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LABOUR MARKET INSTITUTIONS, PRODUCT MARKET REGULATION, AND INNOVATION: CROSS-COUNTRY EVIDENCE

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ABSTRACT/RESUME

Labour Market Institutions, Product Market Regulation, and Innovation : Cross Country Evidence

In this paper we present comparative evidence from OECD countries concerning the impact of product and labour market regulations on innovation. While product and labour market policies usually aim at objectives other than innovation, they may have important consequences for the profitability of firms' innovative strategies. Our regression analysis provides some cross-country evidence that enhancing competition in the product market -- while guaranteeing intellectual property rights -- seems to have a positive impact on the innovation performance of a country. Conversely, the relationship between innovation and job protection does not seem to be univocal. The sign and magnitude of the effect of the latter crucially depends on the systems of industrial relations and the specific characteristics of each industry. Indeed, the larger the scope for resorting to internal labour markets, the lower the adjustment costs imposed by labour market regulation. Moreover, in industries with a cumulative knowledge base, employment protection and co-ordinated industrial relation regimes, by aligning workers' and firms' objectives and encouraging firm-sponsored training as well as the accumulation of firm-specific competencies, allow firms to fully exploit the potential of the internal labour market.

JEL Classification: O31, O33, J50.

Keywords: Regulation, Industrial relations, Technological regimes, Competence accumulation, Technological specialisation.

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Institutions du marché du travail, réglementation du marché des produits et innovation: évidence en coupe transversale

Dans ce papier nous présentons de l'évidence comparative concernant l'impact de la réglementation des marchés du travail et des produits sur l'innovation dans les pays de l'OCDE. Même si une telle réglementation a en général pour but des objectives autres que l'innovation, elle peut avoir des conséquences importantes pour la rentabilité des stratégies innovatrices des entreprises. Nos régressions avancent de l'évidence transversale qu'une augmentation de la concurrence sur le marché des produits – tout en garantissant les droits de propriété intellectuelle – semble avoir un impact positif sur la performance innovatrice d'un pays. En revanche, la relation entre l'innovation et la protection de l'emploi ne semble pas être sans ambiguïté. Le signe et l'importance de cette dernière dépend de manière cruciale du système des relations industrielles et des caractéristiques de chaque industrie. En effet, plus les marchés internes du travail sont importants, moins la réglementation du marché du travail impose des coûts d'ajustement. Par ailleurs, dans les industries avec une base de connaissance cumulative, la protection de l'emploi et la coordination du système des relations industrielles permettent aux entreprises d'exploiter pleinement le potentiel du marché interne du travail en alignant les objectifs des employés et des employeurs et en encourageant la formation financée par les entreprises ainsi que l'accumulation des compétences spécifiques à la firme.

Classification JEL : O31, O33, J50.

Mots-clefs : Réglementation, Relations industrielles, Régimes technologiques, Accumulation des compétences, Spécialisation technologique.

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LABOUR MARKET INSTITUTIONS, PRODUCT MARKET REGULATION, AND INNOVATION: CROSS-COUNTRY EVIDENCE

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Introduction

1. In recent years, there has been quite a lot of attention to the role of institutions in shaping economic performance and specialisation patterns across countries. In this paper we present comparative evidence from OECD countries concerning the impact of product and labour market regulations on innovation. While product and labour market policies usually aim at objectives other than innovation, they may have important consequences for the profitability of firms' innovative strategies.

2. Concerning product market competition, the theoretical literature on its effect on innovation is quite rich but has yielded ambiguous results on the sign and magnitude of this relationship. Nonetheless, the empirical literature seems to have recently reached a consensus that, for a given level of protection of intellectual property rights, product market competition is positively associated with innovation. However, as far as we know, only little cross-country evidence on this relationship has been provided to date. One of the aims of this paper is to try to bridge this gap, by exploiting the set of cross-country comparable indicators on the regulatory framework (including tariffs and non-tariff barriers to trade; inward-oriented economic regulation and state control; administrative barriers on enterprise start-ups; and regulation on intellectual property rights). A further advantage of relying on indicators of regulation rather than more direct measures of competition is to mitigate endogeneity problems as well as issues related to the fact that usual measures (such as the Lerner index) are often non-monotonic in competition.

3. Concerning labour market institutions, the links with innovation have been less intensely researched. However, few authors have argued that they may have important consequences for the profitability of firms' innovative strategies (e.g. Boyer, 1988, Soskice, 1997, Eichengreen and Iversen, 1999). Indeed, labour market institutions are likely to affect both the size and appropriability of innovation rents. For instance, in industries where the elasticity of demand is low, technological change is likely to result in employment downsizing. Thus, institutions that make post-innovation employment adjustment more difficult or costly are likely to reduce innovation rents accruing to firms and hence innovative effort. Furthermore, implementing an innovation also requires shifting from one optimal mix of human and physical capital to another. The innovating firm can accomplish this task either by hiring new staff on the

1. The views expressed here cannot be attributed to the OECD Secretariat or its Member Countries. We thank especially Eve Caroli, Sebastien Jean and Giuseppe Nicoletti for many comments and discussions on a previous draft. Helpful comments were also provided by Giovanni Dosi, Ignazio Visco, Jorgen Elmeskov, Mike Feiner, John Martin, Stefano Scarpetta, Paul Swaim, and Dominique Guellec to whom we are also in debt for providing us with the data on patents. We are also grateful to Walter Park for providing us with data on IPR protection. Olivier Boylaud was very helpful in data management and Martine Levasseur provided excellent research assistance. Usual disclaimers apply.

external market, possibly poaching on other firms' pool of skilled workers, or by training its own workforce. The specific nature of the technology of each industry has a bearing on the effectiveness of each of these strategies. Thus, the interplay between industry-specific competence requirements, regulations that limit the flexibility of the labour market and industrial relations systems that modify the incentives for firm-supported training is likely to affect the viability of different strategies, thereby partially shaping industry patterns of technological comparative advantage in different countries.

4. This paper aims at providing broad cross-country econometric evidence on the association of innovation patterns, product market regulation and different labour market institutional regimes. To this end, we develop an empirical analysis of patterns of R&D intensity in a cross-section of 18 OECD countries and 18 manufacturing industries.

5. We find an unambiguous negative association between R&D intensity and indicators of non-tariff barriers and inward-oriented economic regulation. Conversely, stronger protection of intellectual property rights tends to be positively associated with higher R&D intensity, although endogeneity problems do not enable us to identify this association as a causal relationship. Regarding the relationship between labour market institutions and innovation our results provide evidence that some aspects of labour market flexibility are positively associated with R&D intensity in low-tech industries and in all industries in countries with decentralised wage-bargain with little coordination. Conversely, in countries with a co-ordinated system of industrial relations there seems to be a negative association between labour market flexibility and R&D intensity in industries with a more cumulative knowledge base. These results, we argue, can be related to the combination of two opposite forces. On the one hand, innovation may lead to downsizing or reshuffling of the workforce, especially in industries where there is limited scope to expand production. Therefore innovation is discouraged by legislation hindering labour adjustments. On the other hand, the larger the scope for resorting to internal labour markets, the lower the adjustment costs imposed by hiring and firing restrictions. In the context of a cumulative and specific knowledge base, employment protection and co-ordinated industrial relation regimes, by aligning workers' and firms' objectives and encouraging firm-sponsored training as well as the accumulation of firm-specific competencies, allow firms to fully exploit the potential of the internal labour market.

6. The plan of the paper is as follows: in Section 1 we start by reviewing theory and evidence on the relationship between competition in the product market and innovation; in Section 2 we discuss the main economic mechanisms that relate labour market institutions to innovative performance; Section 3 maps these mechanisms into differences across technological regimes characterising each industry; our empirical strategy is set forth in Section 4, with data issues discussed in Section 5; Section 6 develops an empirical analysis of product and labour market institutions and patterns of technological specialisation, while in Section 7 we consider an extension to assess the impact of labour market institutions and product market regulations on innovative performance; some concluding remarks will be set forth in Section 8.

1. Innovation and product market competition

7. The theoretical literature has yielded ambiguous results about the sign and the magnitude of the impact of competition on innovation. The standard Schumpeterian argument is that the relationship between competition and innovation is negative, due to the hypothesised negative impact of competition on the appropriability of innovation profits (see *e.g.* Aghion and Howitt, 1998). Post-innovation perfect competition makes firms indifferent *vis-à-vis* the choice of whether to innovate or not. Conversely, the expectation of some degree of post-innovation market power pushes firms to engage in innovative effort and undertake the required resource investment. In general, the statement that post-innovation rents should be high enough to cover the cost of innovation is relatively uncontroversial (see *e.g.* Kamien and Schwartz,

1982 and Geroski, 1990). The policy implication is that some protection of intellectual property rights is needed (IPRs hereafter).

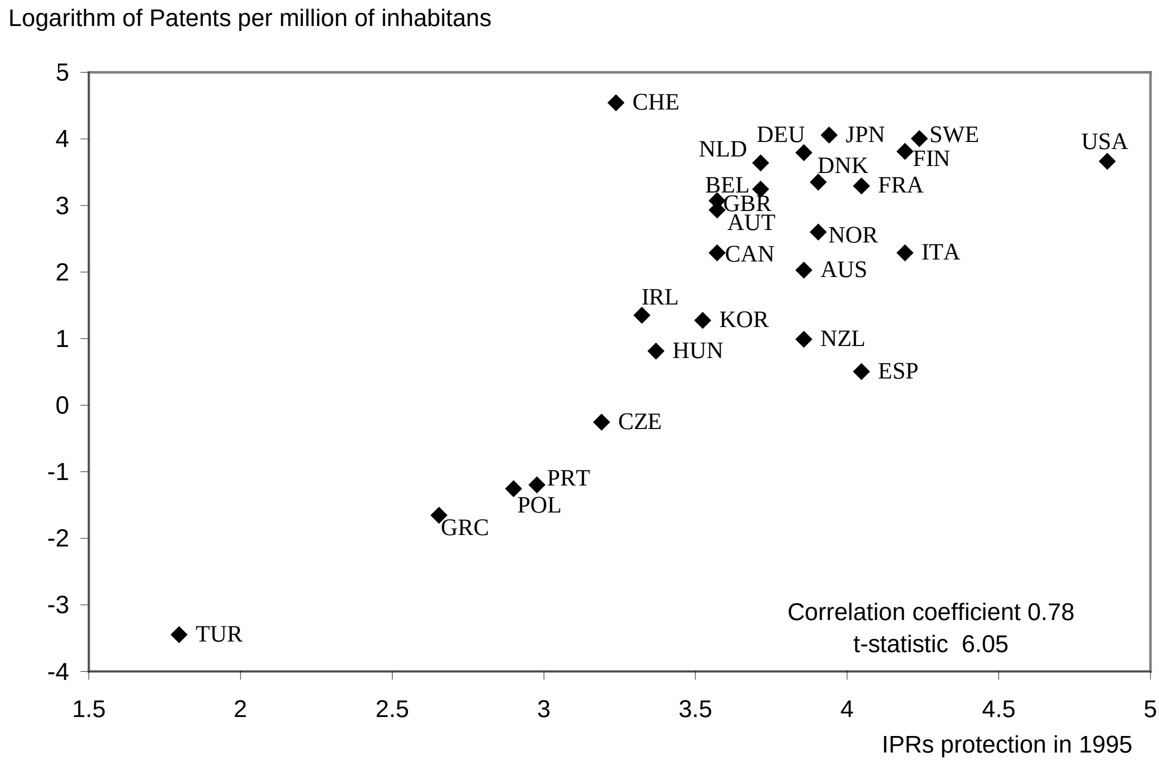
8. By contrast, reasons why pre-innovation monopoly power would be a requisite for innovation are much less intuitive. Nelson and Winter (1982), among others, point to the role of retained profits in financing innovation in a world of imperfect capital markets. Levin (1978) emphasises the role of pre-innovation barriers to enforce post-innovation monopoly power. Others argue that, in certain industries, to the extent that future innovations complement past ones, incumbents may have higher returns from innovation than entrants. However, the threat of entry limiting exploitation of monopoly power is usually an important component of this argument: incumbents might be pushed to innovate in order to pre-empt rivals (*e.g.* Gilbert and Newbery, 1982, Klette and Griliches, 2000). Moreover the argument can be reversed, since incumbents usually have higher opportunity cost of adopting potentially superior technologies whenever the knowledge acquired to master the old technology is only partially transferable to the new one (*e.g.* Arrow, 1962, Reinganum, 1983, Perez and Soete, 1988, Jovanovic and Nyarko, 1996). Furthermore, other authors have observed that competitive pressure have a positive effect on innovative effort when there exist agency problems between managers and owners (Aghion *et al*., 1999, Aghion and Howitt, 1998) because, in these models, striving for survival is the main motivation for managers to implement costly innovations.

9. The relevant dimension of appropriability conditions in the context of product market competition is not the size of the innovation rent *per se* but rather the difference between the rent accruing to the successful innovator and the rent the same agent would have enjoyed without innovating. Drawing on this observation, Aghion *et al.* (2001*a*) argue that, for any given level of protection of IPRs, fierce competition between firms with similar technological competencies (neck-and-neck competition) may force them to innovate in order to escape competition. More generally, the relationship between competition and innovation may be hump-shaped. On the one hand, when rent protection is strong enough, both incumbents and entrants have no or low incentive to engage in innovation. Indeed, rents accruing to potential entrants would be low and incumbents' profit gains from innovation will be negligible if barriers to entry are high (since the dominant position of the latter is not challenged). On the other hand, post-innovation rents must be large enough to pay back the cost of innovation. They conclude that the combination of relatively high levels of protection of IPRs -- to reduce imitation and thereby ensure post-innovation rents -- and product market competition -- defined in terms of the threat of entry or the elasticity of substitution between products -- is likely to give the best innovation outcome at the aggregate level.[2] This statement finds some support in simple cross-country correlations. In fact, as shown in Figure 1, there is a robust positive correlation between the Ginarte and Park's indicator of protection of IPRs (Ginarte and Park, 1997) and aggregate patenting in 26 OECD countries[3]:

2. Winter (1971) and Vickers (1995) point also to the positive selection effect of competition in raising the aggregate efficiency of an industry and wiping out less innovating firms from the market.

3. Nonetheless, although indicators based on legal provisions usually have the advantage of being relatively exogenous with respect to variables of innovation performance, this does not seem to be the case with the indicator of protection of IPRs that is found to be endogenous to R&D expenditure (Ginarte and Park, 1997). Furthermore, a main disadvantage of this type of indicators is that they do not take into account many aspects of actual competition as well as of enforcement practices. The latter drawback is common to most of the indicators considered in this paper.

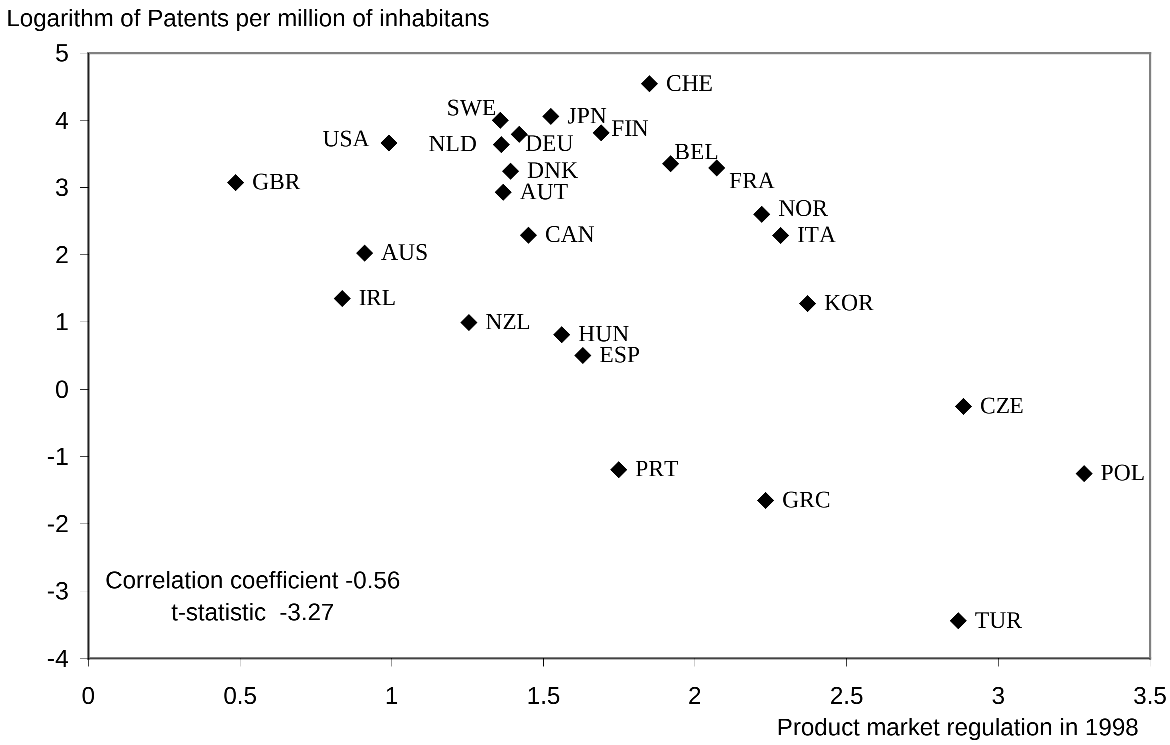
Figure 1. **Patents per million of inhabitants and protection of IPRs**[1]



1. The summary index of IPR protection was kindly provided by Walter Park. Patents are defined as consolidated family of patent at EPO, USPTO and JPO by country of invention and priority year 1993.
Source: OECD.

10. Likewise, Figure 2 presents evidence of a negative bivariate correlation between patent performance and the OECD summary indicator of product market regulation that includes aspects of inward- and outward-oriented economic and administrative regulation, but excludes regulation on IPRs (see Nicoletti *et al.,* 1999). The correlation is robust to the elimination of single outliers (such as Turkey), although its significance depends considerably on a small group of countries with significantly lower patent performance (Portugal, Greece, the Czech Republic, Poland and Turkey), whose elimination makes the correlation coefficient insignificant at standard statistical level. Similar correlations are found with R&D intensity.

Figure 2. **Patents per million of inhabitants and product market regulation[1]**



1. The OECD summary index of product market regulation is from Nicoletti *et al.* (1999). Patents are defined as consolidated family of patent at EPO, USPTO and JPO by country of invention and priority year 1993.
Source: OECD.

11. Cross-country evidence on competition and innovation is however limited and often confined to bivariate correlations (*e.g.* Koedijk and Kremers, 1996), case studies (*e.g.*Havrylyshin, 1990, Porter, 1990), or the inclusion of a tariff rate or import restriction variable in cross-country growth regressions (*e.g.* Lee, 1993). Some authors also provide indirect evidence on the association of import penetration with innovation and growth, although import penetration may proxy international technological spillovers rather than the level of competitive pressure (*e.g.* Coe and Helpman, 1995, Frantzen, 2000).

12. By contrast, recent evidence at the sector- and firm-levels for the United Kingdom is rather abundant and suggests a positive relationship between product market competition and innovation once differences in technological opportunity across sectors (inherent differences in the propensity to innovate) have been controlled for. Using innovation counts (number of innovations) as dependent variable and concentration indexes as measures of competition, Geroski (1990) and Blundell *et al.* (1995, 1999) find that the latter negatively affects the former in panels of British industries and firms, respectively. The results of Blundell *et al.* (1999) are however somewhat mixed since, although competition is positively associated with innovation, it is the firm with the largest market share that appears to have the higher probability to innovate. They interpret these findings as consistent with models in which incumbents are pushed to innovate in order to pre-empt rivals. Conversely, Aghion et al. (2001*b*) find an hump shaped relation between patents and competition as measured by the Lerner index (or price-cost mark-up) in a

panel of British firms. They also find evidence supporting the hypothesis that *ceteris paribus* neck-and-neck competition, as measured in each industry by the distance between average productivity and the international technological frontier, is associated with greater innovation performance and a more negative relationship between patents and the industry's Lerner index.

13. Other microeconomic evidence comes from studies that use TFP growth as an indicator of performance. This evidence is somewhat more indirect, because, on the one hand, TFP growth is not observable and is derived as a residual and, on the other hand, it might not reflect innovation only, but also adoption, greater labour and managerial effort, etc. Using the natural experiment of the introduction of the European Single Market Program (SMP) that led to a sharp reduction of non-tariff barriers, Griffith (2001) finds support for agency cost arguments in a panel of British firms. She shows that the implementation of the SMP yielded no efficiency gain in sole proprietor plants but only in establishments that belong to a group. Similarly, Nickell *et al.* (1997) estimate that the presence of a dominant shareholder led to a more negative impact of the Lerner index on TFP growth in a small panel of 125 British companies.

14. The interpretation of these results is somewhat difficult since they use only one measure of competitive pressure.[4] In fact, Boone (2000*b*) suggests that different dimensions of product market competition might have different effects and that these effects should be distinguished between more and less efficient firms as well as between incumbents and entrants.[5] In contrast with the empirical studies mentioned above, Nickell (1996) uses simultaneously different measures of competition (Lerner index, 5-firm concentration ratio, and a measure of the number of competitors). Less competition is found to be associated with less TFP growth for all variables except the dummy on the number of competitors, that is found to have a negative and significant effect only when the Lerner index is not included in the equation. In order to take these observations into account, in the multivariate analysis conducted for this paper, we take simultaneously into account several indicators of different aspects of product market regulation.

2. Labour market institutions matter for innovation

15. Labour market policies and institutions affect the scope for the firm to appropriate the rents generated through innovative activity. Additionally, these policies have a bearing on the size of innovation rents, through their impact on the cost of implementing innovations. In this section we discuss the interplay between labour market regulation and institutions in shaping the incentives for (and the viability of) different innovation strategies. In the next section we will argue that the outcomes of these interactions differ across industries depending on their technological regime.

16. Following Soskice (1997), we focus on the potential impact of hiring and firing restrictions and the degree of co-ordination of industrial relations regimes. The system of industrial relations of a country can be defined by the set of bargaining institutions, business associations, trade unions, and codes of conduct among firms, prevailing in that country. An industrial relations system can be said to be co-ordinated when: i) the wage-bargaining process is centralised or co-ordination among employers and/or trade unions sets a uniform band of wages; ii) employers and trade unions co-operate with regard to decision-making inside the firm; and iii) business associations (and/or a tacit code of conduct concerning

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4. An additional problem concerning most of these works is that measures such as concentration indexes (*e.g.* *n*-firm concentration ratios and the Herfindahl index) or the Lerner index are likely not to be monotone with respect to common notions of competition (see Boone 2000a, 2001).

5 For instance, Boone (2000b) shows that, with Cournot competition, measures affecting the elasticity of substitution between incumbents' products are likely to have a more positive impact on innovation than measures more directly associated to the number of firms in the market.

firm behaviour) have an active role in solving free-riding problems across firms (*e.g.* related to training, standard-setting, fair competition, basic research).

Wage re-negotiation

17. Labour market arrangements, which increase the bargaining power of insiders or allow wage re-negotiation at the firm level after an innovation has been implemented, may reduce post-innovation profits, by making firms share innovation rents with workers. In decentralised systems of wage-bargaining, where wages are subject to re-negotiation at the firm level (at the time of contract renewal), a classical hold-up problem[6] may occur, with firms partially restraining from undertaking innovative investment. Indeed, after successful innovation has taken place, the firm has already met with R&D expenditures and/or adoption costs. Therefore, to the extent that searching for new staff is costly, employed workers have a stronger bargaining power and can partially appropriate innovation rents.

18. By making labour turnover more difficult, employment protection adds to the bargaining power of insiders. It can be argued that strict hiring and firing regulations increase the leverage unions have at the firm level, hence worsening the rent-appropriability problem when the wage can be negotiated after innovation has taken place. However reduced employment flexibility may have the opposite effect: longer tenure (which in turn is enhanced by less flexible labour markets) raises the time horizon of workers, who consequently might not try to maximise current wages and may limit their search for alternative jobs (Acemoglu, 1997*a*, 1997*b*).

19. The hold-up problem can be partly mitigated when bargaining, occurring at the national or industry level, pins down a general frame for the wage schedule. In such a case, the reservation wage is fixed for all lower-level bargaining units and is adjusted mainly in response to aggregate shocks. As a consequence, innovative investment by the firm no longer depends on the bargaining power of its own workers (Teulings and Hartog, 1998).

Competence formation and training

20. Employment protection provisions, industrial relation regimes (as well as the tax and benefit system) affect the quality and availability of skilled labour, which is frequently seen as a complementary input to new technologies. Different issues emerge here as regard to who is paying for the investment in human capital and what is the nature of the competencies to be acquired.

21. Skills of a general nature can be used in different firms and industries, and thus increase the market value of workers. Therefore, it has been argued that workers will pay for acquiring these skills (Becker, 1964). In this context incentives for the labour force to invest in education may be affected by the fact that wages in centralised/co-ordinated industrial relations systems are typically compressed over the skill dimension.[7] For instance, lower expected earnings for the upper range of skills may decrease expected returns to schooling and lead to a reduced participation of young people in tertiary education. However, higher contractual wage floors for low wage earners or statutory minimum wages dampen labour demand for unskilled workers and may consequently have incentive effects to prolong schooling and/or vocational

6. See Malcomson (1997) for a review.

7. See Davis (1992), Blau and Kahn (1996), Blinder and Krueger (1996), Gottschalk and Smeeding (1997) and Kahn (1998) for evidence on compressed wage structure and centralisation/co-ordination of wage bargaining systems.

education, leading to a more homogeneous but on average more educated workforce (Agell, 1999; Cahuc and Michel, 1996).

22. Firms too invest in general training. A firm has an incentive to pay for training when wages are compressed over the skill dimension, so that it can reap the greater difference between the marginal productivity of skilled workers and their earnings, and when there is an economic mechanism preventing other firms from poaching on its pool of skilled workers. Co-ordination provides at least two institutional arrangements that tend to inhibit poaching[8]: i) centralised and co-ordinated wage-bargaining settings may extend contracts to cover almost all firms and workers and allow only limited variability of wage offers across firms, thereby dampening poaching since workers have no incentive to change job if no better wage offer can be made by the poaching firm (Teulings and Hartog, 1998; Acemoglu and Pischke, 1999b); and ii) customary inter-firm practices, typical of co-ordinated industrial relation regimes, may enforce an equilibrium wherein poaching is considered as unfair behaviour.[9] Furthermore, the cost of training is often shared among employers when business associations have a prominent role (Soskice, 1997, Casper *et al.*, 1999).

23. As a consequence, the only unambiguous effect of the wage compression associated with industrial relations regimes is to partially swap the roles of agents as regards to paying for training. Indeed, Lynch (1994), Blinder and Krueger (1996), Acemoglu and Pischke (1998, 1999) and OECD (1993 and 2000) report scattered evidence of more firm-sponsored training in more coordinated countries. In other words, two different human resource strategies characterise two different institutional systems. On the one hand, in uncoordinated decentralised industrial relations systems (such as in the United States or the United Kingdom) firms satisfy their competence requirements by hiring adequately skilled workers on the labour market. On the other hand, in coordinated industrial relations systems firms resort more frequently to their internal labour market and pay themselves for the cost of competence accumulation through training and on-the-job learning.

24. Competencies can be also firm-specific. Firm-specific competencies increase the employee's productivity only inside the firm but not its outside market value. Becker (1964) argues that the firm pays for firm-specific training since, in principle, it can appropriate the returns to training because the worker cannot re-sell the acquired competencies elsewhere. Nevertheless, problems of appropriability may arise since firm-specific and generic components of training are difficult to separate and both training content and worker's effort are not entirely controlled by the firm. Indeed, a moral hazard problem may arise to the extent that the accumulation of competencies is not fully observable, as is often the case when they are acquired on the job. In this case, the worker may try to acquire generic rather than firm-specific competencies, in order to increase its outside market value. Co-ordination between employers and trade unions may help setting a co-operative environment and align workers' and firm's objectives, due to workers' participation in firms' decisions and the establishment of an environment of mutual trust and loyalty. Furthermore, since the incentive to increase one's own generic human capital (at the detriment of

8. Other mechanisms singled out by the literature are: lack of information on previous training of job candidates (Katz and Ziderman, 1990; Chang and Wang, 1996, Acemoglu and Pischke, 1998); frictions and search costs (Acemoglu, 1997a, 1997b); and impossibility to separate general from firm-specific skills (Stevens, 1994; Acemoglu and Pischke, 1999a).

9. For instance Blinder and Krueger (1996) report that inter-firm job mobility is virtually non-existent in Japan due to firms' customary practices of refusing to employ people already working for other firms. Similarly Casper *et al.* (1999) report about legal provisions in Germany that reduce workers' mobility after training. Correspondingly, there is empirical evidence that there are no wage gains to switching jobs in Germany (Zimmermann, 1998) but they are substantial in the United States (McCue, 1996). Also, Blinder and Krueger (1996) report that many Japanese multinational firms have been forced to revise training strategies in their American affiliates due to poaching by competing firms.

firm-specific one) is larger the smaller the credibility of the career prospects within the same firm, stringent (statutory or contractual) employment protection complements these arrangements by introducing a commitment mechanism that enforces an otherwise time-inconsistent implicit contract.

Labour turnover and employment downsizing

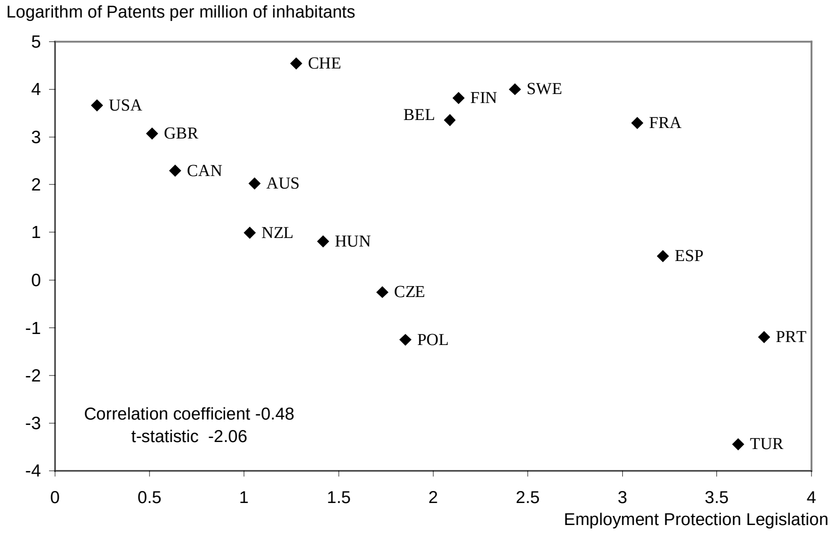
25. Hiring and firing restrictions may increase implementation costs of innovations by hindering labour adjustments (*e.g.* downsizing and/or reshuffling of the workforce), which are often needed after innovations have been introduced (see *e.g.* Cappelli, 2000). *Ceteris paribus* the potentially negative effect of hiring and firing restrictions is stronger the smaller the scope for resorting to internal labour markets. As a matter of fact, in countries with co-ordinated industrial relations regimes, for the reasons discussed above, firms tend to reallocate labour internally to a larger extent than in unco-ordinated countries, and are therefore less sensitive to the adjustment costs imposed by firing restrictions.

Discussion

26. On the basis of this discussion, there is no *a priori* reason to expect a better innovation performance in one system of industrial relations than in another. Nevertheless, the complementarity between labour market regulation and co-ordination of industrial relations suggests that hiring and firing restrictions can be expected to be less negative (or more positive) the more co-ordinated the system of industrial relations. Figure 3 provides some suggestive evidence in favour of this hypothesis. In panel A the logarithm of patent per capita is plotted against the indicator of stringency of employment protection legislation in countries with low or intermediate levels of co-ordination of the wage-bargain.[10] Two country clusters appear in the figure: English-speaking liberal countries and transition economies on the left and other countries (with intermediate levels of coordination) on the upper right corner. Correspondingly, two subgroup-specific downward-sloped lines can fit the relationships between employment protection and patent performance. By contrast, no systematic relationship appears between the same two variables in countries with high coordination (Panel B).

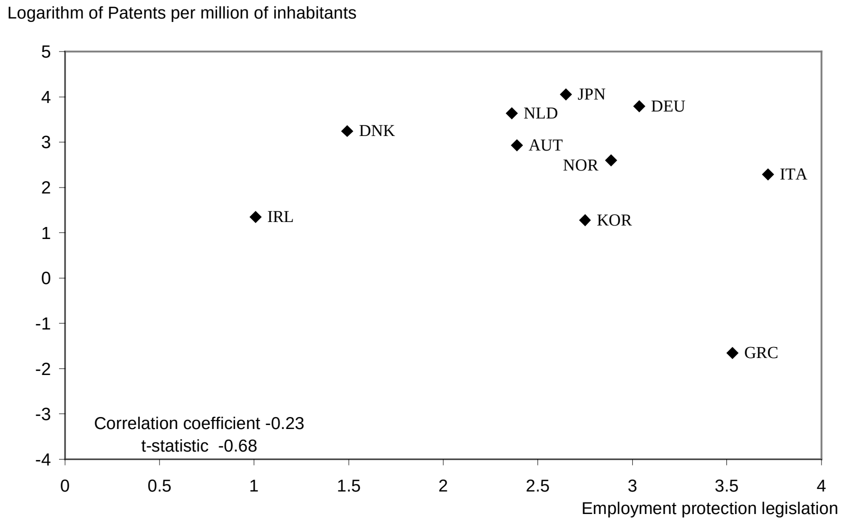
10. See section 5 for definitions and sources of these data.

Figure 3. **Patents per million of inhabitants and employment protection**[1]
Panel A: Countries with low and intermediate levels of coordination



1. The OECD summary index of employment protection legislation is from Nicoletti *et al.* (1999). Patents are defined as consolidated family of patent at EPO, USPTO and JPO by country of invention and priority year 1993.
Source: OECD.

Figure 3. **Patents per million of inhabitants and employment protection**[1] (continued)
Panel B: Coordinated countries



1. The OECD summary index of employment protection legislation is from Nicoletti *et al.* (1999). Patents are defined as consolidated family of patent at EPO, USPTO and JPO by country of invention and priority year 1993.
Source: OECD.

3. Sectoral patterns

27. Differences in the impact of labour market institutions across industries essentially emerge because the scope to reallocate resources internally rather than externally depends on industry specific features (Bassanini and Ernst, 2002). Two dimensions are relevant in this perspective: dynamics of industry-specific demand, and industry-specific characteristics of technological change and associated competence requirements:

- If the scope for expanding production is limited (because the firm core activity is in industries characterised by product lines at the end of their life-cycles with a slow dynamics of demand), innovation will more frequently lead to downsizing, forcing firms to adjust externally. These industries are mainly low technology industries, with firms undertaking little in-house R&D activity and mostly adopting technology produced elsewhere (see *e.g.* Pavitt, 1984).

- If the competencies required to implement innovations are rarely available inside the firm, the adjustment cost imposed by hiring and firing restrictions will be high. Conversely, if the competencies required to carry on the innovation process are more easily developed in-house, these adjustment costs will be relatively low. Furthermore, in that case, the role of coordination and employment protection in sustaining incentives for investment in appropriate human capital will be emphasised.

28. Two regimes can be distinguished on the basis of industry-specific innovation patterns: *Entrepreneurial* and *Routinised* (Audretsch, 1995).[11] In industries characterised by an entrepreneurial technological regime (*e.g.* precision instruments, standardised software, household appliances), firms often undertake sequences of short-lived projects on the basis of the same general knowledge but different specific realisations (e.g. as a consequence of short life-cycles of products and rapid capital depreciation). In this process, they rely on a one-shot match of human and physical capital requiring (or at least not being impaired by) a quick turnover of workers (or even firms themselves). Indeed, in these industries, newly hired personnel brings in new ideas and allows substituting for older organisational routines, while the use of a standardised knowledge base allows newly hired staff to quickly learn specific applications. Conversely, in industries characterised by a routinised regime (*e.g.* electronic components, aircrafts and spacecrafts) firms undertake incremental innovations along an existing technological trajectory. The best available competencies for this type of innovations can be often found inside the firm itself. Due to the specificity of the required competencies and the complexity of the relationships among system components, the loss of few staff members may involve significant costs for firms operating in these industries. Also, newly hired staff have to spend time and make effort in learning specialised routines before becoming fully operational.

29. Since in industries characterised by a routinised regime there is a strong incentive to using the firm's internal labour market, it seems natural to expect that these industries loom large in countries where institutional arrangements favour the exploitation of the internal labour market. Similarly, we can expect that entreprenurial industries tend to flourish in countries characterised by a flexible labour market. Put it in an empirically testable format, this means that we can expect that countries with coordinated industrial relations systems and relatively stringent employment protection have greater technological comparative advantage in routinised industries than in entrepreneurial industries, while we can expect the reverse to occur in uncoordinated systems.[12]

11. Also called *Schumpeter Mark I* and *Schumpeter Mark II*, respectively (Kamien and Schwarz, 1982, Nelson and Winter, 1982, Malerba and Orsenigo, 1995, Breschi *et al.*, 2000).

12. For a more detailed discussion of these issues, see Bassanini and Ernst (2002).

30. Coupling the discussion of this section with that of the previous one leads us to formulate three testable hypotheses:

i) *Direct effect on technological specialisation*: Countries with an uncoordinated (resp. co-ordinated) industrial relation system have a technological comparative advantage (resp. disadvantage) in industries characterised by an entrepreneurial technological regime.

ii) *Complementarity effect on technological specialisation*: Countries with a co-ordinated industrial relation system have a greater technological comparative advantage in industries with a routinised technological regime and a smaller comparative advantage in low-technology industries (characterised by smaller scope to expand production) the greater the level of employment protection.

iii) *Overall effect on innovation*: Employment protection can be expected to have a negative impact on innovation in countries with uncoordinated industrial relations systems regardless of the type of industry. Nevertheless, the impact of employment protection can be expected to be less negative (or even positive) in countries with a co-ordinated industrial relations system.

31. An empirical evaluation of the first two hypotheses is provided in section 6, while Section 7 deals with the third one and provides also an assessment of the empirical relationship between product market regulation and innovation.

4. The empirical framework.

32. Following a large empirical[13] and theoretical literature[14], the simplest possible model of innovative effort relates the latter to the expected profit differential - that is the expected difference between profits that the firm can earn once it has successfully innovated and profits that would be earned otherwise. In turn, the expected profit differential depends on market structure, industrial relations and other factors, including the dynamics of the industry's domestic and world demand, minimum efficiency scale and prevailing capital intensity, the extent of knowledge spill-overs, technological opportunity[15], appropriability conditions, accessibility of knowledge, cumulativeness of knowledge. Furthermore, we assume that market structure and industrial relations are the outcome of existing institutions (and regulation) in the product and labour market.[16] Taking the ratio of business-performed R&D expenditure to output (R&D intensity hereafter) as the indicator of innovative activity, we can write the following reduced form equation:

$$R\&D = f(\mathbf{LMR}, \mathbf{PMR}, \mathbf{OTHER}) \qquad [1]$$

where *R&D* stands for R&D intensity, **LMR** and **PMR** for vectors of indicators of labour and product market regulation (and/or institutions) respectively, and **OTHER** is a vector of other variables including controls for technological opportunity.

13. See *e.g.* Geroski (1990) and Aghion *et al.* (2001*b*).

14. See *e.g.* Aghion *et al.* (2001*a*) and Boone (2000*b*) for recent examples.

15. Technological opportunity can be defined as the easiness of successfully innovating for any given amount of resources invested.

16. Political economy considerations are beyond the scope of this paper. On that see *e.g.* Duso and Röller (2001).

33. In the following, equation [1] is implemented empirically on a cross-section of 18 manufacturing industries and 18 OECD countries. As indicators of product market regulation we use measures of inward-oriented economic regulation (state control, legal barriers to entry, price controls, etc…), administrative regulation (administrative barriers on start-ups, features of the licensing and permit system, etc…), indicators of tariffs and non-tariffs trade barriers, plus an indicator of global protection of Intellectual Property Rights (IPRs hereafter).[17] Labour market institutions are summarised by dummies concerning the industrial relation regime (decentralised vs. coordinated regimes) and a cardinal indicator of the strictness of employment protection legislation (EPL hereafter), which we take as a proxy for labour market rigidity. In order to test the hypotheses spelled out in section 3, the coefficient of EPL is allowed to vary between coordinated and decentralised countries through interactions with the industrial relations dummies. Furthermore, we use import penetration as a proxy for international technological spillovers, the intuition being that trade openness increases product variety in domestic markets and induces imitation by domestic producers, which in turn requires spending on R&D (Cohen and Levinthal, 1989). Finally, most of the other factors can be controlled for either by industry dummies (technological opportunity, returns to scale, dynamics of industry's world demand) or by country dummies (such as aggregate demand, supply of human capital etc.). However, other factors (such as capital intensity and the dynamics of industry's domestic demand), being co-determined in equilibrium, are not included in the reduced form, since, in a cross-section, it is impossible to find valid instruments for these variables.[18] A control for the average size of firms represents an exception. In fact, this control captures the bias in R&D intensity across industries and countries due to different accounting practices between large and small firms and has been proved to play an important role (see *e.g.* Griliches, 1990, Geroski, 1990). The robustness of the results is however tested by dropping the size variable.

34. Choosing a log-linear form for convenience, equation [1] can be re-written as:

$$\log R\&D_{ij} = \alpha + \sum_k \beta_k LMR_{ij}^k + \sum_h \gamma_h PMR_{ij}^h + \delta IMP_{ij} + \phi SIZE_{ij} + \mu_i + \chi_j + \varepsilon_{ij} \qquad [2]$$

where *IMP* and *SIZE* denote import penetration and average size, μ stands for the country dummy, χ stands for the industry dummy, ε is the standard error term, while *h*, *k*, *i* and *j* index labour market institutional variables, product market regulatory indicators, countries and industries, respectively.

35. Statements on the technological specialisation of different institutional systems can be derived from tests of hypotheses in this framework. In the case of balanced samples, a standard indicator of revealed technological comparative advantage is[19]:

$$C_{ij} = \frac{R\&D_{ij} \,/\, R\&D_{i\_}}{R\&D_{\_j} \,/\, R\&D_{\_,\_}} \qquad [3]$$

where the underscore denote the average over the corresponding country (industry) dimension. A monotone transformation of equation [3] is the following:

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17. In view of the potential endogeneity of the indicator of protection of IPRs, in the following it will be used only as a control in order to correctly identify the effect of other regulatory indicators.

18. Furthermore, we lack good cross-country comparable data on capital intensity both at the aggregate and industry level. Obviously this shortage limits the scope of the empirical analysis, which falls short of fully identifying the underlying economic mechanisms and therefore cannot provide a complete test of the theoretical hypothesis.

19 . See *e.g.* OECD (1999).

$$\log C_{ij} = \log R\&D_{ij} - \log R\&D_{i\_} - \log R\&D_{\_j} + \log R\&D_{\_,\_} \qquad [4]$$

36. Inserting equation [2] into equation [4] we have:

$$\log C_{ij} = \mathrm{A} + \sum_k \beta_k LMR_{ij}^k + \sum_h \gamma_h PMR_{ij}^h + \delta IMP_{ij} + \phi SIZE_{ij} + \mathrm{M}_i + \mathrm{X}_j + \varepsilon_{ij} \qquad [5]$$

where A=log$R\&D_{_,_}+\alpha$, M_i= log$R\&D_{i_}+\mu_i$ and X_j=log$R\&D_{_j}+\chi_j$. Hence, the slope coefficients of equation [2] can be interpreted as slope coefficients of equation [5] wherein the dependent variable is the indicator of comparative advantage logC_{ij}. Equation [2] can therefore be used to estimate the relationship between institutional variables and revealed comparative advantage, except that the interpretation of the estimated coefficients of country and industry dummies is different. The advantage of using equation [2] rather than equation [5] is that the former does not involve measures of R&D averages, which are not available in the case of unbalanced samples. In practice, the estimation of the slope coefficients using a specification like equation [2], which allows controlling for country and industry effects, corrects for biases due to missing observations.

37. In section 6, using the sector taxonomy discussed in section 3, we examine how the technological comparative advantage in a given sector depends on national institutional variables. In practice, this involves testing for differences in the coefficients of institutional variables across different clusters of industries and industrial relation systems. This will be accomplished by multiplying indicators of institutions and regulations by dummies characterising sector types. For instance, finding the estimated coefficient of the dummy for co-ordinated countries greater when multiplied by a dummy for industries characterised by a routinised regime than when multiplied by a dummy for industries characterised by an entrepreneurial regime will be interpreted as evidence of the “direct effect” hypothesis.

38. With the exception of indicators of tariffs and non-tariff barriers and inward-oriented economic regulation, all other regulatory and institutional indicators refer to economy-wide regulation and institutions that are by definition identical across industries in each country and therefore cannot be identified in the presence of country dummies. Moreover, the same applies to the indicator of inward-oriented economic regulation for which no sector breakdown is available, leading us to proxy it with an economy-wide indicator. Therefore, to go beyond the analysis of comparative advantages allowed by specification [2] and gather some evidence on the absolute impact of economy-wide product and labour market regulation on R&D intensity we need to complement equation [2] with a specification of the determinants of the country fixed effect, that is:

$$\mu_i = a + \sum_k b_k LMR_i^k + \sum_h c_h PMR_i^h + \sum_m d_m CNTRL_i^m \qquad [6]$$

where *CNTRL* stands for a number of other economy-wide control variables that are indexed by *m*. Inserting equation [6] into equation [2] we obtain the following specification:

$$\begin{aligned} \log R\&D_{ij} = \alpha + \sum_k \beta_k LMR_{ij}^k + \sum_h \gamma_h PMR_{ij}^h + \sum_k b_k LMR_i^k + \sum_h c_h PMR_i^h \\ + \delta IMP_{ij} + \phi SIZE_{ij} + \sum_m d_m CNTRL_i^m + \chi_j + \varepsilon_{ij} \end{aligned} \qquad [7]$$

that can be estimated by adjusting standard errors for cluster level effects on countries using the procedure suggested by Moulton (1986).

39. Aggregate and semi-aggregate models of the type used in this paper can be extremely sensitive to few outliers and influential observations usually due to measurement errors or specific omitted variables

(see *e.g.* Scarpetta; 1996, Temple, 1999, 2001). For this reason we use multiple techniques for the identification and elimination of outliers and influential observations that are based on leverage and residual of each observation.[20]

5. Data issues

40. Our sample includes all manufacturing industries at the 2-digit level of the ISIC Rev. 3 classification except that Manufacturing not elsewhere classified (ISIC 36 and 37), being a residual sector, has been excluded, while Food, beverages and tobacco (ISIC 15 and 16) and Textiles (ISIC 17, 18 and 19) have been aggregated due to lack of data availability. Countries considered, again due to data availability, are Austria, Belgium, Canada, Denmark, France, Finland, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom, and the United States. If not differently specified, all variables have been averaged across 1993-1997, excluding years in which observations were missing within the period for most of the industries.

41. R&D intensity is defined as the ratio of Business Expenditure in Research and Development (BERD) to output. Data on industry-level BERD are drawn from the OECD ANBERD database, except in the case of Austria, for which the OECD R&D database was used. Data on industry output are the result of the harmonisation of different sources (OECD STAN Database -- edition 2000, OECD Annual National Accounts Database, OECD Industrial Structure Statistics -- ISIS). Data on the ratio of government-financed BERD to total BERD (used only in the sensitivity analysis) are from the OECD R&D database. The advantage of using R&D intensity data is that they are available for many countries on a comparative basis. Nevertheless, it must be borne in mind that the use of R&D intensity as an indicator of innovation suffers from important limitations (for a general discussion, see Griliches, 1990). R&D intensity is an indicator of input in the innovative process rather than output. Consequently improvements in the efficiency of the innovation process (greater output with less input) can be mistakenly interpreted as a reduction of the innovative effort. Moreover, R&D intensity conveys only information about formal innovation expenditure. In many industries informal innovation is a sizeable component of overall innovation activity. Also, reported data tend to overestimate R&D intensity of large incumbents relative to small firms and new entrants. Small firms typically undertake much informal R&D and are not included in the R&D statistics if they do not have at least one full-time research employee. In the case of entrants, expenditure made before entering the industry is generally not recorded or might be recorded in other industries.

42. Import penetration is defined as the ratio of total imports to apparent demand (import plus output minus export). Data on imports are from OECD Foreign Trade Statistics. Consistent with the computation

20. The simplest possible indicator that we could use is the *studentised residual* of each observation *i*, which corresponds to the t-statistics of a dummy variable for *i* that has been added to the original regression equation. Although appealing and quite intuitive, this statistics tends to eliminate observations with large residual but low leverage that do not influence the estimated coefficient very much (that is in the case where the dummy variable is orthogonal to the other regressors), biasing upwards goodness-of-fit statistics. Other more complex indicators are based on the notion of influence curve. The influence curve assesses the asymptotic marginal effect on the coefficient estimates of adding a specific observation *i*, on the basis of the original regression model. The influence curve is only an asymptotic concept. In this paper, however, we use two indicators, the *DFITS* or *Welsch-Kuh distance* and the *Welsch distance*, that try to approximate empirically the influence curve and detect influential observations from that. Finally, other indicators assess the effect of adding one specific observation on the estimated confidence ellipsoids: among these, the covariance ratio is equal to the ratio of the determinants of the coefficients' variance-covariance matrices with and without the additional observation. Values far from 1 are taken to signal influential observations (see Chatterjee and Hadi, 1988).

of R&D intensity, the data on output used in the computation of apparent demand are the result of the harmonisation of different sources (OECD STAN Database -- edition 2000, OECD Annual National Accounts Database, OECD Industrial Structure Statistics-ISIS). Data on the employment share of foreign enterprises (used only in the sensitivity analysis) are from the OECD AFA Database and refer to 1996.

43. Data on firm size are from the OECD SME Database. Common dimensional classes have been reconstructed on the basis of available raw information on total employment. Furthermore, firms with less than 10 employees have been excluded due to concerns on the quality and comparability of the corresponding data. Consequently, only total employment for two dimensional classes is available on a comparable basis (firms with 10 to 49 employees and firms with 50 or more employees). The final measure used in the regression analysis is the ratio of total employment of firms with 50 or more employees to total employment of all firms in the sample. In the case of Canada dependent employment is used instead of total employment, due to lack of data for total employment. Experimentation on countries where both total and dependent employment are available showed that regressing total employment shares on dependent employment shares leads to a unitary coefficient and a non-significant constant. Thus, no bias seems to be introduced by this approximation.

44. Data on trade barriers are from the OECD Indicators of Tariff & Non-tariff Trade Barriers and refer to 1996. Tariffs are defined as the simple average of *ad valorem* tariff rates applied to the most favoured nation. The indicator of non-tariff barriers is a frequency ratio: it corresponds to the proportion of tariff lines to which anti-competitive non-tariff barriers apply. To avoid tariff measures being non-representative, observations in which the frequency ratio of non-*ad valorem* tariffs is greater than 20 per cent (Coke, refined petroleum and nuclear fuel -- ISIC 23 -- in Japan; Other non-metallic mineral products -- ISIC 26 -- and Telecommunication equipment -- ISIC 32 -- in Norway) are dropped from the sample.

45. The indicator of protection of IPRs has been developed by Ginarte and Park (1997). It varies between 0 and 5 from least to most stringent. The data used in this paper refer to 1995 and have been kindly supplied by Walter Park. All other regulatory indicators (administrative regulation, anti-competitive inward-oriented economic regulation, and EPL) are from Nicoletti *et al.* (1999). They vary between 0 and 6 from least to most restrictive and refer to 1998 (except EPL that is averaged over 1993-1997).

46. The classification of countries as regard to the degree of co-ordination of their industrial relation system is based on the indicator of the level of co-ordination of the wage-bargain used in Elmeskov *et al*. (1998). This indicator classifies countries into three groups (low, intermediate, and high co-ordination). Due to the small number of countries in the low co-ordination group, these countries are grouped together with intermediate co-ordination countries, and they will be called decentralised hereafter. A dummy for low co-ordination is however introduced in the regressions that do not include country effects.

47. The aggregate human capital measure used in section 7 is the share of the working-age population that completed at least upper-secondary education and is from the OECD *Education at a Glance* database. Data on GDP are from the OECD *Analytical* database (ADB) and are converted using PPPs for 1996 from Scarpetta *et al*. (2000).

6. Searching for regulatory determinants of technological specialisation

48. We start our analysis by using a standard classification of industries (high-tech, low-tech)[21] that will be refined later on to take into account differences in technological regimes. Column 1 in Table 1

21. Throughout the paper high-tech industries refer to high and medium-high technology industries according to the OECD classification (Hatzichronoglou, 1997).

reports the results from the estimation of the baseline specification including trade barriers, size and import penetration, as well as interaction terms between institutional variables and a dummy for high-technology industries. As discussed, due to the presence of country dummies, the coefficient of institutional variables that are identical across industries (within the same country) cannot be identified. Conversely, the interactions of these variables with dummies characterising industry types can be identified if at least one industry-type dummy is omitted. Hence, in the presence of industry dummies, all the estimated coefficients of these interaction variables must be interpreted in terms of differences from a benchmark (the omitted industry type), which in Table 1 and 2 is represented by low-technology industries. For example, in Table 1, the coefficients of the interactions with the high-tech dummy must be interpreted as representing differences in the impact of product and labour market regulations between high-tech and low-tech industries. A positive and significant coefficient of any given variable in high-tech industries means that the greater that variable the greater the estimated comparative advantage in high-tech industries.

Table 1. **High-tech and low-tech industries**

OLS with country and industry dummies

Dependent variable: logarithm of R&D intensity

	Full sample			Welsch[1]		Welsch-Kuh and covratio[2]	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Specification and method	All PMR controls	Baseline unweighted	Baseline weighted	Baseline unweighted	Baseline weighted	Baseline unweighted	Baseline weighted
Independent variables							
Employment share of large firms	0.013	0.013	0.015 *	0.023 **	0.022 **	0.022 **	0.021 **
	(1.90)	*(1.95)*	*(2.32)*	*(3.82)*	*(3.51)*	*(3.62)*	*(3.48)*
Import penetration	0.003 *	0.003 *	0.002	0.004	0.003	0.005 *	0.005
	(2.07)	*(2.04)*	*(1.33)*	*(1.93)*	*(1.26)*	*(2.29)*	*(1.70)*
Non-tariff barriers	-0.014 **	-0.014 **	-0.011 *	-0.014 **	-0.012 *	-0.014 **	-0.012 *
	(-2.77)	*(-2.79)*	*(-2.21)*	*(-3.12)*	*(-2.44)*	*(-3.16)*	*(-2.52)*
Tariff barriers	0.003	0.003	0.002	0.023	0.015	0.023	0.016
	(1.16)	*(1.28)*	*(1.11)*	*(1.34)*	*(1.04)*	*(1.37)*	*(1.11)*
EPL*high-tech*decentralised[3]	-0.037	-0.052	-0.130	-0.140	-0.167 *	-0.160	-0.195 *
	(-0.26)	*(-0.55)*	*(-1.62)*	*(-1.66)*	*(-2.10)*	*(-1.94)*	*(-2.54)*
EPL*high-tech*coordinated[3]	0.575 *	0.553 *	0.379	0.523 **	0.368 *	0.589 **	0.394 *
	(2.15)	*(2.52)*	*(1.90)*	*(3.03)*	*(1.99)*	*(3.28)*	*(2.12)*
high-tech*coordinated[3]	-1.756 **	-1.739 **	-1.421 *	-1.834 **	-1.483 **	-2.066 **	-1.607 **
	(-2.76)	*(-2.82)*	*(-2.47)*	*(-3.66)*	*(-2.74)*	*(-3.97)*	*(-2.96)*
Administrative regulation*high-tech[3]	-0.011						
	(-0.06)						
Inward-oriented economic regulation*high-tech[3]	-0.022						
	(-0.12)						
Difference between EPL coefficients[4]							
EPL*high-tech*coordinated - EPL*high-tech*decentralised	0.612 *	0.605 *	0.509 *	0.663 **	0.535 **	0.749 **	0.589 **
	(2.46)	*(2.48)*	*(2.32)*	*(3.42)*	*(2.62)*	*(3.76)*	*(2.89)*
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RESET[5]	4.28 **	3.76 *	2.55	2.33	2.46	1.90	2.36
R-squared	0.84	0.84	0.86	0.88	0.89	0.88	0.89
F-test on country dummies	8.24 **	10.28 **	11.02 **	11.30 **	11.38 **	13.94 **	14.18 **
F-test on industry dummies	9.81 **	12.82 **	16.76 **	18.60 **	19.47 **	19.17 **	21.05 **
Observations	265	265	265	257	257	256	256
Countries	18	18	18	18	18	18	18

1. Sample adjusted by excluding influential observations identified by the asymptotic Welsch distance cut-off.
2. Sample adjusted by excluding influential observations identified by the Welsch-Kuh distance (DFITS) cut-off combined with the covariance ratio cut-off.
3. "high-tech", "coordinated", and "decentralised", denote dummies for high-tech industries and types of industrial relation systems.
4. Difference in the estimated coefficient of EPL in high-tech industries between coordinated and decentralised countries .
5. Ramsey's omitted-variable test: F-test on the joint significance of the additional terms in a model augmented by including the second, third and fourth powers of the predicted values of the original model.

All equations include a constant. *, ** denote significance at the 5% and 1% level, respectively. t-statistics adjusted for heteroskedasticity of unknown form in parentheses.

49. In column 2 non-significant product market regulation terms are excluded. The latter specification is then re-estimated by weighting industries by their average employment size across countries and the corresponding results are presented in column 3. Results from the preferred specification re-estimated after eliminating influential observations identified through the asymptotic Welsch distance cut-off and the Welsch-Kuh distance cut-off combined with the covariance ratio (see Chatterjee and Hadi, 1988 and footnote 20) are reported in column 4-5 and 6-7, respectively.[22] We also tried augmented specifications including the ratio of government-financed BERD to total BERD and the employment share of foreign enterprises (not shown in the table). However, coefficient estimates of these variables never turned out significant (even when controlling for outliers), without changing the significance of other coefficients. Given that our sample size drops to 180-190 observations when adding these controls, we did not include them in further refinements of the specification.

50. The importance of controlling for influential observations is shown by the RESET test statistics. In columns 1-2 they show evidence of misspecification at the 5% confidence level. It is however sufficient to weigh industries by their average employment across countries (column 3) to obtain a better statistic, suggesting that its value might be driven by smaller industries where typically data quality is lower and omitted idiosyncratic effects more important. Columns 4-5 confirm this fact, by showing that it is sufficient to eliminate 8 observations (over 265)[23], that are singled out by the asymptotic Welsch distance cut-off as being particularly influential, to make the test statistic insignificant. Moreover, the latter result is robust to further elimination of observations by using tighter statistical cut-offs.

51. Controls for size and import penetration have the expected sign. A negative estimated coefficient of non-tariff barriers is also robust across all specifications. Conversely, the estimated coefficient of tariff barriers is not significant. This might be due to controlling for import penetration (which might capture some aspects of competitive pressure) and the lack of variability of the indicator resulting from the fact that trade barriers are the same across all EU countries. Nonetheless, according to Boone (2000a) there might be good theoretical reasons for less negative impact of tariffs (rather than non-tariff barriers) on innovation. Under Cournot competition in partial equilibrium, conditional to the level of knowledge spillovers, tariffs have a positive impact on profits because they add to competitors' costs without changing the incentive to reduce own costs via innovation. However, in general equilibrium, tariffs interact negatively with imports and might then have a negative overall impact due to their indirect effect on knowledge spillovers. Conversely, non-tariff barriers have a greater impact on the diffusion of products and, eventually, the possibility of imitation and reverse engineering by domestic firms. Moreover high non-tariff barriers can be thought to directly affect the elasticity of substitution between imported and domestically produced products, thereby inducing low incentives to innovate when domestic and foreign firms have similar levels of competitiveness (the case of "neck and neck" competition).

52. Column 1 does not identify any effect of inward-oriented economic and administrative regulation on patterns of comparative advantage. By contrast, in virtually all the specifications of Table 1, in coordinated countries the estimated coefficient of EPL in high-tech industries (that is the estimated coefficient of the interaction EPL*high-tech*coordinated) is positive and significant. In other words,

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22. Since heteroskedasticity tests show some evidence of exponential heteroskedasticity with respect to size, import penetration and tariffs, all specifications in Tables 1 and 2 are re-estimated by taking logarithms of these three variables. All the results are robust to this change in specification, which in addition yields better RESET test statistics and a smaller number of outliers. Full regression results with log-log specifications are available from the authors upon request.

23. These observations are Food, beverages and tobacco (ISIC 15-16) in Norway, Computers (ISIC 30), Telecommunication equipment (ISIC 32) and Wood (ISIC 20) in Ireland, Other transport (ISIC 35) in Greece, Coke, petroleum and nuclear fuel (ISIC 23) in the United Kingdom, Motor vehicles (ISIC 34) in Belgium and Electrical Machinery (ISIC 31) in the Netherlands.

results in Table 1 suggest that coordinated countries with high EPL have a greater technological comparative advantage in high-tech industries (as opposed to low-tech industries) than coordinated countries with low EPL. Conversely, we find little difference in the impact of EPL between high and low-tech industries in decentralised countries.

53. These results could merely reflect the fact that in coordinated economies firms adjust less frequently on the external labour market when the dynamics of demand is such that an innovation can be followed by output expansion and no employment contraction (which is often the case in high-tech industries). However, on the basis of the theoretical discussion made in the previous section, it is legitimate to suspect that the results for EPL are also due to the fact that no further distinction is made in Table 1 between industries characterized by different technological regimes. In practice estimates of Table 1 suffer from misspecification to the extent that high-tech industries characterised by entrepreneurial and routinised regimes (hereafter entrepreneurial and routinised industries respectively for brevity) are grouped together.

54. To go further down the road of technological regimes and labour market regulation, we need a mapping classifying our 2-digit industries into their corresponding regime. A specific measure of the degree of "routinisation" (as opposed to "entrepreneurship") is provided by Malerba and Orsenigo (1997) and Breschi *et al.* (2000). Their principal component indicator characterises 26 technological classes (obtained through aggregation of 12-digit International Patent Classification classes) that account for about two-thirds of total patenting activity in the major European countries. This indicator allows the authors to map these classes into routinised, entrepreneurial and mixed regimes. Since virtually all high-tech 2-digit industries are composed of technological classes belonging to different regimes an exact mapping with ISIC Rev.3 2-digit industries is not readily available. Three industries represent an exception (Telecommunication equipment - ISIC 32 -, Computers - ISIC 30 - and Motor vehicles - ISIC 34) and can be classified as routinised. We add Other transport (ISIC 35) to this group, because Aircrafts and spacecrafts (ISIC 353), a technological class unambiguously classified as routinised (Malerba and Orsenigo, 1997), accounts on average for over 60 per cent of all R&D expenditure of this industry (with a median of 75 per cent). In contrast, we can place the remaining 4 high-tech industries (Chemicals, including drugs - ISIC 24 - Machinery not elsewhere classified. - ISIC 29 - Electrical machinery - ISIC 31- Precision and optical instruments - ISIC 33) under the heading of "prevailing entrepreneurial regime". Table 2 reports estimates[24] of the preferred specification of Table 1 (corresponding to columns 2-7) augmented by grouping high-tech industries according to this classification.

24. The table reports both unweighted and weighted estimates, with different controls for influential observations.

Table 2. **Technological regimes and technological specialisation**

OLS with country and industry dummies

Dependent variable: logarithm of R&D intensity						
	Unweighted			Weighted with average employment		
	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Full sample	Welsch[1]	Welsch-Kuh and covratio[2]	Full sample	Welsch[1]	Welsch-Kuh and covratio[2]
Independent variables						
Employment share of large firms	0.013	0.020 **	0.019 **	0.015 *	0.020 **	0.019 **
	(1.88)	*(3.49)*	*(3.37)*	*(2.34)*	*(3.31)*	*(3.30)*
Import penetration	0.003 *	0.004	0.005 *	0.003	0.003	0.004
	(2.46)	*(1.73)*	*(2.01)*	*(1.83)*	*(1.06)*	*(1.49)*
Non-tariff barriers	-0.014 **	-0.014 **	-0.014 **	-0.011 *	-0.012 *	-0.012 *
	(-2.68)	*(-2.95)*	*(-2.99)*	*(-2.17)*	*(-2.40)*	*(-2.46)*
Tariff barriers	0.003	0.025	0.025	0.002	0.017	0.017
	(1.31)	*(1.47)*	*(1.48)*	*(1.19)*	*(1.14)*	*(1.20)*
EPL*entrepreneurial*decentralised[3]	-0.070	-0.135	-0.154	-0.125	-0.141	-0.171 *
	(-0.75)	*(-1.51)*	*(-1.76)*	*(-1.60)*	*(-1.77)*	*(-2.23)*
EPL*entrepreneurial*coordinated[3]	0.273	0.231	0.233	0.208	0.153	0.165
	(1.58)	*(1.46)*	*(1.47)*	*(1.14)*	*(0.88)*	*(0.94)*
entrepreneurial*coordinated[3]	-1.060	-1.177 *	-1.218 *	-0.984	-0.927	-1.011
	(-1.96)	*(-2.48)*	*(-2.57)*	*(-1.76)*	*(-1.75)*	*(-1.91)*
EPL*routinised*decentralised[3]	-0.033	-0.123	-0.140	-0.147	-0.184	-0.208
	(-0.25)	*(-1.10)*	*(-1.28)*	*(-1.19)*	*(-1.66)*	*(-1.92)*
EPL*routinised*coordinated[3]	0.948 *	1.069 **	1.144 **	0.897 *	1.101 **	1.135 **
	(2.79)	*(4.84)*	*(5.90)*	*(2.46)*	*(4.72)*	*(5.19)*
routinised*coordinated[3]	-2.727 *	-3.106 **	-3.358 **	-2.797 **	-3.367 **	-3.499 **
	(-3.02)	*(-4.51)*	*(-5.41)*	*(-2.89)*	*(-4.72)*	*(-5.19)*
Differences between EPL coefficients[4]						
EPL*routinised*coordinated -	0.675 *	0.838 **	0.911 **	0.689 *	0.948 **	0.970 **
EPL*entrepreneurial*coordinated	*(2.21)*	*(3.84)*	*(4.90)*	*(1.99)*	*(4.23)*	*(4.66)*
EPL*routinised*decentralised -	0.037	0.012	0.014	-0.021	-0.043	-0.037
EPL*entrepreneurial*decentralised	*(0.32)*	*(0.10)*	*(0.14)*	*(-0.20)*	*(-0.42)*	*(-0.36)*
EPL*routinised*coordinated -	0.981 **	1.192 **	1.285 **	1.044 **	1.286 **	1.342 **
EPL*routinised*decentralised	*(2.61)*	*(4.82)*	*(5.74)*	*(2.63)*	*(4.98)*	*(5.50)*
(EPL*routinised*coor.-EPL*routinised*decentr.) -	0.638	0.826 **	0.897 **	0.711	0.991 **	1.006 **
(EPL*entrepren.*coor.-EPL*entrepren.*decentr.)	*(1.91)*	*(3.37)*	*(4.14)*	*(1.93)*	*(4.01)*	*(4.34)*
Derived estimated effect of coordination[5]						
At the median level of EPL:						
entrepreneurial industries	-0.233	-0.296	-0.284	-0.182	-0.216	-0.201
	(-1.17)	*(-1.70)*	*(-1.65)*	*(-0.94)*	*(-1.21)*	*(-1.15)*
routinised industries	-0.364	-0.233	-0.262	-0.282	-0.268	-0.263
	(-1.39)	*(-1.02)*	*(-1.19)*	*(-1.04)*	*(-1.13)*	*(-1.15)*
At the third quartile of EPL:						
entrepreneurial industries	-0.003	-0.051	-0.024	0.041	-0.019	0.024
	(-0.01)	*(-0.24)*	*(-0.12)*	*(0.20)*	*(-0.09)*	*(0.12)*
routinised industries	0.293	0.565 *	0.598 *	0.417	0.593 *	0.636 *
	(0.75)	*(2.28)*	*(2.49)*	*(1.05)*	*(2.26)*	*(2.52)*
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
RESET[6]	3.67 *	2.32	2.09	2.36	2.58	2.58
R-squared	0.84	0.89	0.89	0.86	0.89	0.90
F-test on country dummies	10.84 **	11.81 **	14.79 ***	11.47 **	12.07 **	15.11 **
F-test on industry dummies	13.81 **	19.53 **	20.19 ***	16.89 **	20.75 **	22.00 **
Observations	265	257	256	265	257	256
Countries	18	18	18	18	18	18

1. Sample adjusted by excluding influential observations identified by the asymptotic Welsch distance cut-off.
2. Sample adjusted by excluding influential observations identified by the Welsch-Kuh distance (DFITS) cut-off combined with the covariance ratio cut-off.
3. "routinised", "entrepreneurial", "coordinated", and "decentralised", denote dummies for technological regimes and types of industrial relation systems.
4. Differences between estimated coefficients of EPL variables.
5. The coefficient of the overall effect of coordination for a given industry type is obtained as the sum of the estimated coefficient of the dummy for that industry type in coordinated countries and the difference in the estimated coefficients of EPL for that industry type between coordinated and decentralised countries multiplied by a chosen value of EPL.
6. Ramsey's omitted-variable test: F-test on the joint significance of the additional terms in a model augmented by including the second, third and fourth powers of the predicted values of the original model.

All equations include a constant. *, **, denote significance at the 5% and 1% level, respectively. t-statistics adjusted for heteroskedasticity of unknown form in parentheses.

55. The main result that emerges from Table 2 is that in coordinated countries EPL is significantly associated with a technological specialisation in routinised industries with respect to both entrepreneurial and low-tech industries: in coordinated countries the estimated coefficient of EPL in routinised industries (that is the estimated coefficient of the interaction EPL*routinised*coordinated) is significantly positive and greater than the estimated coefficient of EPL in entrepreneurial industries.[25] The reverse is true for decentralised countries, although often not significantly, therefore pointing to a minor role of EPL in shaping technological specialisation patterns in these countries. Consistently, results in Table 2 show that there is a structural difference between coordinated and decentralised countries in the relationship between EPL and revealed comparative advantage in routinised industries. More precisely, estimates reported in Table 2 show that: a) the difference between the coefficients of EPL for routinised industries in coordinated and decentralised countries is positive; and b) the difference between the coefficients of EPL for routinised industries corresponding to coordinated and decentralised countries is greater than the difference between the coefficients of EPL for entrepreneurial industries in coordinated and decentralised countries. Both results are significant at the 1 per cent level when influential observations are controlled for. Overall, these results yield some support to the complementarity hypothesis discussed in section 3. Put it another way, patterns of technological specialisation seem to be differently affected by EPL in coordinated and decentralised countries.

56. The estimated coefficients of EPL for entrepreneurial industries are not (or weakly) significant, suggesting that EPL does not affect technological specialisation between entrepreneurial and low-tech industries. This is also not surprising in the view of the theoretical discussion of the previous sections, given the limited scope for internal labour markets in both entrepreneurial and low-tech industries, albeit for different reasons.

57. We can also try to assess the effect of coordination *per se* on patterns of technological specialisation (the direct effect hypothesis of section 3). To do so we need to simulate the effect of coordination for a given level of employment protection .[26] As shown in Table 2, at a median level of the indicator of EPL there are no significant differences in technological specialisation between coordinated and uncoordinated countries. This suggests that, due to the complementarity between employment protection and coordination, significant differences in the patterns of technological specialisation can exist only in the presence of stringent regulation. Indeed, at the third quartile of the distribution of the indicator of EPL, coordinated countries show significant evidence (at the 5 per cent level upon exclusion of outliers) of technological specialisation in routinised industries with respect to both low-tech and entrepreneurial industries.

58. Average firm size (or any variable that can proxy for it) is an endogenous variable that typically is positively affected by R&D intensity (*e.g.* Dasgupta and Stiglitz, 1980, Sutton, 1998). Although, as discussed in section 4, there are good reasons for including this control, to the extent that regulation and

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25. As discussed, due to the presence of country dummies, all the estimated coefficients of interaction variables are expressed with respect to a benchmark, which in Table 1 and 2 is represented by low-tech industries. The estimated differences between the coefficients of EPL in routinised and entrepreneurial industries are reported as derived coefficients at the bottom of Table 2.

26. The coefficient of the overall effect of coordination for a given industry type can be obtained as the sum of the estimated coefficient of the dummy for that industry type in coordinated countries and the difference in the estimated coefficients of EPL for that industry type between coordinated and decentralised countries multiplied by a chosen value of EPL. In Table 2 derived coefficients are shown with reference to the median and the third quartile of the distribution of EPL (2.41 and 3.08, respectively). Note that the coefficient of the dummy for a given industry type in coordinated countries have no immediate interpretation (representing the predicted effect of coordination for EPL equal to 0, a value well beyond the limits of the distribution of EPL, at least in coordinated countries).

institutions are correlated with firm size, including this variable in the regression may bias the estimates of the parameters of interest. Nevertheless, excluding firm size from the regression, we obtain identical results (not shown in the table) in terms of both sign and significance as well as tests of hypotheses. These results are also robust to variation of country samples as well as to varying the classification of high-tech industries by switching one industry at a time from the entrepreneurial to the routinised group and viceversa (see Bassanini and Ernst, 2002).

7. Beyond technological specialisation: Some results on institutional determinants of innovation

59. Although we can claim to have found empirical support to the hypothesis that co-ordinated countries have a greater technological specialisation in routinised industries the more stringent the employment protection legislation, this does not amount to say that employment protection has a beneficial effect in these industries and countries. Indeed, these results might mean that since the scope for internal labour reallocations is greater in routinised industries and encouraged in co-ordinated industrial relation regimes, firms are simply less sensitive to legislation hindering workforce adjustment on the external market. In other words, to fully assess the role of both product market regulation and labour market institutions within an absolute metric space, we need to go beyond the analysis of the patterns of technological comparative advantage discussed in the previous section.

60. We attempt to overcome this limitation by estimating a simple regression model of the type described in equation [7], whose results are presented in Table 3. Determinants of the country specific effects must be introduced at this stage, although in a limited number to avoid problems of multicollinearity. As a consequence, the analysis has a somewhat more tentative (or descriptive) flavour. We included a dummy for countries with low co-ordination (Canada, the United Kingdom and the United States), to distinguish more liberal economies from mixed systems, in all specifications, and a control for the aggregate supply of human capital (as measured by the share of the population with working age that completed upper-secondary education) in columns 1-5. We experimented also with the level of GDP in PPP terms instead of human capital and obtained similar results (not shown in the table). The level of GDP is however somewhat more endogenous than the supply of human capital and for this reason we tend to prefer the latter.

Table 3. **The impact of product and labour market regulation on R&D intensity**
OLS adjusted for cluster level effects on countries[1]

Dependent variable: logarithm of R&D intensity							
	Controlling for human capital			Interactions between human capital and industrial relations		Without controlling for human capital	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Specification	No IPR	All PMR variables	No admin. regulation	All PMR variables	No admin. regulation	All PMR variables	No admin. regulation
Independent variables							
Employment share of large firms	0.025 *	0.024 *	0.022 *	0.025 **	0.023 *	0.022 *	0.020
	(2.76)	*(2.70)*	*(2.39)*	*(3.05)*	*(2.71)*	*(2.27)*	*(1.90)*
Import penetration	0.006 *	0.005 *	0.005 *	0.006 *	0.005 *	0.005 *	0.005 *
	(2.29)	*(2.28)*	*(2.24)*	*(2.31)*	*(2.30)*	*(2.28)*	*(2.21)*
Non-tariff barriers	-0.017 **	-0.019 **	-0.018 **	-0.018 **	-0.018 **	-0.023 **	-0.022 **
	(-2.91)	*(-4.88)*	*(-5.51)*	*(-4.85)*	*(-5.27)*	*(-5.13)*	*(-5.86)*
Tariff barriers	-0.013	-0.001	-0.004	0.010	0.006	-0.001	-0.005
	(-0.62)	*(-0.03)*	*(-0.19)*	*(0.55)*	*(0.31)*	*(-0.06)*	*(-0.20)*
EPL*entrepreneurial*decentralised[2]	-0.651 *	-0.439 *	-0.457	-0.489 *	-0.503 *	-0.527 *	-0.552 *
	(-2.58)	*(-2.28)*	*(-2.07)*	*(-2.57)*	*(-2.27)*	*(-2.85)*	*(-2.51)*
EPL*entreprenuerial*coordinated[2]	-0.128	-0.112	0.003	-0.124	-0.002	-0.119	0.004
	(-0.38)	*(-0.43)*	*(0.01)*	*(-0.52)*	*(-0.01)*	*(-0.41)*	*(0.02)*
entrepreneurial*coordinated[2]	-1.462	-0.879	-1.284	-1.444	-1.809	-1.077	-1.521
	(-1.28)	*(-0.94)*	*(-1.58)*	*(-1.32)*	*(-1.76)*	*(-1.08)*	*(-1.77)*
EPL*routinised*decentralised[2]	-0.648 *	-0.423 *	-0.433	-0.470 *	-0.475	-0.503 *	-0.518
	(-2.58)	*(2.22)*	*(-1.88)*	*(-2.50)*	*(-2.07)*	*(-2.44)*	*(-2.09)*
EPL*routinised*coordinated[2]	0.557	0.556	0.709 **	0.559	0.719 **	0.512	0.674 **
	(1.78)	*(2.04)*	*(3.09)*	*(2.08)*	*(3.11)*	*(1.87)*	*(3.01)*
routinised*coordinated[2]	-2.974 *	-2.332 *	-2.822 **	-2.915 *	-3.366 *	-2.415 *	-2.945 **
	(-2.61)	*(-2.33)*	*(-3.13)*	*(-2.39)*	*(-2.84)*	*(-2.24)*	*(-3.02)*
EPL*low-tech*decentralised[2]	-0.431	-0.239	-0.268	-0.309	-0.332	-0.378 *	-0.415
	(-1.85)	*(-1.42)*	*(-1.31)*	*(-1.95)*	*(-1.65)*	*(-2.24)*	*(-1.98)*
EPL*low-tech*coordinated[2]	-0.521 *	-0.455 *	-0.320	-0.460 *	-0.318	-0.471 *	-0.328
	(-2.53)	*(-2.43)*	*(-1.96)*	*(-2.40)*	*(1.87)*	*(-2.36)*	*(-1.97)*
low-tech*coordinated[2]	0.379	0.796	0.314	0.174	-0.265	0.432	-0.102
	(0.49)	*(1.13)*	*(0.47)*	*(0.20)*	*(-0.30)*	*(0.61)*	*(-0.16)*
Administrative regulation	0.384 *	0.214		0.226		0.228	
	(2.37)	*(1.56)*		*(1.73)*		*(1.40)*	
Inward-oriented economic regulation	-0.319 *	-0.328 *	-0.349 *	-0.274 *	-0.302 *	-0.419 *	-0.446 *
	(-2.12)	*(-2.49)*	*(-2.68)*	*(-2.24)*	*(-2.60)*	*(-2.73)*	*(-2.78)*
IPRs protection		0.528 **	0.634 **	0.556 **	0.664 **	0.546 **	0.659 **
		(4.20)	*(4.49)*	*(4.44)*	*(4.64)*	*(3.66)*	*(4.05)*
Low-coordination dummy[3]	-1.248 *	-1.067 *	-1.479 **	-0.989	-1.429 **	-1.161 *	-1.606 **
	(-2.21)	*(-2.38)*	*(-3.64)*	*(-2.09)*	*(-3.43)*	*(-2.28)*	*(-3.48)*
Human capital	0.021	0.020	0.020				
	(1.90)	*(1.82)*	*(1.96)*				
Human capital*decentralised[2]				0.008	0.010		
				(0.93)	*(1.33)*		
Human capital*coordinated[2]				0.031	0.031		
				(1.61)	*(1.57)*		
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	No	No	No	No	No	No	No
RESET[4]	3.22 *	1.68	1.47	1.57	1.36	1.77	1.41
R-squared	0.85	0.86	0.86	0.87	0.86	0.86	0.86
F-test on industry dummies	704.59 **	135.52 **	95.51 **	1957.49 **	50397.59 **	1186.03 **	88.31 **
Observations	257	257	257	257	257	257	257
Countries	18	18	18	18	18	18	18

1 Sample adjusted by excluding influential observations identified by the asymptotic Welsch distance cut-off.

2 "low-tech", "routinised", "entrepreneurial", "coordinated", and "decentralised", denote dummies for types of industries and industrial relation systems.

3 Dummy for liberal economies (Canada, the United States, the United Kingdom).

4 Ramsey's omitted-variable test: F-test on the joint significance of the additional terms in a model augmented by including the second, third and fourth powers of the predicted values of the original model.

All equations include a constant. *, ** denote significance at the 5% and 1% level, respectively. t-statistics adjusted for cluster level effects on countries in parentheses.

61. Across all specifications (columns 1-7), both non-tariff barriers and inward-oriented economic regulation seem to be negatively associated with R&D intensity. Conversely, in column 1 more burdensome administrative regulation appears to enhance R&D intensity. Various explanations can be developed to explain this result. Probably, the most likely is related to the fact that in each country there is a close relationship between the regulatory stance concerning administrative procedures and that concerning protection of IPRs, which in turn guarantees ex-post appropriation of innovation rents.[27] In other words, omitting a control for IPRs from the specification biases upward the estimated coefficient of administrative regulation. Indeed, the latter becomes insignificant once a control for the protection of IPRs is included (column 2). Further exclusion of administrative regulation (column 3) does not change the significance of the estimated coefficients of both economic regulation and protection of IPRs. Moreover, the coefficient of economic regulation remains significant when the specification corresponding to column 3 is re-estimated without the control for IPRs (not shown in the Table). Finally, administrative regulation is still insignificant, and both economic regulation and protection of IPRs still significant, if the coefficient of human capital is allowed to vary across industrial relation systems (columns 4-5) or human capital is excluded from the specification (columns 6-7). Overall this piece of evidence suggests that there is, according to the regulatory variable, either a negative or an insignificant cross-country association between product market regulation and R&D intensity, consistent with the existing empirical evidence, available mainly for the United Kingdom and discussed in Section 1.

62. Results concerning employment protection and industrial relations regimes are broadly consistent with the analysis of the patterns of technological specialisation developed in the previous section.[28] Indeed, the tests of hypothesis on the impact of EPL on technological specialisation yield the same outcomes (in terms of both sign and significance) as those based on the specifications of the previous section, and are therefore not shown in the table for simplicity. In co-ordinated countries the stringency of employment protection seems to be negatively associated with R&D intensity in low technology industries, but positively associated in routinised industries, although the magnitude of this effect depends on whether administrative regulation is included.[29] Conversely, in decentralised countries, EPL has always a negative association with R&D intensity. Statistical significance varies across different specifications. Particularly, the coefficient of EPL in decentralised countries and low-tech industries is not significant in most specifications, although its point estimate is not statistically different from that of the same coefficient for co-ordinated countries. The latter result is somewhat at odds with our theoretical predictions, but is probably due to a problem of multicollinearity between EPL and human capital in decentralised countries that, as shown in Figure 4, are almost perfectly correlated. As a matter of fact, the significance of the EPL

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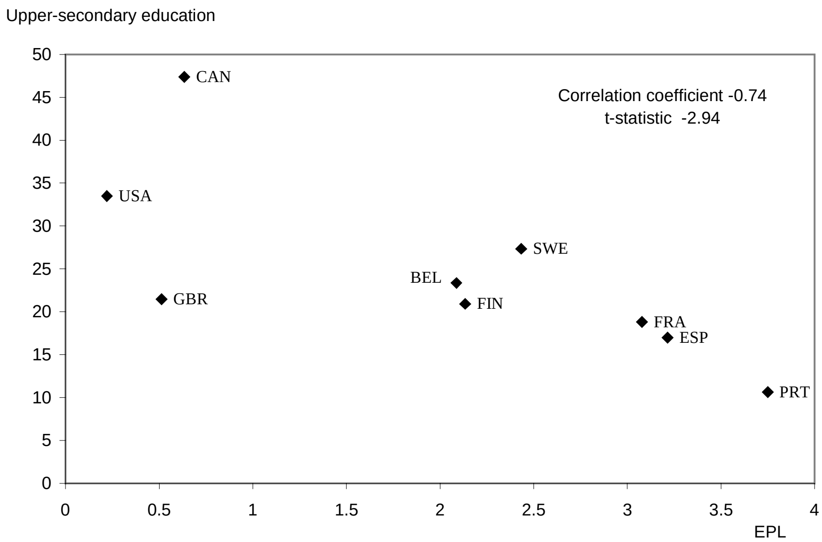
27. In our sample of 18 countries, 55 per cent of the variance in the indicator of administrative regulation can be explained by the variances in the indicators of EPL and IPR protection. However, the positive sign of administrative regulation may have several other interpretations: i) by reducing competitive pressures, high administrative barriers may also reduce competitive selection and, hence, overall industry efficiency (Vickers, 1995; Nickell, 1996), including efficiency in turning R&D into innovation (in this case R&D is less productive and the recorded R&D intensity higher, without implying that firms are innovating more); ii) tight administrative regulation may generate rents and wage premia, pushing towards more capital-intensive and higher-technology production processes (see e.g. Chennels and van Reenen, 1998, and Acemoglu and Shimer, 2000); iii) administrative regulation may add to the effect of IPR protection as regard to increasing *ex post* innovation rents and improving appropriability conditions; and iv) the stringency of administrative regulation may proxy for size, compensating for possible errors in the measurement of this variable.

28. Note that, in contrast with Table 1 and 2, in Table 3 the coefficients of EPL are not defined with respect to the low-tech benchmark but can be considered estimates of the absolute effect of EPL in different institutional systems and industry types.

29. The estimated coefficient for entrepreneurial industries is approximately equal to zero.

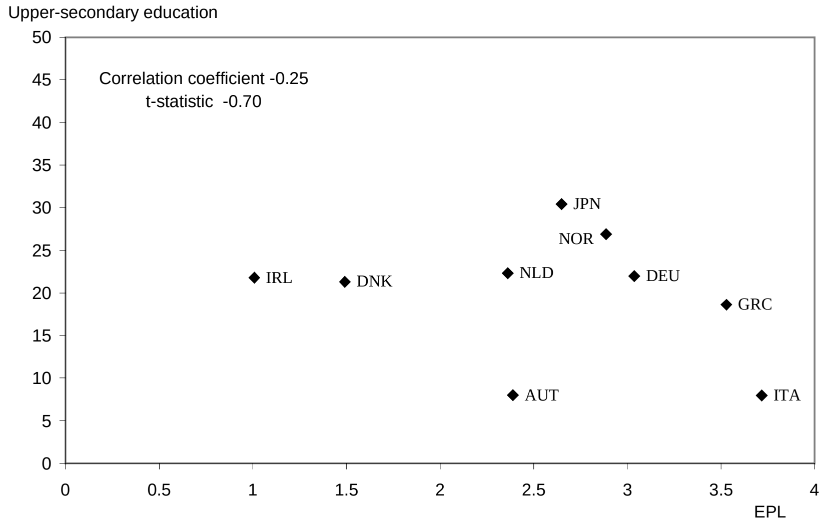
coefficient increases if the coefficient of human capital is allowed to vary across country types as well as if the variable is dropped.

Figure 4. **Human capital and employment protection legislation**[1]
Panel A: Decentralised countries



1. Share of the population with working age that completed upper-secondary education and EPL
Source: OECD.

Figure 4. **Human capital and employment protection legislation**[1] (continued)
Panel B: Coordinated countries



1. Share of the population with working age that completed upper-secondary education and EPL.
Source: OECD.

8. Concluding remarks

63. The regression analysis we have presented, provides evidence that countries with a co-ordinated system of industrial relations tend to exhibit greater technological specialisation in industries characterised by a routinised technological regime the more stringent the restrictions on hiring and firing. Furthermore, these countries tend to have greater technological comparative advantage in low-technology industries the lower the degree of employment protection. These results seem to reflect a general tendency for hiring and firing restrictions to depress the incentive to innovate to a greater extent the slower the dynamics of demand and thus the larger the need of employment downsizing after having successfully innovated. These negative effects are however smaller the larger the scope for internal labour markets. In the context of a cumulative and specific knowledge base, stringent employment protection and co-ordinated systems of industrial relations, by aligning workers' and firms' objectives, enhancing the accumulation of firm-specific competencies and encouraging firm-sponsored training, may allow firms to fully exploit the potential of the internal labour market.

64. Regression results discussed in Section 7 allow us framing the evidence on technological specialisation in such a way as to provide a tentative assessment of the direction of the absolute effect of employment protection and institutions on innovation. Job protection is negatively associated with R&D intensity in low-tech industries as well as in decentralised countries across all industries. Conversely, in countries with a co-ordinated industrial relations system, there is a negative association between labour market flexibility and R&D intensity in industries with a more cumulative knowledge base.

65. In terms of policy implications our results are mixed. Decentralised countries seem to have an institutional structure that allows them to benefit from a flexible labour market. However, the relationship between hiring and firing restrictions and innovation in co-ordinated economies is more ambiguous. Indeed in these countries, greater employment protection corresponds to better innovative performance in industries characterised by a routinised technological regime that account on average for 40 per cent of business-performed R&D expenditure in manufacturing.

66. Furthermore, the results we have presented in the last section allow us to reach some tentative conclusions also as regard to the cross-country empirical relationship between product market regulation and innovation:

- There is an unambiguous negative association between R&D intensity and indicators of non-tariff barriers and inward-oriented economic regulation. As regards to the effects of tariffs and administrative regulation, the evidence is less clear-cut.

- Stronger protection of intellectual property rights tends to be positively associated with higher R&D intensity, although endogeneity problems do not enable us to identify this association as a causal relationship.

APPENDIX

Table A1. **Descriptive statistics**

Variable	Measurement unit	Mean	Standard Deviation
R&D (BERD) intensity	percentage of total output	2.43	3.39
Import penetration	percentage of apparent demand	50.50	52.01
Employment share of large firms	percentage	78.38	15.01
Tariff barriers	percentage	6.05	10.04
Non-tariff barriers	percentage	5.58	16.62
EPL	0-6 index	2.35	1.04
coordinated[1]	dummy	0.47	0.50
routinised[1]	dummy	0.53	0.50
Low coordination dummy	dummy	0.15	0.35
high-tech[1]	dummy	0.46	0.50
low-tech[1]	dummy	0.54	0.50
entrepreneurial[1]	dummy	0.24	0.43
routinised[1]	dummy	0.22	0.42
IPR	0-5 index	3.84	0.46
Administrative regulation	0-6 index	2.00	0.77
Inward-oriented Economic reg.	0-6 index	1.94	0.77
Human capital	percentage	21.78	8.40
GDP in 1996 PPP terms	percentage of US GDP	75.30	11.63
Employment share of foreign affiliates	percentage	26.00	23.76
Government-financed BERD	percentage of total BERD	8.95	11.00

1 "high-tech", "low-tech", "routinised", "entrepreneurial", "coordinated", and "decentralised", denote dummies for types of industries and industrial relation systems.

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