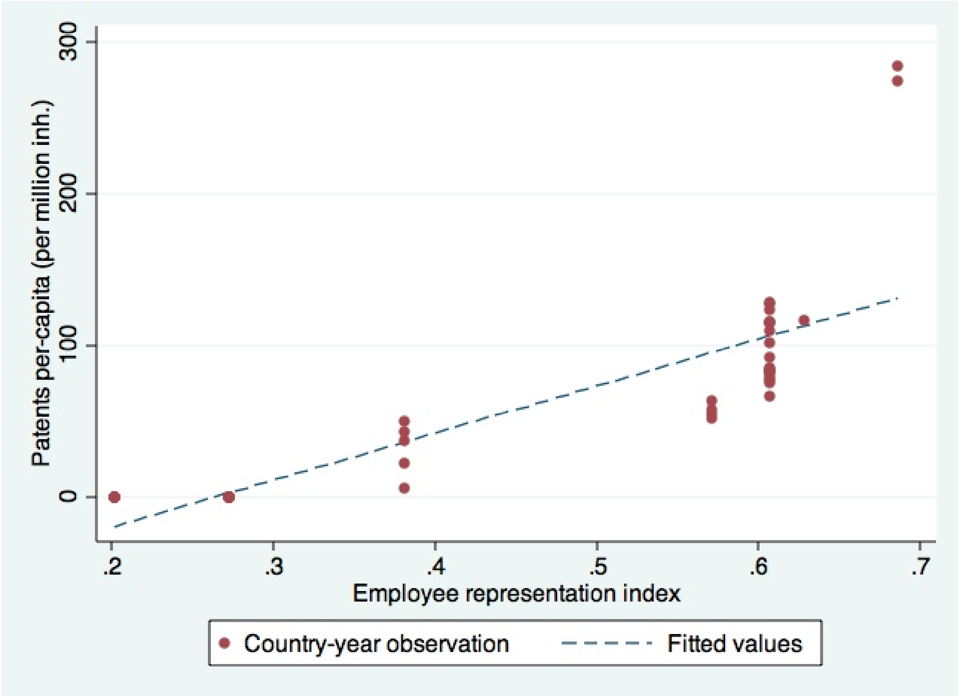
Table 9: Additional variables' description.

Variable	Description	Source of the data
$\left(\frac{\Delta PK}{VA}\right)_{c,m,y}$	Gross fixed capital formation to value added ratio. Standardized values.	OECD (2015)
$\left(\frac{\Delta PK}{L}\right)_{c,m,y}$	Gross fixed capital formation to the number of employees ratio. Standardized values.	Author's own calculation on OECD's (2015) data
$PO_{c,y}$	Government's political orientation (from -1, conservative, to 1, socialist) times the total vote share of all government parties.	Author's own calculation Beck *et al.* (2001) data
$SP_{c,y}$	It measures the strength of shareholder protection, calculated as the sum of 60 sub-indicators, each of them ranging from 0 (no protection) to 1 (max protection), covering protection against board and management (including powers of the general meeting, board composition rules and directors' duties) and protection against other shareholders (including cumulative voting, right to exit and oppressed minority norms).	Author's own calculation Lele and Siems (2007) data
T_y	Dummy variable. It equals 0 for $y \leq 1994$ and 1 for $y > 1994$.	Author's own coding

Table 10: Industry classification (manufacturing).

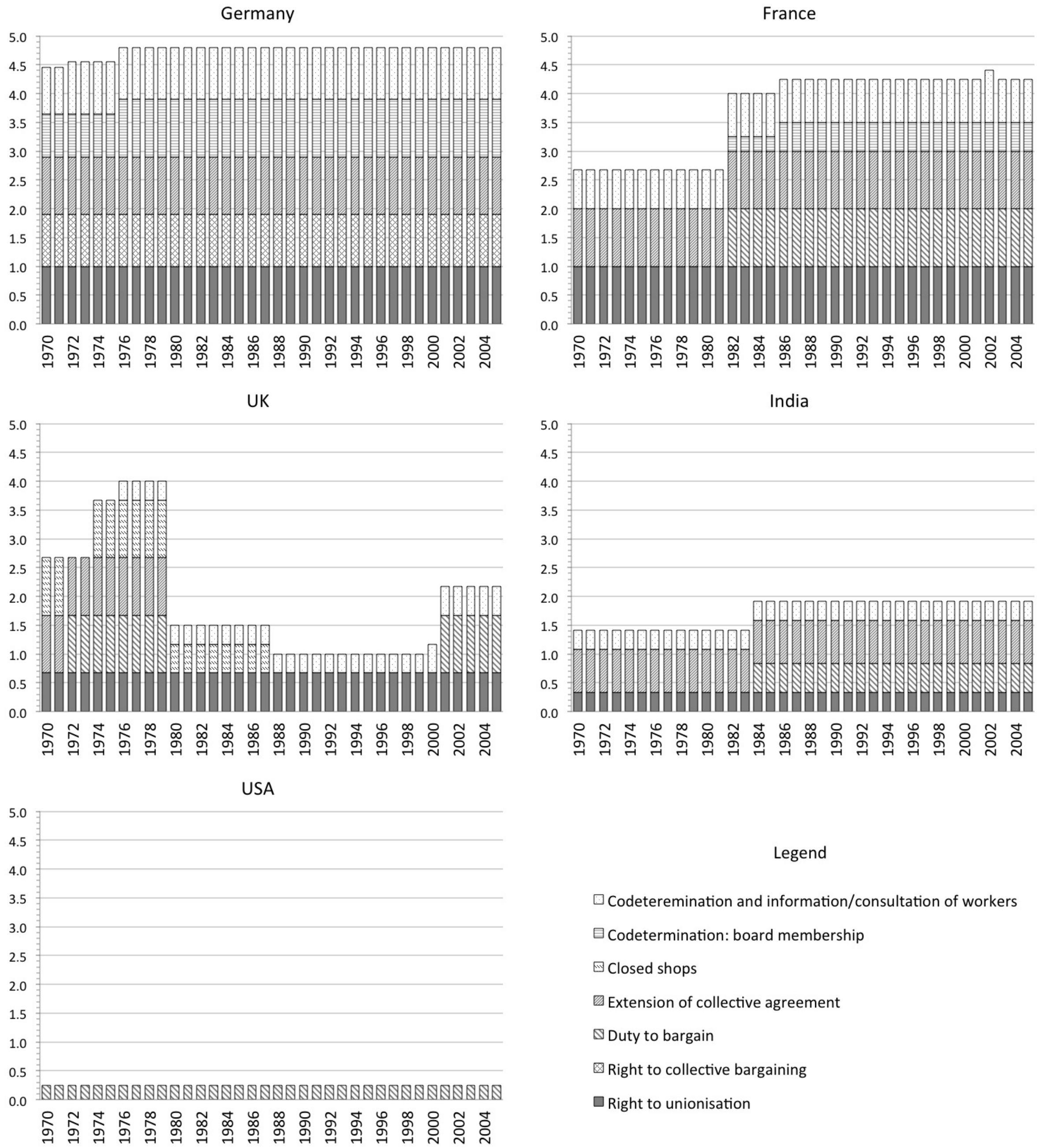
2-digit NACE	Description
10-11	Manufacture of food products and beverages
12	Manufacture of tobacco products
13	Manufacture of textiles
14-15	Manufacture of wearing apparel and manufacture of leather and related products
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment n.e.c.
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment
31	Manufacture of furniture
32	Other manufacturing

Figure 1: Innovation and ERL under strict dismissal laws.



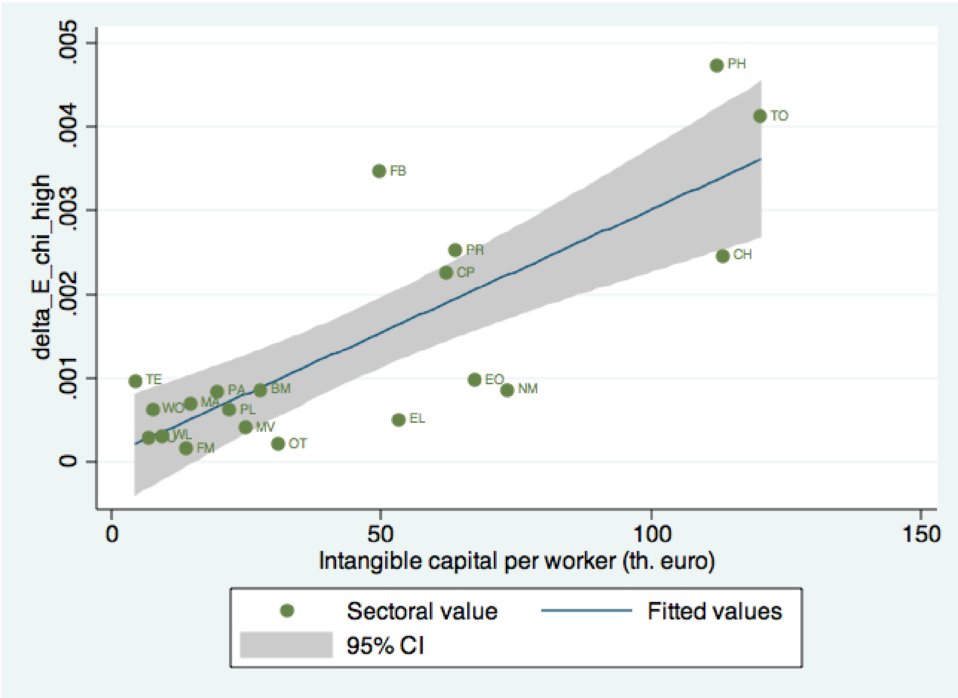
The graph shows the relationship between yearly manufacturing patents filed at the EPO and ERL for France, Germany, India, UK and USA, over the period 1977 to 2005. The x-axis shows the country-year ERL level. The y-axis shows for each country and year the number of patents per-capita (per million inhabitants). Only country-year observations with a positive value of a standardized index of regulation of dismissal are considered. See section 5 for details of the data used.

Figure 2: Sub-indicators of the Deakin *et al.*'s (2007) index of ERL.



Author's elaboration on Deakin *et al.*'s (2007) data. The sample covers France, Germany, India, UK and USA over the 1970-2005 period. Each sub-indicator ranges from 0 (weaker regulation) to 1 (more stringent regulation); see Deakin *et al.*'s (2007) for details. The overall ERL index, used in our econometric study, is calculated as the average of these 7 sub-indicators, at a country- and year-level.

Figure 3: Sectoral ERL effects versus sectoral intangible capital-to-employees ratios.



Legend: BM = basic metals, CH = chemicals, CP = coke and petroleum, EL = electrical products, EO = electronic and optical, FB = food and beverages, FM = fabricated metals, FU = furniture, MA = machinery, MV = motor vehicles, NM = non-metallic minerals, OT = other transports, PA = paper, PH = pharmaceuticals, PL = plastic and rubber, PR = printing, TE = textile, TO = tobacco, WL = wearing and leather, WO = wood. $Corr(\delta_E, \frac{IK}{L})$ = 0.797 [p-value = 0.000], where parameters $\delta_{E^{\chi_{high}}}$ are obtained by estimating $I_{c,m,y} = \delta_0 + \delta_{E^{\chi_{low}}} \cdot E^{\chi_{low}}_{c,y-1} + \delta_{E^{\chi_{med}}} \cdot E^{\chi_{med}}_{c,y-1} + \delta_{E^{\chi_{high}}} \cdot E^{\chi_{high}}_{c,y-1} + \delta_1 \cdot I_{c,m,y-1} + \delta_c + \delta_y + \varepsilon_{c,m,y}$ sector-by-sector, and where $\frac{IK}{L}$ indicates the sectoral average of intangible capital per worker (in thousand of euro). $\frac{IK}{L}$ values are calculated at a sectoral level from balance sheet data of a sample of 45168 firms from UK, USA, India, France and Germany included in the ORBIS database (Bureau van Dijk, 2013). The estimated sectoral parameters $\delta_{E^{\chi_{high}}}$ reported in the Figure are statistically significant at a 1% level.

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