ESRI

Working Paper No. 445

December 2012

Employment Protection and Innovation Intensity

Gavin Murphy,[a,b] Iulia Siedschlag,[a,b] and John McQuinn[a,b]

Abstract: We examine the impact of the strictness of employment protection legislation on innovation intensity. To this purpose, we use a panel of annual data from OECD countries over the period 1990-1999 and estimate difference-in-difference models to explain the variation of innovation intensity between industries within countries. Our estimates indicate that stricter employment protection legislation led to significantly lower innovation intensity in industries with higher job reallocation rates or higher layoff propensities. Further, we find that the strictness of employment regulations on the use of temporary contracts had a stronger impact on innovation intensity than the strictness of employment protection for regular contracts. Our findings are robust to additional industry covariates and to other labour market institutions that may affect innovation performance and industry job reallocation propensity. In addition, our sensitivity analysis indicates that our results are not driven by the particular measures of employment protection legislation and industry layoff propensity that we use or by any country in our sample.

Keywords: Employment Protection; Innovation; Industry Specialisation.

JEL Classification: F43; O31; O43.

Corresponding Author: iulia.siedschlag@esri.ie

[a] Economic and Social Research Institute, Dublin
[b] Department of Economics, Trinity College Dublin

* This paper is part of the NEUJOBS project funded by the European Commission under the 7th Framework Programme, Theme 8: Socio-Economic Sciences and Humanities. Grant Agreement no: 266833. We thank Miroslav Beblavý, Petra Gerlach, Paul Gorecki, Anna Thum, Olaf van Vliet, and participants in research presentations at the Economic and Social Research Institute in Dublin, the NEUJOBS Conference in Bratislava and the University of Marburg for helpful comments and suggestions.

Employment Protection and Innovation Intensity

1. Introduction

This paper examines the relationship between the strictness of employment protection legislation (EPL) and innovation performance. This question is interesting and relevant for both research and policy. Modern economic theory has identified innovation as a major driver of economic growth.[1] While there is a well established literature on the effects of institutions on economic growth[2] there is little evidence about the effect of labour market institutions and labour market reforms on innovation. From a policy perspective, innovation is particularly important for sustainable economic growth and for maintaining high living standards in developed economies in the context of increased global competition from low-wage countries. Our analysis provides empirical evidence to inform policy design on the role of labour market institutions and labour market reforms on innovation performance.

Theoretical predictions on the effects of labour market institutions, such as employment protection legislation, on innovation are ambiguous. On the one hand, strong employment protection increases job security and incentivises employees to invest in firm-specific human capital and to engage in innovation activities. On the other hand, high hiring and firing costs increase the adjustment cost firms face when they need to adjust to idiosyncratic shocks and thus, they discourage firms from innovating. Which effect dominates in reality is a matter of empirical analysis.

Existing empirical evidence on the effects of labour market institutions and labour market reforms on innovation is not clear-cut. Acarya et al (2010) used country-industry data for the United States (US), United Kingdom (UK), France, Germany and India as well as within-US data and found that stronger dismissal laws had a positive impact on innovation intensity at the industry level and that they led to relatively more innovation in the innovation-intensive industries than in traditional industries. Barbosa and Faria (2011), using country-industry data for European Union countries, found that stricter employment protection legislation led to less innovation intensity at the industry level. Griffith and Macartney (2010) used data on the location of innovative activity by multinational firms across twelve OECD countries and found that, while multinational firms located more innovative activity in countries with high EPL, they located more radical (technologically advanced) innovation activity in countries with low EPL.

The main challenge in the analysis of the effect of country level employment protection on innovation performance is to identify a causal link in the presence of many confounding factors, many of them unobservable. To address this identification issue, we improve on these previous contributions in two ways. First, we use a panel of country-industry data and estimate difference-in-difference models to account for the fact that EPL may be more relevant in industries with a higher layoff propensity, where EPL is likely to be more binding. Thus, we control for all unobserved country

[1] See for example Aghion and Howitt (1992, 1997), Acemoglu et al. (2006).

[2] An excellent review of the theoretical and empirical literature on the impact of institutions on long-run growth is provided by Acemoglu et al. (2005).

and industry characteristics that are unlikely to have on average different effects on innovation intensity between industries with high layoff propensities and the other industries, including institutions which do not affect directly industry layoff propensity. Second, in contrast to previous studies, we consider three EPL indicators to distinguish between overall EPL, EPL for regular contracts, and EPL for temporary contracts.

Our estimates indicate that stricter employment protection legislation led to significantly lower innovation intensity in industries with a higher job reallocation propensity. Further, we find that the strictness of employment regulations on the use of temporary contracts had a stronger impact on innovation intensity than the strictness of employment protection for regular contracts. Our findings are robust to additional industry covariates and to other labour market institutions that may affect innovation performance and industry job reallocation propensity. Innovation intensity was significantly higher in industries with a higher import competition and in industries with less strict product market regulations. We find that the generosity of unemployment benefit systems led to lower innovation intensity in industries with a higher job reallocation propensity, while higher co-ordination and higher centralisation of wage setting led to higher innovation intensity in the same group of industries. It appears that a decrease in the gross unemployment benefit led to higher innovation intensity in industries with a higher job reallocation propensity. In addition, our sensitivity analysis indicates that our results are not driven by the particular measures of employment protection legislation and industry layoff propensity that we use or by any country in our sample.

The rest of the paper is structured as follows. Section 2 discusses some stylized facts on the relationship between the strictness of employment protection legislation and innovation intensity in OECD countries. Section 3 presents the theoretical and empirical background of our analysis. We discuss our empirical strategy and model specifications in Section 4. Section 5 describes the data that we use. Section 6 discusses the empirical results. Section 7 concludes.

2. Stylized Facts

In this Section we discuss some stylized facts on the relationship between the strictness of employment protection legislation (EPL) and innovation intensity in OECD countries.[3]

We start with a summary of patterns and trends of EPL. We use three OECD indicators on the strictness of EPL[4] as follows: a composite index (EPL) measuring the strictness of regulation and dismissal for regular and temporary contracts; a sub-indicator measuring the strictness of dismissal of employees on regular contracts (EPLR) and a sub-indicator measuring the strictness of regulation on the use of temporary contracts (EPLT). These measures evaluate the strictness of employment protection on a scale of 0 to 6 with higher values indicating stricter employment protection.

[3] For a more detailed descriptive analysis of the link between EPL and innovation intensity see Koster et al. (2011).

[4] The data is available from www.oecd.org/employment/protection. The latest updated estimates of the OECD indicators on employment protection legislation and methodology are discussed in Venn (2009).

Table 1 shows the averages and changes in EPL in OECD countries over the period 1985-2008. There is a large variation between the countries for which we have data available. The United States, the United Kingdom and Canada had the least strict EPL whereas Greece, Portugal and Turkey had the strictest EPL. Futhermore, EPL has decreased in many countries over time with the exception of France whereas some of the countries with the least strict EPL have experienced increases in EPL strictness albeit much smaller in magnitude.

[Table 1 here]

While the averages give insight into the level of EPL over time, the change in EPL measured as the difference between the final year (2008) and the initial year (1985) show where reform has been the greatest. In Figure 1, we can see that observations in the right hand side of the forty five degree line are the most prevalent indicating decreases in EPL. The observations along the forty five degree line show no change in EPL over time whereas there are some instances of small increases in EPL in the left hand side of the forty five degree line. Breaking this down into EPLR and EPLT in Figures 2 and 3, respectively, reveals little change in EPLR with most observations on or near the forty five degree line. However, EPLT shows substantial decreases in employment protection strictness. This demonstrates that labour market reforms have occured largely in temporary rather than regular contracts.

[Figures 1-3 about here]

We discuss next patterns and trends in industry innovation intensity in OECD countries. We proxy industry innovation intensity with the number of patents per hour worked by employees. The data source is the EU KLEMS Database.[5] Patents have been widely used as an innovation indicator although they measure invention rather than innovation (Griliches, 1990). In addition, the use of patents to protect inventions varies across industries (Kortum and Lerner, 1999). Alternative measures that have been used include R&D expenditure intensity and innovation outcomes from enterprise survey data. While the first measure is an innovation input, data for the second innovation measure is available for a limited number of countries (European countries only) and for a limited number of time points.[6]

Table 2 shows the average patent intensity and the change in patent intensity over the period 1989-1999 in OECD countries. The United States had the highest average patent intensity, substantially above the next highest performing countries (Japan, Sweden and Finland) while Portugal, Greece and Spain show the lowest average patent intensity. Those countries with the greatest change in patent intensity (Korea, Greece and Denmark) have low to medium average patent intensity whereas the countries with the smallest change in patent intensity (Netherlands, Spain and Ireland) had both low and high average patent intensity. As such, changes in patent intensity vary widely

[5] These data are available from http://www.euklems.net/. The patent counts are based on patents granted by the USPTO until 2002 available from the NBER Database published by Hall et al. (2001). Details about the methodology and the assignment of patents by country, industry and year are given in O' Mahony et al. (2008).

[6] Innovation outcomes aggregated from Community Innovation Surveys (CIS) are available from the EUROSTAT for European Union countries for two time points: 2002-2004 and 2004-2006. While we have considered using these broader measures of innovation, these data limitations do not allow us to improve our analysis.

even across countries with different average patent intensity levels. Figure 4 illustrates this variation across countries in the innovation intensity changes over the period 1989-1999.

[Table 2 about here]

[Figure 4 about here]

Finally, Figures 5-7 summarize the relationship between EPL and innovation intensity at the country level. Figure 5 illustrates a negative relationship between average EPL and average innovation intensity (the Pearson correlation coefficient is - 0.52). Countries with stricter average EPL such as Italy, Spain, Greece and Portugal are associated with very low average innovation intensity. Nevertheless, the converse does not hold with countries such as the United Kingdom, Ireland and Australia showing low average innovation intensity despite low average EPL although the United States had both the lowest average EPL and the highest innovation intensity. Hence, additional factors are likely to influence the relationship between EPL and innovation intensity. It is also noteworthy that some of the countries with the highest average innovation intensity - Japan, Finland and Sweden – had moderately strict EPL.

[Figures 5-7 about here]

Figures 6 and 7 show that average EPLR and EPLT are negatively related innovation intensity (the related Pearson correlation coefficients are -0.46 and -0.45, respectively). Again, it appears that these relationships are conditioned by other factors which we discuss in the next Section.

3. Theoretical and Empirical Framework

In theory, there are two channels through which employment protection legislation (EPL) impacts on innovation. The first channel is human capital investment documented by the literature of efficiency wages. Existing theoretical contributions suggest that increased job security due to employment protection increases the propensity of employees to invest in firm-specific and industry-specific human capital and to engage in innovative activity (Shapiro and Stiglitz, 1984; Acemoglu, 1997; Akerloff, 1999; Belot et al., 2007). Recent empirical evidence indicates that in countries with stricter EPL, employees invest more in firm-specific and industry-specific skills instead of portable general skills (Estevez-Abe et al 2001). Further, stricter employment legislation increases employees' bargaining power and their incentives to invest in firm-specific human capital. Tang (2012) shows that countries with stricter EPL specialise in industries where firm-specific skills are more important. Wasmer (2006) shows that stricter EPL raises the relative returns to specific skills in equilibrium due to the fact that higher firing costs increase labour market frictions and the average duration of employment. Acarya et al (2010) found that stronger dismissal laws in the US had a positive impact on innovation intensity at the industry level and that they led to relatively more innovation in the innovation-intensive industries than in traditional industries. However, Barbosa and Faria (2011) found that stricter EPL led to less innovation intensity at the industry level in EU countries.

The second channel through which EPL impacts on innovation is adjustment costs faced by firms when they need to adjust to idiosyncratic shocks. High hiring and firing costs may lead to under-investment in innovative activities that require adjustment, in particular in technologically advanced

industries (Saint-Paul, 1997; 2002; Samaniego, 2006; Cuñat and Melitz, 2010). Stricter layoff regulations discourage firms from experimenting with new technologies with higher returns but also with higher volatility (Bartelsman et al., 2010). Firing restrictions are more costly in industries with rapid technological change such as information and communication technologies (ICT) which implies that countries with stricter EPL tend to specialise in industries with a low rate of technical change (Samaniego, 2006). Koeniger (2005) finds that dismissal costs are negatively associated with R&D intensity across countries and positively linked to R&D intensity within countries over time. Further, he demonstrates theoretically that while stricter layoff regulations foster innovation of incumbent firms they deter the entry of innovative firms.

Pierre and Scarpetta (2006) find evidence showing that innovative firms are the most negatively affected by stricter EPL. Bartelsman et al. (2010) find that high-risk innovative sectors are relatively smaller in countries with stricter EPL. Theoretical models on labour market regulations and international specialisation (Saint-Paul, 1997; 2002) suggest that countries with stricter EPL specialise in incremental innovation while new products are first produced in countries with low EPL. It follows that high firing costs lead to a lower number of new products in the world economy with negative welfare implications if efficiency improvements from incremental innovation are not large enough. In addition, recent theoretical contributions (Cuñat and Melitz, 2007; 2010) suggests that given the relationship between EPL and firms' adjustment to idiosyncratic shocks, countries with more flexible labour markets specialise in more volatile industries.

Another strand of empirical literature has found that stable and more co-operative relationships between employees and employers support incremental innovation while more flexible labour markets support more radical innovation (Soskice, 1997; Hall and Soskice, 2001).

Griffith and Macartney (2010) analysed the effect of EPL on innovation by multinational firms. They distinguish between incremental and radical innovation. Their theoretical model suggests that while EPL is negatively related to the optimal level of investment in radical innovation, it is positively linked to the optimal level of investment in incremental innovation. Using data on the location of innovative activity by multinational firms across twelve OECD countries they find that while multinational firms locate more innovative activity in countries with high EPL, they locate more radical (technologically advanced) innovation activity in countries with low EPL.

Another strand of relevant literature focuses on the effects of competition on innovation. The theoretical predictions about the effects of competition on the incentives of firms to innovate are ambiguous. On the one hand, competition may incentivise firms to innovate in order to protect or enhance their market position ("escape-competition" effect).[7] On the other hand, competition may reduce the returns to innovation or entry and thus reduce the incentives of firms to innovate ("Schumpeterian effect").[8]

Recent theoretical and empirical contributions models bring these two effects together (Aghion et al. 1999, 2001, 2005, 2009). In industries closer to the technology frontier ("neck-and-neck industries") the "escape-competition" effect is stronger and increased competition leads to more

[7] Aghion et al. (2001, 2005).
[8] Grossman and Helpman (1991), Aghion and Howitt (1992).

innovation, while in the laggard industries, the "Schumpeterian effect" prevails. In this latter case, increased competition reduces the incentives of firms to innovate. The outcome of these contributions suggests that both effects are at work. The overall aggregate effect of increased competition depends on the initial level of competition and the industry composition with respect to the distance to the technology frontier.

The relationship between competition and innovation is an inverted U-shaped one illustrating the presence of an escape competition effect versus a Schumpeterian effect (Aghion and Griffith, 2005). The escape competition effect is more likely at low initial levels of competition whereas the Schumpeterian effect tends to dominate at higher levels of competition.

Aghion et al. (2005) find that competition discourages laggard firms from innovating but encourages neck-and-neck firms to innovate. Griffith et al. (2010) show that the EU Single Market Programme was associated with increased product market competition and subsequently with a higher innovation intensity and productivity growth in the manufacturing sectors.

The effect of EPL on innovation may depend on other labour market institutions regulating wage rigidity and redistributive patterns (Belot et al., 2007). Haucap and Wey (2004) analysed the effects of wage bargaining regimes on innovation and found that firms' incentives to innovate were largest under centralised wage setting and smallest under co-ordinated wage setting. Bassanini and Ernst (2002) find that, in countries with co-ordinated wage setting, R&D expenditure intensity was negatively correlated with labour market flexibility for high-tech industries. Another strand of literature has focused on the relationship between unions and innovation. A number of studies suggest that firms that face strong unions have a higher incentive to innovate than firms that face weaker unions (Tauman and Weiss, 1987; Ulph and Ulph, 1994, 1998, 2001). Menezes-Filho et al (1998) found a positive link between union density and a firm's relative R&D performance. However, when union density was very high, the effects of the union power on R&D performance turned negative.

While most of existing literature has focused on EPL for regular contracts, recent contributions have also analysed the effects of the use of temporary contracts on firm productivity. An empirical established fact is that employees with temporary contracts participate less in firm-specific training than permanent employees (Arulampalam and Booth, 1998; Albert et al., 2005; Bassanini et al., 2007; Fouarge et al., 2012; Martin and Scarpetta, 2012). In theory, the use of temporary contracts could have both positive and negative effects on firm productivity. On the one hand, the use of temporary contracts could increase firm productivity via increased flexibility, while the lower firm-specific human capital could impact negatively firm productivity (Hirsh and Mueller 2012). Existing empirical evidence on the effects of using temporary contracts on firm productivity is mixed. While a number of studies find positive but insignificant effects of the temporary contracts use on firm productivity (Arvanitis 2005; Bassanini et al. 2009), Hirsch and Mueller (2012) find evidence that the relationship between temporary contracts use and firm productivity is an inverted U-shaped one. Cappellari et al. (2012) examined the effects of reforming temporary contracts use on firm productivity in Italy. They find that the reform of apprenticeship contracts increased productivity while the liberalisation of the use of fixed contracts lowered firm productivity. Jahn et al. (2012) suggest that there might be a trade-off between efficiency and equity effects of labour market

deregulation. They show that stricter EPL is associated positively with labour productivity and negatively with an equal income distribution.

In summary, existing theoretical and empirical contributions suggest that the relationship between EPL and innovation could be both positive and negative. Furthermore, it appears that the effects of EPL on innovation are conditioned by industry and country characteristics such as layoff propensity, technology intensity, skills intensity, competition pressures, openness, and other labour market institutions such as wage setting institutions.

4. Empirical Methodology

Our review of existing theoretical and empirical literature suggests that the effect of EPL on innovation will differ across countries and between industries within countries. Bassanini et al. (2009) use a difference-in-differences empirical methodology and show that the effect of EPL on productivity growth is larger in industries where dismissal regulations are more binding. We build on this approach[9] and assume that the effect of EPL on innovation will be larger in industries with a higher layoff propensity, where EPL is likely to be more binding. These industries are industries with a relatively high propensity to adjust their human resources through layoffs due to industry-specific technological and market-driven factors. In the rest of industries where firms restructure through internal restructuring or by natural attrition of staff, we expect that EPL will have a lower or little impact on the incentive to innovate.

To identify the effects of EPL on innovation intensity we adopt a difference-in-differences empirical approach similar to Bassanini et al. (2009) and explain the variation of innovation intensity within countries between industries with high layoff propensities (EPL-binding industries) and the rest of industries as a function of the EPL level and changes in EPL.[10] The basic identification assumption of this empirical approach is that the effect of EPL on innovation intensity will be greater in industries with higher layoff propensities. The advantage of this approach is that we can control for all unobserved country and industry characteristics that may affect innovation intensity but are unlikely to have on average different effects on innovation intensity between industries with high layoff propensities and the other industries, including institutions which do not affect directly industry layoff propensities.

Baseline Model Specification

The simplest model specification relates the innovation intensity at industry level to country EPL and EPL change as follows:

$$\ln INNO_{ijt} = \alpha L_j EPL_{it-1} + \beta L_j \Delta EPL_{it} + \lambda_{it} + \mu_{jt} + \varepsilon_{ijt} \quad (1)$$

[9] Rajan and Zingales (1998) have proposed this econometric framework in their analysis of the role of financial development on economic growth. Murphy and Siedschlag (2011) used a similar empirical approach to analyse the role of human capital on economic growth.

[10] The effect of the level of EPL on innovation may be conditioned by the change in EPL.

The dependent variable, $INNO_{ijt}$, is a measure of innovation intensity in country *i*, industry *j*, at time *t*. L_j is a measure of layoff propensity in industry *j*. EPL_{it-1} is an indicator of the strictness of employment protection in country *i* lagged one year to alleviate concerns about possible endogeneity. ΔEPL_{it} is the first-difference change in EPL in country *i*. λ_{it} controls for unobserved country-time effects,[11] while μ_{jt} controls for unobserved industry-time effects that may affect innovation intensity and have no direct effect on industry layoff propensity. ε_{ijt} is an idiosyncratic error term.

The parameters of interest to be estimated are α and β. α can be interpreted as the long-run effect of EPL on innovation intensity, while β captures its short-run effect. α > 0 (β > 0) implies that in countries with stricter EPL (increased EPL strictness), innovation intensity is higher in industries with high layoff propensities than in the rest of industries. This result would suggest that EPL impacts on innovation intensity mainly via the human capital investment channel. Alternatively, α< 0 (β < 0) would indicate that in countries with stricter EPL (increased EPL strictness), innovation intensity in industries with high layoff propensities is lower than in the rest of industries. This result would suggest that the adjustment cost effect of EPL on innovation intensity dominates.

Econometric Issues

Innovation intensity at the industry level may be driven by other industry and country characteristics that may have a differential effect on innovation intensity in industries with high layoff propensities and the rest of industries. To account for these effects, we augment Equation (1) with other country-industry covariates, $X_i Y_j$:

$$\ln INNO_{ijt} = \alpha I_j EPL_{it-1} + \beta I_j \Delta EPL_{it} + \gamma X_{i,t-1} Y_{j,t-1} + \lambda_{it} + \mu_{jt} + \varepsilon_{ijt} \quad (2)$$

Following on the literature review discussed in Section 3, we account for potential effects of industry specialisation (capital intensity, skills intensity), technology intensity (the distance to the technology frontier), international competition pressures (import penetration), industry competition (product market regulations).

In addition, we control for the effect of other country-level labour market institutions that might condition the effect of EPL on innovation intensity.

We estimate models (1) and (2) with the three EPL indicators discussed in Section 2: the overall composite indicator on the strictness of employment protection legislation (EPL), the indicator on the strictness of the employment protection legislation on regular contracts (EPLR), and the indicator of the strictness of employment protection legislation on temporary contracts (EPLT).

Detailed definitions of variables and data sources are given in Table A1 in the Appendix.

[11] λ_{it} controls also for the average country level and change effects of employment protection legislation on innovation intensity.

5. Data and Descriptive Statistics

Country-Industry Data

The country-industry data used in our analysis are mainly taken from the EU KLEMS database.[12] The EU KLEMS data are based on the ISIC Rev. 3 classification and the baseline level of aggregation in the database is between one and two digits. Variables included in the database include nominal gross output, value added, industry price deflators, number of employees, number of hours worked by employees, share of hours worked by high, median and low skilled employees, nominal and real fixed assets. Data are available for EU countries along with data for the US, Canada, Japan, South Korea, Australia, Norway. Time coverage of the data varies by country with data reported for the period 1970 to 2007 in the best cases and for the period 1995 to 2007 for new EU Member States. The patents data are taken from the EU KLEMS *Linked Data 2008 Release* with data reported for the period 1970 to 1999.[13]

Innovation Intensity (INNO), the dependant variable that we use in this paper is defined as the natural logarithm of the ratio of total patents to total hours worked by employees (millions) in each country-industry grouping in each period.[14] The *Distance to the Technology Frontier (dtf)* is calculated as the natural logarithm of the industry's labour productivity (i.e. gross value added to total hours worked by employees) divided by labour productivity in the country-industry group with the highest labour productivity in each year (i.e. technology frontier). We use data on nominal gross output, exports and imports from the OECD STAN Database for Structural Analysis to construct an *Import Competition (impcomp*) measure which is calculated as the ratio of total imports divided by the sum of gross output minus exports plus imports for each year in each industry.[15] We account for the potential direct and indirect costs of market entry regulation in highly regulated industries on manufacturing sectors of the economy by including an industry measure of the potential costs of anti-competitive regulation, Product Market Regulations (*pmr*). These data are taken from Nickell (2006).

Industry-Level Data

We proxy the layoff propensity in industry *j* in period *t* with the *Job Reallocation Rate* (jr_{jt}) defined following Davis and Haltiwanger (1992):

$$jr_{jt} = \frac{jdes_{jt} + jcr_{jt}}{1/2 \sum_{t-1}^{t} emp_{jt}} \qquad (3)$$

[12] The EU KLEMS database provides data on measures of economic growth, productivity, employment creation, capital formation and technological change at the industry level for all European Union Member States from 1970 onwards. More information is available at http://www.euklems.net.

[13] For description see O'Mahony et al (2008).

[14] Two measures of patents are provided in the database. We use the fractional based patents measure which means that if a patent is assigned k codes, it counts 1/k for each industry. To avoid losing observations which are equal to zero, we add one to the obtained innovation intensity before we take the natural logarithm of this variable.

[15] For a number of countries, production data is only available from 1990 onwards. Export and import data is available for South Korea from 1994 onwards.

where $jdes_{jt}$ represents the total number of jobs terminated in industry *j* in period *t*, $jcrt_{jt}$ denotes jobs created in industry *t* in period *t*. The denominator is the average employment over the period *t-1* and *t* in t industry *j*. Data on industry-level job flows are taken from the EU KLEMS database. These job flow variables were constructed using firm-level data from the AMADEUS dataset from Bureau Van Djik. Coverage of these variables is available from 1990 to 2004 for 28 industries.

We use US data to proxy for an industry's intrinsic job reallocation propensity.[16] The underlying motivation for this approach is that job reallocation rates from other more rigid labour markets are likely to be correlated with the country's level of EPL and this could result in biased estimates of the impact of EPL on patent intensity, (for a related discussion see Cingano et al. 2010). Therefore, it is important that each industry's intrinsic job reallocation requirements are correctly measured in order to ensure that the estimate of the effect of EPL is unbiased. The US job reallocation rates are used as the US has the lowest EPL value and is one of the most flexible labour markets in the world (see Table 1).

Bassanini et al. (2009) use US layoff rates in their analysis of the differential effects of EPL on industry labour productivity growth. They contend that EPL primarily relates to dismissal regulations, therefore layoff rates are a more appropriate variable to characterise each industry's intrinsic labour adjustment rate. However, one can argue strongly that stricter EPL increases the cost of dismissal workers and should in turn influence firm's job creation rate. Therefore, we focus on job reallocation rates as our proxy for an industry's intrinsic labour adjustment rate.[17]

The methodological approach we take in this paper is based on the assumption that our choice of country-industry benchmark is an appropriate approximation of the industry job reallocation across all countries. To support this assumption, we undertake a number of robustness checks. First, we examine the distribution of US job reallocation rates over time. If the industry job reallocation rates were not stable over time, they would not be very informative in identifying those industries which are more likely to be affected by EPL. To check the stability of industry job reallocation rates over the analysed period, we calculate the Spearman rank correlations for pairs of two periods between 1990 and 2003. The results are presented in Table 3. The correlations suggest that the industry distribution of US job reallocation rates remained stable over the analysed period. For example, the Spearman correlation between job reallocation rates in 1990-1991 and in 2002-2003 is very high with a value of 0.83.

[Table 3 about here]

Second, it is possible that US specific institutional characteristics may influence US job reallocation rates. Ciccone and Papaioannou (2006) show that biased estimates of the interaction of interest can occur due to mis-measurement of the intrinsic industry benchmark arising from idiosyncratic shocks and other influences. Third, as discussed in Cingano et al. (2010), this benchmark approach is

[16] A number of recent studies have followed this approach (Cingano *et al.*, 2010; Bassanini *et al.*, 2009; Micco and Pages, 2006).

[17] In our sensitivity analysis, we use the US industry layoff rates taken from Bassanini *et al.* (2009). This variable is only available for the period 2001 to 2003.

appropriate only if the intrinsic job reallocation rate is similar for each of the sub-industries included in an industry grouping, or that the average of sub-industry components in each of the aggregate industry classifications are similar, across countries. One way to address these issues is to use an alternative benchmark measure. In our sensitivity analysis, we re-estimate the model using US industry layoff rates. This variable is taken from Bassanini et al. (2009) and is defined as the percentage ratio between annual recorded layoffs and wage and salary employment in that year in each US industry.

Table 4 shows averages for industry characteristics that we use in our analysis. When we combine the industry job reallocation rates with the patents intensity variable, we have eleven industries across which data is available for both variables.[18] We exclude from our analysis Coke, Refined Petroleum Products and Nuclear Fuel due to measurement issues for a number of variables (i.e. cases of negative value added values observations) and limited data coverage for other variables. The panel data sample begins in 1990 as this is the first period for which job reallocation rate data is available. The patents data is available up to 1999 which determines the end of our panel dataset.[19]

[Table 4 about here]

To account for potential effects of industry specialisation on innovation intensity we use a number of additional industry-level variables. We include a measure of *Physical Capital Intensity* which is equal to the US industry capital stock divided by output averaged over the period 1985 to 2007. To control for an industry's *Human Capital Intensity*, we include the average share of US high and medium skilled employees over the period 1985 to 2007.

Country-Level Data

We use three measures of EPL taken from the OECD Indicators of Employment Protection database. The three measures used in this paper are (i) a composite index measuring the strictness of regulation and dismissal for regular and temporary contracts, EPL; (ii) an indicator measuring the protection of workers against individual dismissal on regular contracts, EPLR. Some of the main factors that this index attempts to quantify include regulation dealing with notification procedures, severance pay entitlements and the grounds for unfair dismissals. (iii) an indicator measuring the strictness of regulation on the use temporary forms of employment (EPLT). This index takes into account regulation which addresses the maximum number and length of temporary contract renewals allowed, as well as conditions under which temporary and fixed contracts can be offered.

These measures evaluate the strictness of employment protection on a scale of 0 to 6. A higher value indicates stricter employment protection. The dataset contains information for 30 OECD countries and 10 non-OECD countries. The start date of the data coverage varies across countries

[18] Patents data was available at more a disaggregated level for a number of industries. We combine the patents data in these industries to match the more aggregated industry classification for which the job reallocation rate variable is available for.

[19] The list of countries included in our sample are Australia, Austria, Belgium, Denmark, Spain, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Netherlands, Portugal, Sweden and United Kingdom. Due to limited data for a number of variables, Korea and Ireland are excluded from the model specification which includes additional covariates.

with data available from 1985 to 2008 in the best cases. In our analysis we use each of the EPL indices and their respective annual logarithmic growth rates.

Other country-level controls used in the analysis include union density, the average tax wedge, the average gross unemployment benefit, a measure of net unemployment benefit, an index which measures the degree of coordination in the wage bargaining process, an index of wage bargaining centralization, and expenditure on active labour market policies as a percentage of GDP. The description of these variables and data sources are given in Table A1 in the Appendix.

Table A2 in the Appendix shows summary statistics of the main explanatory variables.

6. Empirical Results

Table 5 reports the estimates obtained from our baseline difference-in-differences model described by Eq. (1). Our econometric model estimates the effect of EPL on innovation intensity between industries with high job-reallocation rates (EPL-binding) and the other industries. The dependent variable is the number of patents granted at industry level per total hours worked in the industry. The explanatory variables include the EPL interacted with industry job reallocation rates ($jr_{us,j} * EP_{i,t-1}$), the change in EPL interacted with industry job reallocation rates, ($jr_{us,j} * \Delta EP_{i,t}$), along with country-time and industry-time dummies. We estimate the model for three employment protection measures: the aggregate EPL index and the two sub indices EPLR and EPLT. The results in column 1 suggest that in countries with stricter EPL, industries with high job reallocation rates had lower innovation intensity. This result is consistent with findings in the literature which suggests that high firing costs due to stringent EPL discourage investment in innovative activities that require adjustment (e.g. Saint-Paul, 1997; Bartelsman et al., 2004). Comparing the effect of EPL for regular and temporary contracts on innovation, we find that the effect is negative and significant for the EPL of temporary contracts, while the effect of EPL for regular contracts appears negative but not significant. Column 4 shows the estimates when both EPLR and EPLT are included in the same model. We continue to find that stricter regulation on temporary contracts had a negative effect on innovation intensity while the effect of EPLR is negative but not significant. The use of temporary employment has become an increasingly important channel of adjustment for firms. Our results suggests that the strictness of regulations on the use of temporary contracts which limit a firm's ability to respond to shifts in demand for products and to changes in technology discourages firms from innovating. The effect of the strictness of regulations on the use of temporary contracts on innovation intensity appears to be the main driver of the effect of the overall EPL on innovation intensity.

[Table 5 about here]

We find that changes in each of the EPL measures had no significant effect on industry innovation performance. This suggests that annual changes in EPL had no immediate impact on firms' innovation intensity. This is perhaps unsurprising as it is likely to take time for firms to restructure their human resources in response to EPL changes. Given the short time period over which our analysis is conducted we cannot estimate precisely the delay with which changes in EPL impact on innovation intensity.

To assess the economic importance of the statistically significant effect of the EPL on industry innovation performance, we calculate the effect of an increase in EPL from the 25th to the 75th percentile level on the innovation intensity differential between industries located at the 25th and 75th percentile levels of job reallocation rates. Based on the estimates in Table 5 column 1, the implied innovation intensity differential between the industry at the 25th percentile with respect to the job reallocation rate (i.e. Chemicals and Chemical Products) and the industry at the 75th percentile (i.e. Electrical and Optical Equipment) is 1.7 percentage points in a country with EPL at the 25th percentile (i.e. Japan) compared with a country at the 75th percentile (i.e. France).

Next, we estimate the augmented model described by Eq. 2 which includes additional industry-level covariates that may affect industry innovation intensity as well as job reallocation rates. Specifically, we control for the distance to the technology frontier (*dtf),* import competition (*impcomp*), and the strictness of product market regulations (*pmr*). In addition, we include other country-industry interactions which could potentially affect differences in innovation intensity between the industries with high job reallocation rates and the other industries. For example, differences in country-industry specialisation may affect differently industry innovation intensity (see for example Griffith and Macartney 2010). We account for the role that a country's physical capital abundance may have on industry innovation by interacting each country's physical capital ratio with the industry physical capital intensities. [20] To control for the possibility that human capital intensive industries may have higher innovation intensity in high human capital intensive countries, we include an interaction between industry human capital intensities[21] and a country level human capital index.[22] The estimates of these models are shown in Table 6.

[Table 6 about here]

As shown in Table 6, our results from the baseline regression are robust to the inclusion of these additional covariates. It appears that in countries with stricter EPLR, innovation intensity was lower in industries with higher job reallocation rates. However, as shown in column 4 this effect does not hold when we include both interactions of industry job reallocation rates with EPLR and EPLT in our models. The signs of the coefficients of the additional control variables are as expected. We find that greater import competition had a positive effect on innovation intensity, while the strictness of industry product market regulations was associated with lower innovation intensity. In terms of the country-industry specialisation covariates, we find that industries with high physical capital intensities had greater innovation intensity in capital abundant countries. Further, our results indicate that high human capital intensive industries had greater innovation intensity in countries which had a high human capital index.

We next examine whether the EPL effect partly captures the effect of other country-level labour market institutions which may affect industry job reallocation propensity. We consider the following labour market institutions (LMI) measures: (i) union density; (ii) the average tax wedge; (iii) the average gross unemployment benefit; (iv) a measure of net unemployment benefit; (v) an index which measures the degree of coordination in the wage bargaining process; (vi) an index of wage

[20] We use industry data for the US to calculate physical capital intensity at the industry level.
[21] We use industry data for the US to calculate human capital intensity at the industry level.
[22] These data are taken from the OECD database. For more details see Table A1 in the Appendix.

bargaining centralization, and (vii) expenditure on active labour market policies as a percentage of GDP.

Table 7 reports the estimates obtained for the overall EPL.

[Table 7 about here]

The estimates shown in Table 7 suggest that stricter EPL led to lower innovation intensity in industries with higher job reallocation rates, over and above the effect of other labour market institutions on innovation intensity. In addition, it appears that the generosity of unemployment benefit systems led to lower innovation intensity in industries with higher job reallocation rates, while higher co-ordination and higher centralisation of wage setting led to higher innovation intensity in the same group of industries. These later results are in line with findings reported in Haucap and Wey (2004). Further, it appears that a decrease in the gross unemployment benefit led to higher innovation intensity in industries with higher job reallocation rates.

Table 8 reports the estimates for EPLR and EPLT on innovation intensity.

[Tables 8 about here]

While the effect of EPLR on innovation intensity appears insignificant, stricter EPLT led to lower innovation intensity in industries with higher job reallocation rates over and above the effect of other labour market institutions. Again we find that in industries with higher job reallocation rates, the generosity of unemployment benefit systems led to lower innovation intensity while higher co-ordination and centralisation of wage setting institutions increased the innovation intensity. In addition, a reduction of gross unemployment benefits increased innovation intensity in these industries.

Sensitivity Analysis

We next conduct a number of sensitivity checks. First, we use an alternative measure of EPL which is taken from Allard (2005a). This EPL measure uses the OECD methodology and generates an index which ranges from 0 and 5. Second, we use a measure of industry layoff propensities as an alternative to the job reallocation rates. Finally, we re-estimate our model with additional industry controls (see Eq. 2 and Table 6) and exclude one country at a time.

Our results are robust to these sensitivity checks. Table 9 reports the estimates obtained with an alternative EPL measure. This EPL measure is an index for overall strictness of employment protection which ranges from 0 to 5 constructed yearly. The data are taken from Allard (2005a).

[Table 9 about here]

Table 9 shows that our main results are robust to using this alternative EPL measure. We find that stricter EPL led to lower innovation intensity in industries with higher job reallocation rates over and above the effect of other industry covariates and labour market institutions. In industries with higher job reallocation rates, the generosity of unemployment benefits led to lower innovation intensity, while higher wage centralisation led to higher innovation intensity. An increased tax wedge and lower gross unemployment benefits led to higher innovation intensity in industries with higher job reallocation rates.

Tables 10 and 11 report the estimates obtained with an alternative measure of industry layoff propensities. We use the US industry layoff rates taken from Bassanini et al. (2009). The layoff rate for each industry in a particular year is defined as the percentage ratio between annual recorded layoffs and wage and salary employment in that year.

[Tables 10 and 11]

As shown in Table 10, our main empirical findings are robust to using this alternative measure of industry layoff rates. Stricter EPL led to lower innovation intensity in industries with higher job layoff propensities. In these industries, a higher tax wedge led to higher innovation intensity while higher unemployment benefits led to lower innovation intensity.

Finally, Table 11 shows that while stricter EPLT led to lower innovation intensity in industries with higher layoff rates, the effect of stricter EPLR appears insignificant with the exception of the models which control for the effect of wage co-ordination and labour market activation measures. In these latter two cases, the evidence suggests that stricter EPLR led to lower innovation intensity in industries with higher layoff rates. Again we find that in industries with higher layoff rates, a higher tax wedge led to higher innovation intensity while the generosity of the unemployment benefit led to lower innovation intensity.

As a final robustness check, we re-estimate the augmented model (Eq. 2) which includes the EPL and job reallocation interaction excluding one country from the sample at a time. The estimated coefficient of the $jr_{us,j} * EP_{i,t-1}$ interaction for each sample with one country excluded at a time are presented in Figure 8. The 95% confidence interval bounds for each coefficient are denoted by ci_u and ci_l in Figure 8. The country excluded from the estimated sample is shown along the x-axis. Figure 8 shows that the findings regarding the $jr_{us,j} * EP_{i,t-1}$ interaction are unlikely to be driven by a set of observations specific to one country. The interaction term remains stable and significant for each alternative sample, although the estimated interaction is notably larger when the UK is excluded from the sample.

[Figure 8 about here]

7. Conclusions

We analysed the link between the strictness of employment protection legislation and innovation intensity in OECD countries. We considered two channels through which employment protection impacts on innovation: human capital investment and adjustment costs to industry-specific shocks. We used a panel of annual data over the period 1990-1999 and estimated difference-in-difference models to explain the variation of innovation intensity between industries within countries.

Our estimates indicate that stricter employment protection legislation led to significantly lower innovation intensity in industries with higher job reallocation rates or higher layoff propensities, where EPL are likely to be more binding. Further, in industries with higher job reallocation rates or higher layoff propensities, the strictness of employment regulations on the use of temporary contracts had a stronger impact on innovation intensity than the strictness of employment

protection for regular contracts. The short-run effect of the EPL on innovation intensity appears insignificant in most cases.

Our findings are robust to additional industry covariates as well as to other labour market institutions that may affect industry innovation intensity and job reallocation propensity. Innovation intensity was higher in industries with a higher import competition and in industries with less strict product market regulations. Further, in countries more abundant in human capital, we found that innovation intensity was higher in industries with higher human capital intensities. In countries abundant in physical capital, innovation intensity was found to be higher in industries intensive in physical capital. These results are in line with Saint-Paul (1997, 2002) and Griffith and Macartney (2010).

Furthermore, we find that the generosity of unemployment benefit systems led to significantly lower innovation intensity in industries with higher job reallocation rates, while higher co-ordination and higher centralisation of wage setting led to significantly higher innovation intensity in the same group of industries. These later results are in line with findings reported by Haucap and Wey (2004). It also appears that a decrease in the gross unemployment benefit led to significantly higher innovation intensity in industries with higher job reallocation rates.

In addition, our sensitivity analysis indicates that our results are not driven by the specific measures of employment protection and industry layoff propensity that we use or by any country in our sample. Our results support previous evidence found by Griffith and Macartney (2010) and Barbosa and Faria (2011).

This evidence suggests three policy implications. First, relaxing employment protection legislation would be beneficial for innovation intensity, particularly in industries with a high propensity to adjust to industry-specific technological and market driven factors through job reallocation. Second, relaxing the use of temporary contracts in industries with higher job reallocation rates or higher layoff propensities is likely to pay off more in terms of innovation intensity than reforming the employment protection legislation for regular contracts. Third, labour market reforms, such as relaxing employment protection regulations, are likely to affect significantly innovation performance in the long-run only while their effect in the short-run is unlikely to be sizeable.

Taken together our evidence suggests that, to the extent that enhancing efficiency is desirable, targeted labour market deregulation, such as relaxing the use of temporary contracts in industries with higher job reallocation rates or higher layoff propensities, could be advocated on the grounds of fostering innovation in the long-run.

References

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

Acemoglu, D., S. Johnson, J. A. Robinson (2005). Institutions as a Fundamental Cause of Long-Run Growth, in P. Aghion and S. Durlauf (eds.), *Handbook of Economic Growth*, Amsterdam: North-Holland, 385-472.

Acemoglu, D., P. Aghion, and F. Zilibotti (2006). Distance to the Frontier, Selection, and Economic Growth. *Journal of the European Economic Association*, 4(1), 37-74.

Acharya, V., R. Baghai-Wadji and K. Subramarian (2010). Labour Laws and Innovation. NBER Working Paper no. 16484.

Akerloff, G. (1982). Labor Contracts as Partial Gift Exchange. *The Quarterly Journal of Economics*, 97(4), 543-569

Aghion, P., and P. Howitt (1992). A Model of Growth through Creative Destruction. *Econometrica*, 60, 323-351.

Aghion, P., and P. Howitt (1997). *Endogenous Growth Theory.* Cambridge MA: MIT Press.

Aghion, P., M. Dewatripont, and P. Rey (1999). Competition, Financial Discipline and Growth. *Review of Economic Studies*, 66, 825-852.

Aghion, P., C. Harris, P. Howitt, and J. Vickers (2001). Competition, Imitation and Growth with a Step-by-Step Innovation. *Review of Economic Studies*, 68, 467-492.

Aghion, P. and R. Griffith (2005). *Competition and Growth*. *Reconciling Theory and Evidence*. Cambridge, MA, and London, UK: The MIT Press.

Aghion, P., N. Bloom, R. Blundell, R. Griffith and P. Howitt (2005). Competition and Innovation: An Inverted-U Relationship. *Quarterly Journal of Economics*, 120(2), 701-728.

Aghion, P., N. Bloom, R. Blundell, R. Griffith, P. Howitt, and S. Prantl (2009). The Effects of Entry on Incumbent Innovation and Productivity. *Review of Economics and Statistics*, 91, 20-32.

Albert, C., C. Garcia-Serrano and V. Hernanz (2005). Firm-Provided Training and Temporary Contracts. *Spanish Economic Review*, 7(1), 67-88.

Allard, G. (2005a) Measuring Job Security Over Time: In Search of a Historical Indicator, Instituto de Empressa Working Paper WP-05. http://www.ie.edu/eng/claustro/claustro_working_papers.asp)

Allard, G. (2005b) Measuring The Changing Generosity Of Unemployment Benefits: Beyond Existing Indicators, Instituto de Empressa Working Paper WP-05. http://www.ie.edu/eng/claustro/claustro_working_papers.asp)

Arvanitis, S. (2005). Modes of Labour Flexibility at Firm Level: Are there any Implications for Performance and Innovation? Evidence for the Swiss Economy. *Industrial and Corporate Change*, 14(6): 993-1016.

Arulampalam, W. And A. Booth (1998). Training and Labour Market Flexibility: Is There a Trade Off? *British Journal of Industrial Relations*, 35(4), 521-536.

Bartelsman, E., A. Bassanini, J. Haltiwanger, R. Jarmin, S. Scarpetta, and T. Schank (2004). The Spread of ICT and Productivity Growth: is Europe Really Lagging Behind in the New Economy? in D. Cohen, P. Garibaldi and S. Scarpetta (eds.), *The ICT Revolution: Productivity Differences and the Digital Divide*, Oxford: Oxford University Press.

Bartelsman, E.J., P.A. Gautier and J. De Wind (2010). Employment Protection, Technology Choice and Worker Allocation. CEPR Discussion Paper No. 7806

Bassanini and Ernst (2002). Labour Market Regulation, Industrial Relations and Technological Regimes: A Tale of Comparative Advantage. *Industrial and Corporate Change*, 11(3), 391-426.

Bassanini, A., A.L. Booth. G. Brunello, M. De Paola and E. Leuven (2007). Workplace Training in Europe, in G. Brunello, P. Garibaldi and E. Wasmer (eds.), *Education and Training in Europe*, Oxford University Press, Oxford.

Bassanini, A., L. Nunziata, and D. Venn (2009). Job protection and Productivity, *Economic Policy*, 349-402.

Barbosa, N. and A. P. Faria (2011). Innovation across Europe: How Important are Institutional Differences. *Research Policy*, 40, 1157-1169.

Beck, T., Demirgüç-Kunt, A. and Levine, R. (2010). A New Database on Financial Development and Structure. *The World Bank Economic Review*, 24(1): 77-92.

Belot, M., J. Boone and J.C. van Ours (2007). Welfare Effects of Employment Protection. *Economica*, 74, 381-96.

Boeri and Jimeno (2005). The Effects of Employment Protection: Learning from Variable Enforcement, *European Economic Review*, 49, 2057-2077.

Capellari, L., C. Dell, Aringa and M. Leonardi (2012). Temporary Employment, Job Flows and Productivity: A tale of Two Reforms. *The Economic Journal*. 122, F188-F215.

Cingano, F., M. Leonardi, J. Messina, L. Pica (2010). The Effects of Employment Protection Legislation and Financial Market Imperfections on Investment: Evidence from a Firm-Level Panel of EU Countries. *Economic Policy*, 25(61): 117-163.

Cuñat, A. and M. J. Melitz (2007) "Volatility, Labour market Flexibility and the Pattern of Comparative Advantage", NBER Working Paper No. 13062

Cuñat, A. and M. J. Melitz (2010). A Many-Country, Many-Good Model of Labour Market Rigidities as a Source of Comparative Advantage. *Journal of European Economic Association*, 8(2-3), 434-441.

Davis, S. J. and J. Haltiwanger (1992). Gross Job Creation, Gross Job Destruction, and Employment Reallocation. *Quarterly Journal of Economics*, 107(3): 819-63.

Fouarge, D., A. de Grip, W. Smits, R. de Vries (2012). Flexible Contracts and Human Capital Investments. *De Economist*, 160(2), 177-195.

Griffith, R., R. Harrison, and H. Simpson (2010) Product Market Reform and Innovation in the EU, *Scandinavian Journal of Economics*, 112(2), 389-415.

Griffith, R. and G. Macartney (2010). Employment Protection Legislation, Multinational Firms and Innovation. CEPR Discussion Paper No. 7628.

Griliches, Z. (1990) Patent Statistics as Economic Indicators: A Survey. *Journal of Economic Literature*, 28, 1661-1707.

Grossman, G. and E. Helpman (1991). Quality Ladders in the Theory of Growth. *Review of Economic Studies*, 58, 43-61.

Hall, B. H., A. B. Jaffe, and M. Trajtenberg (2001). The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools. NBER Working Paper 8498.

Haucap, J. And C. Wey (2004). Unionisation Structures and Innovation Incentives. *Economic Journal*, 114(494), C149-C165.

Hirsh, B. And S. Mueller (2012). The Productivity Effect of Temporary Agency Work: Evidence from German Panel Data. *The Economic Journal*, 122, F216-235.

Inklaar, R., M.P. Timmer and B. Van Ark (2008). Market Services Productivity across Europe and the US, *Economic Policy*, 23(1), 139-94.

Jahn, E., R. Riphahn, and C. Schnabel (2012). Flexible Forms of Employment: Boon and Bane, *The Economic Journal*, 122: F115-F124.

Koeniger, W. (2005). Dismissal Costs and Innovation. *Economics Letters*, 88(1), 79-85.

Kortum, S. And J. Lerner (1999). What is Behind the Recent Surge in Patenting? *Research Policy*, 28, 1-22.

Koster, F., J. McQuinn, I. Siedschlag, O. Van Vliet (2011). *Labour Market Models in the EU*, NEUJOBS Special Report No. 1, September 2011.

Martin, J.P., S. Scarpetta (2012). Setting It Right: Employment Protection, Labour Reallocation and Productivity. *De Economist*, 160(2), 89-116.

Menezes-Filho, N., D. Ulph, J. Van Reenen (1998). The Determination of R&D: Empirical Evidence on the Role of Unions. *European Economic Review*, 42, 919-930.

Murphy, G. and I. Siedschlag (2011). Human Capital and Growth of Information and Communication Technology-intensive Industries: Empirical Evidence from Open Economies", *Regional Studies*, first published online, 7 April 2011.

Ochel, W. (2000). Collective Bargaining (Centralisation and Coordination). Ifo Institute, mimeo.

Ochel, W. (2001). Collective Bargaining Coverage in the OECD from the 1960s to the 1990s, CESifo Forum, Winter, 62-65.

OECD (2010). Employment Protection Legislation: Strictness of Employment Protection Legislation: Collective Dismissals. OECD Employment and Labour Market Statistics (database).

OECD (2012). OECD Economic Outlook: Statistics and Projections (database).

O'Mahony, M., C. Castaldi, B. Los, E. Bartelsman, Y. Maimaiti, and F. Peng (2008). EU KLEMS-Linked Data: Sources and Methods, University of Birmingham, www.euklems.net.

Pierre, G. And S. Scarpetta (2006). Employment Protection: Do Firms' Perceptions Match with Legislation?, *Economics Letters*, 90, 328-34.

Rajan, R. and L. Zingales (1998). Financial Dependence and Growth. *American Economic Review*, 88, 559-86.

Saint-Paul, G. (2002). Employment Protection, International Specialization and Innovation, *European Economic Review*, 46, 375-395.

Saint-Paul, G. (1997) Is labour Rigidity Harming Europe's Competitiveness? The Effect of Job Protection on the Pattern of Trade and Welfare, *European Economic Review*, 41, 499-506

Samaniengo, R. (2006) Employment Protection and High-Tech Aversion, *Review of Economic Dynamics*, 9, 224-241

Soskice, D. (1997) German Technology Policy, Innovation and National Institutional Frameworks, *Industry and Innovation*, 4(1), 75-96.

Shapiro, C. and J. Stiglitz (1984). Equilibrium Unemployment as a Worker Discipline Device, *American Economic Review*, 74(3), 433-444.

Tauman, Y. And Y. Weiss (1987). Labour Unions and the Adoption of New Technology, *Journal of Labour Economics*, 5, 477-501.

Tang, H. (2012). Labor Market Institutions, Firm-specific Skills and Trade Patterns. *Journal of International Economics*, 87, 337-351.

Ulph, A. And D. Ulph (1994). Labour Markets and Innovation: Ex-post Bargaining. *European Economic Review* 38, 195-210.

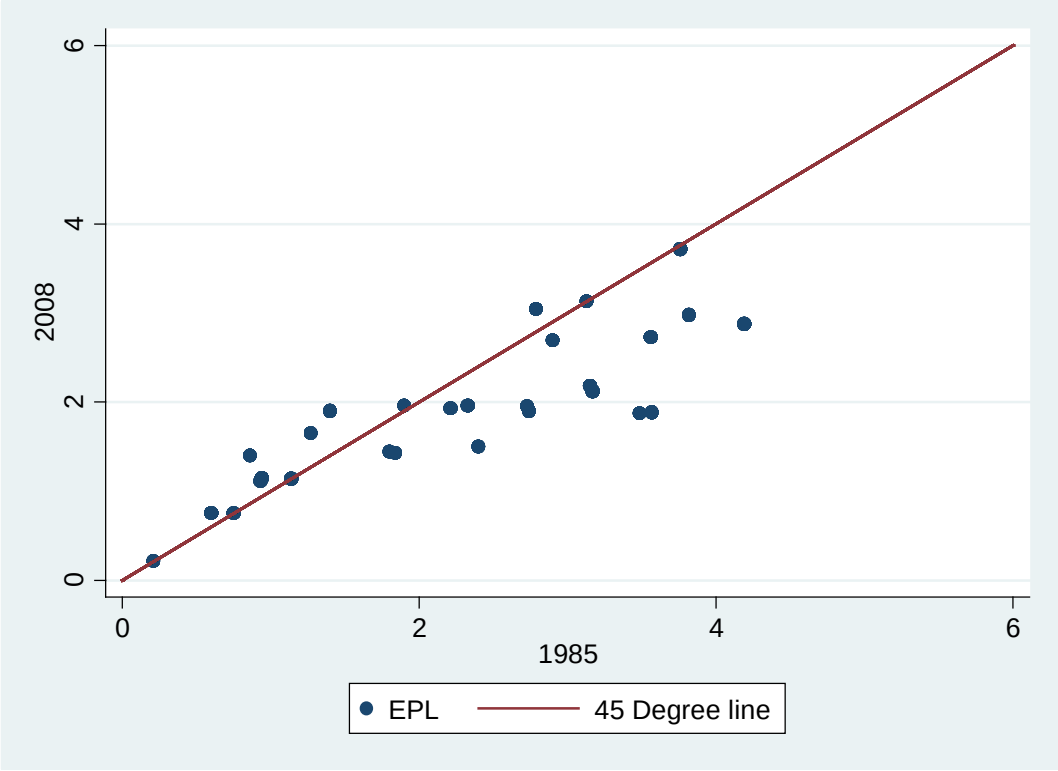
Ulph, A. And D. Ulph (1998). Labour Markets, Bargaining and Innovation. *European Economic Review*, 42, 931-39.

Ulph, A. And D. Ulph (2001). Strategic Innovation with Complete and Incomplete Labour Market Contracts, *Scandinavian Journal of Economics*, 103, 265-82.

Venn, D. (2009). Legislation, Collective Bargaining and Enforcement: Updating the OECD Employment Indicators. OECD Social, Employment and Migration Working Papers No. 89

Wasmer, E. (2006) General versus Specific Skills in Labour Markets with Search Frictions and Firing Costs. *American Economic Review* 94(1), 811-831.

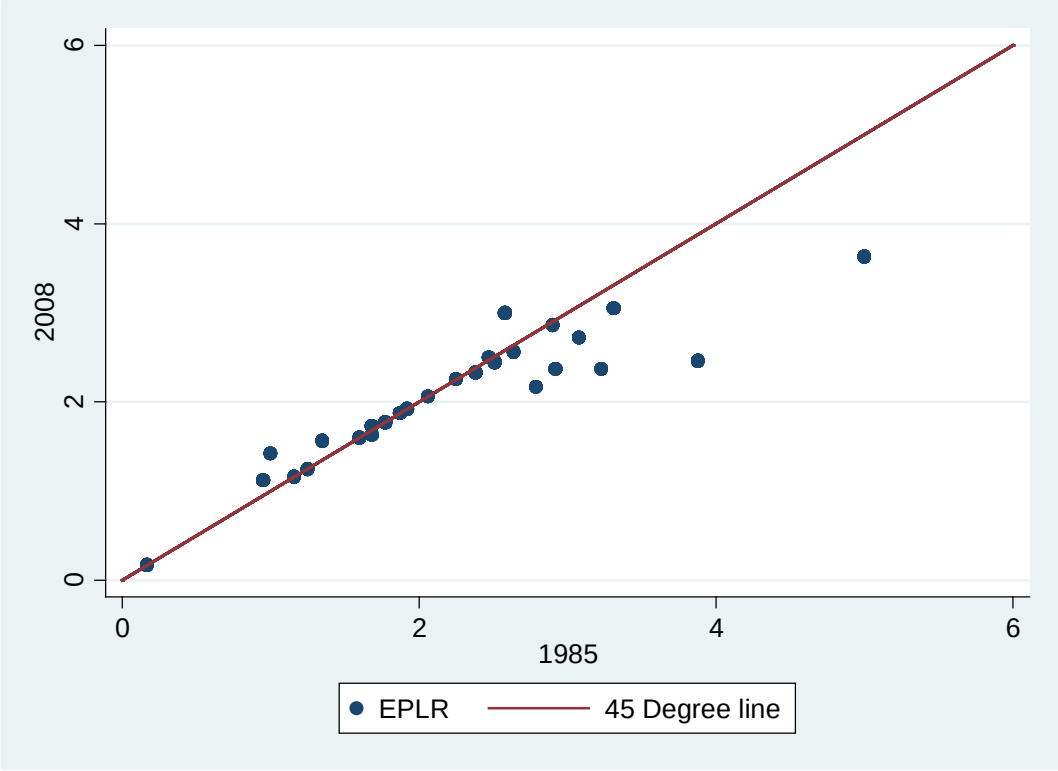
Figure 1: Employment Protection Legislation (EPL) Strictness, OECD Countries



Notes: Employment Protection Legislation is a composite index measuring the strictness of regulation and dismissal for regular and temporary contracts on a scale from 0 (least restrictions) to 6 (most restrictions). Where data is unavailable for the years 1985 or 2008, the closest year available is used. The countries covered are the following: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Mexico, New Zealand, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

Source: OECD (www.oecd.org/employment/protection).

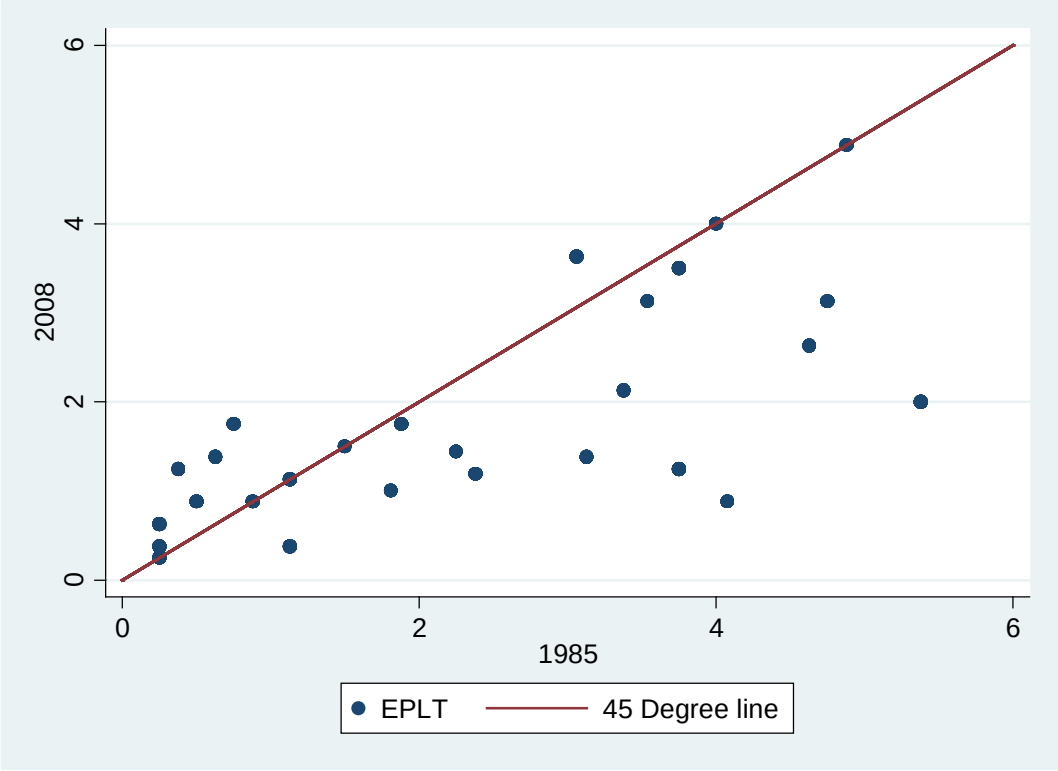
Figure 2: Employment Protection Legislation Strictness for Regular Contracts (EPLR), OECD Countries



Notes: Employment Protection Legislation for Regular Contracts is a sub-indicator measuring the strictness of dismissal of employees on regular contracts. This is calculated on a scale from 0 (least restrictions) to 6 (most restrictions) as a weighted sum of (i) procedural inconveniences of individual dismissals on regular contracts; (ii) notice and severance pay for no-fault individual dismissal; (iii) the difficulty of dismissal. Where data is unavailable for the years 1985 or 2008, the closest year available is used. The countries covered are the following: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Mexico, New Zealand, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

Source: OECD (www.oecd.org/employment/protection).

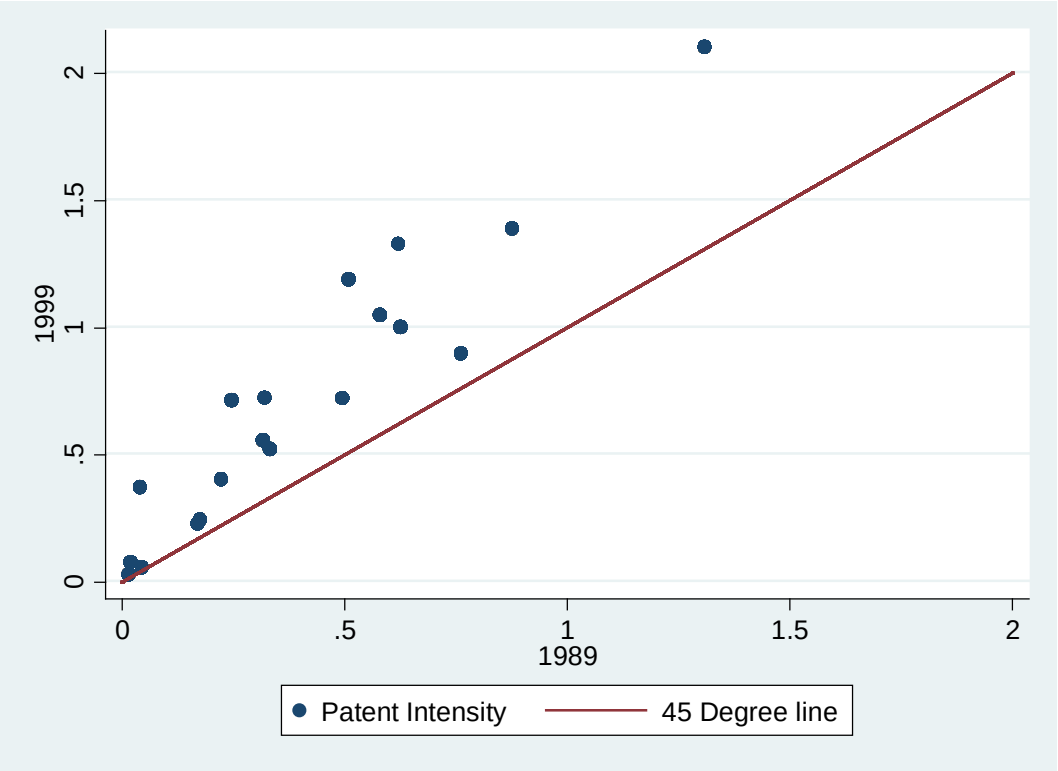
Figure 3: Employment Protection Legislation Strictness for Temporary Contracts (EPLT), OECD Countries



Notes: Employment Protection Legislation for Temporary contracts is a sub-indicator measuring the strictness of regulation on temporary contracts. This is calculated on a scale from 0 (least restrictions) to 6 (most restrictions) as a weighted sum of the strictness of regulation for (i) temporary work agency employment; and (ii) fixed term contracts. Where data is unavailable for the years 1985 or 2008, the closest year available is used. The countries covered are the following: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Mexico, New Zealand, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

Source: OECD (www.oecd.org/employment/protection).

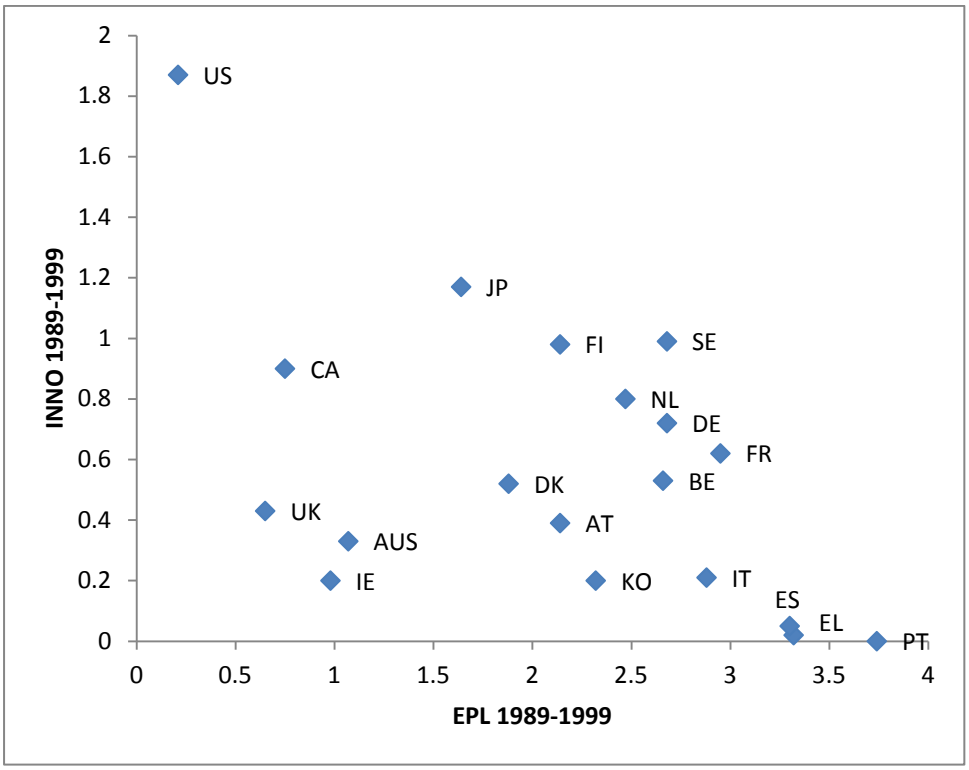
Figure 4: Innovation Intensity, OECD Countries



Notes: Patent Intensity is defined as the total patents for the period 1989-1999 per total hours worked by employees (millions) for the period 1989-1999. Patents are counted fractionally, that is if a patent is assigned k codes, it counts 1/k for each industry. The countries covered are the following: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Netherlands, Norway, Portugal, Slovak Spain, Sweden, United Kingdom, United States.

Source: EUKLEMS Database (http://www.euklems.net/).

Figure 5: Average Strictness of EPL and Average Innovation Intensity, 1989-1999



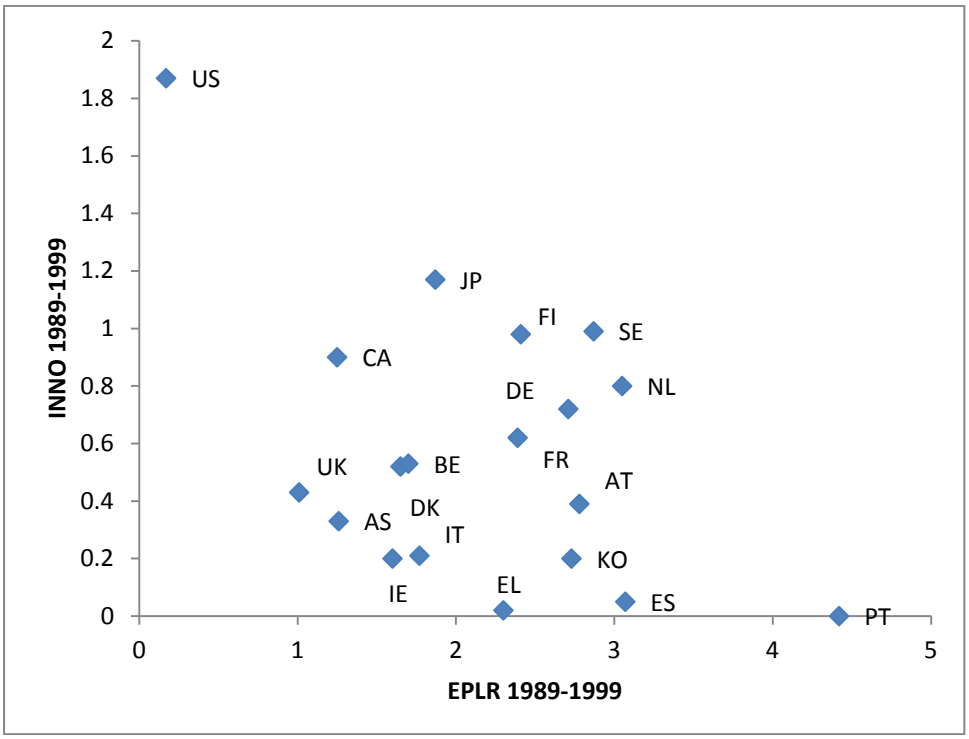
Notes: Employment Protection Legislation (EPL) is a composite index measuring the strictness of regulation and dismissal for regular and temporary contracts on a scale from 0 (least restrictions) to 6 (most restrictions). The average EPL is computed for each country over the years 1989-1999. Innovation intensity (INNO) is defined as the total patents for the period 1989-1999 per total hours worked by employees (millions) for the period 1989-1999. Patents are counted fractionally, that is if a patent is assigned k codes, it counts 1/k for each industry.

Country Codes are shown below:

Country	Code	Country	Code	Country	Code
Australia	AS	France	FR	Korea	KO
Austria	AT	Germany	DE	Netherlands	NL
Belgium	BE	Greece	EL	Portugal	PT
Canada	CA	Ireland	IE	Spain	ES
Denmark	DK	Italy	IT	Sweden	SE
Finland	FI	Japan	JP	United Kingdom	UK
				United States	US

Source: OECD (www.oecd.org/employment/protection) and EUKLEMS Database (http://www.euklems.net/).

Figure 6: Average Strictness of EPLR and Average Innovation Intensity, 1989-1999



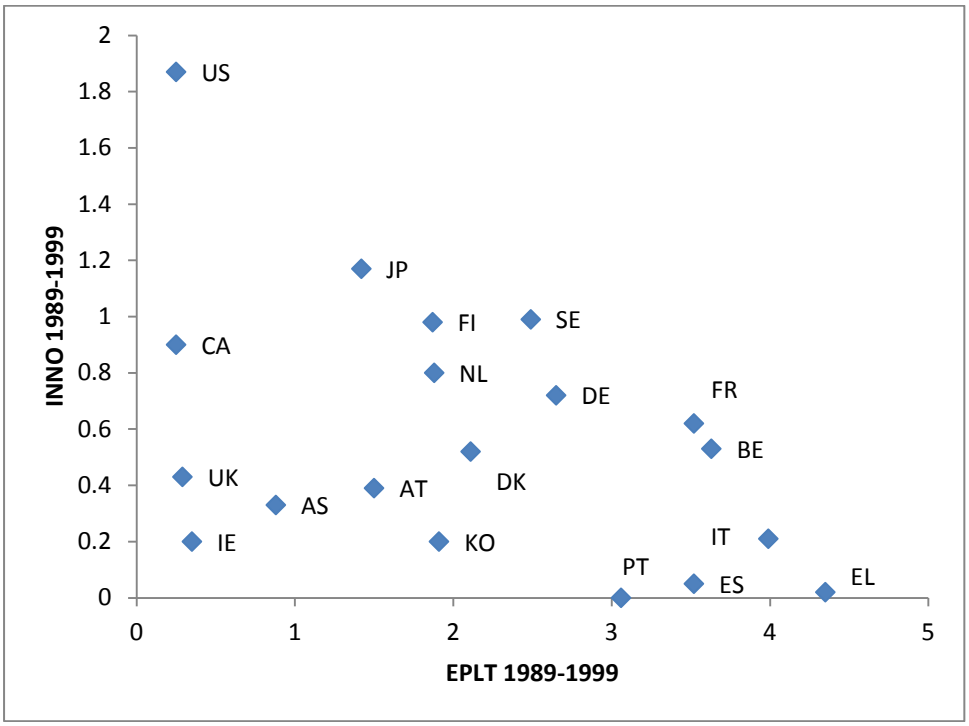
Notes: Employment Protection Legislation for Regular Contracts (EPLR) is a sub-indicator measuring the dismissal of employees on regular contracts. This is calculated on a scale from 0 (least restrictions) to 6 (most restrictions) as a weighted sum of i) procedural inconveniences of individual dismissals on regular contracts, ii) notice and severance pay for no-fault individual dismissal and iii) the difficulty of dismissal. The average EPLR is computed for each country over the years 1989-1999. Innovation intensity (INNO) is defined as the total patents for the period 1989-1999 per the total employee hours (millions) for the period 1989-1999. Patents are counted fractionally, that is if a patent is assigned k codes, it counts 1/k for each industry.

Country Codes are shown below:

Country	Code	Country	Code	Country	Code
Australia	AS	France	FR	Korea	KO
Austria	AT	Germany	DE	Netherlands	NL
Belgium	BE	Greece	EL	Portugal	PT
Canada	CA	Ireland	IE	Spain	ES
Denmark	DK	Italy	IT	Sweden	SE
Finland	FI	Japan	JP	United Kingdom	UK
				United States	US

Source: OECD (www.oecd.org/employment/protection) and EUKLEMS (http://www.euklems.net/).

Figure 7: Average Strictness of EPLT and Average Innovation Intensity, 1989-1999



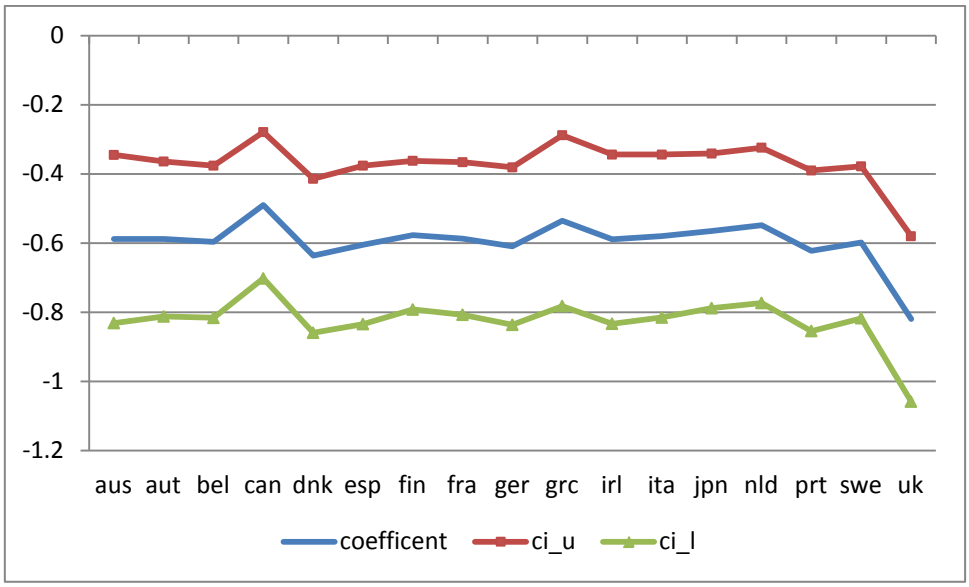
Notes: Employment Protection Legislation for Temporary Contracts (EPLT) is a sub-indicator measuring the strictness of regulation on temporary contracts. This is calculated on a scale from 0 (least restrictions) to 6 (most restrictions) as a weighted sum of the strictness of regulation for i) temporary work agency employment and ii) fixed term contracts. The average EPLT is computed for each country over the years 1989-1999. Innovation intensity (INNO) is defined as the total patents for the period 1989-1999 per total hours worked by employees (millions) for the period 1989-1999. Patents are counted fractionally, that is if a patent is assigned k codes, it counts 1/k for each sector.

Country Codes are shown below:

Country	Code	Country	Code	Country	Code
Australia	AS	France	FR	Korea	KO
Austria	AT	Germany	DE	Netherlands	NL
Belgium	BE	Greece	EL	Portugal	PT
Canada	CA	Ireland	IE	Spain	ES
Denmark	DK	Italy	IT	Sweden	SE
Finland	FI	Japan	JP	United Kingdom	UK
				United States	US

Source: OECD (www.oecd.org/employment/protection) and EUKLEMS (http://www.euklems.net/).

Figure 8: The Effect of EPL on Innovation Intensity Excluding One Country at a Time



Notes: The estimates are obtained with the augmented model (Eq. 2). The countries excluded are shown along the x axis.

Table 1: Summary Statistics of EPL Strictness, OECD Countries, 1985-2008

Country	Average EPL	EPL Change	Average EPLR	EPLR Change	Average EPLT	EPLT Change
United States	0.21	0.00	0.17	0.00	0.25	0.00
United Kingdom	0.65	0.15	1.01	0.17	0.29	0.13
Canada	0.75	0.00	1.25	0.00	0.25	0.00
Ireland	0.98	0.18	1.60	0.00	0.35	0.38
Australia	1.07	0.21	1.26	0.42	0.88	0.00
Switzerland	1.14	0.00	1.16	0.00	1.13	0.00
New Zealand	1.15	0.54	1.51	0.21	0.79	0.87
Hungary	1.36	0.38	1.92	0.00	0.81	0.75
Poland	1.53	0.50	2.06	0.00	1.01	1.00
Slovak Republic	1.63	-0.36	2.42	0.03	0.85	-0.75
Japan	1.64	-0.41	1.87	0.00	1.42	-0.81
Denmark	1.88	-0.90	1.65	-0.05	2.11	-1.75
Czech Republic	1.93	0.06	3.28	-0.26	0.60	0.38
Finland	2.14	-0.37	2.41	-0.62	1.87	-0.13
Austria	2.14	-0.28	2.78	-0.55	1.50	0.00
Korea	2.32	-0.84	2.73	-0.86	1.91	-0.81
Netherlands	2.47	-0.78	3.05	-0.36	1.88	-1.19
Belgium	2.66	-0.97	1.70	0.05	3.63	-2.00
Sweden	2.68	-1.62	2.87	-0.04	2.49	-3.20
Germany	2.68	-1.05	2.71	0.42	2.65	-2.50
Norway	2.75	-0.21	2.25	0.00	3.24	-0.41
Italy	2.88	-1.68	1.77	0.00	3.99	-3.38
France	2.95	0.25	2.39	-0.06	3.52	0.57
Mexico	3.13	0.00	2.25	0.00	4.00	0.00
Spain	3.30	-0.84	3.07	-1.42	3.52	-0.25
Greece	3.32	-0.83	2.30	-0.05	4.35	-1.62
Portugal	3.74	-1.31	4.42	-1.37	3.06	-1.25
Turkey	3.74	-0.04	2.60	-0.08	4.88	0.00

Notes: EPL = Employment Protection Legislation Index; EPLR= Employment Protection Legislation for Regular Contracts Index; EPLT= Employment Protection Legislation for Temporary Contracts Index.

Source: OECD (www.oecd.org/employment/protection).

Table 2: Summary Statistics of Innovation Intensity, OECD Countries, 1989-1999

Country	Patent Intensity	
	Average Patent Intensity 1989-1999	Change in Patent Intensity 1989-1999
Portugal	0.00	0.76
Greece	0.02	1.37
Spain	0.05	0.23
Ireland	0.20	0.28
Korea	0.20	2.22
Italy	0.21	0.32
Australia	0.33	0.58
Austria	0.39	0.56
United Kingdom	0.43	0.45
Denmark	0.52	1.06
Belgium	0.53	0.81
France	0.62	0.38
Germany	0.72	0.59
Netherlands	0.80	0.16
Canada	0.90	0.47
Finland	0.98	0.85
Sweden	0.99	0.76
Japan	1.17	0.46
United States	1.87	0.47

Notes: Average Patent Intensity is defined as the total patents for the period 1989-1999 per total hours worked by employees (millions) for the period 1989-1999. Patents are counted fractionally, that is if a patent is assigned k codes, it counts 1/k for each sector. The change in patent intensity is calculated as the natural logarithm of the patent intensity in 1999 per patent intensity in 1989.

Source: EUKLEMS Database, http://www.euklems.net/.

Table 3: Spearman Rank Correlation for Pairs of Two Periods between 1990 and 2003, 27 Industries

	1990-1991	1992-1993	1994-1995	1996-1997	1998-1999	2000-2001	2002-2003
1992-1993	0.90						
1994-1995	0.87	0.87					
1996-1997	0.87	0.95	0.89				
1998-1999	0.61	0.71	0.74	0.76			
2000-2001	0.59	0.63	0.74	0.67	0.80		
2002-2003	0.83	0.82	0.87	0.85	0.75	0.85	
2004	0.73	0.73	0.83	0.83	0.72	0.71	0.86

Source: Own calculations based on data from the EU KLEMS Database.

Table 4: Industry Job Reallocation Rates, Layoff Rates, Human and Physical Capital Intensity

Industry Description	**Code**	jr_{us}	lr_{us}	hc_{us}	ky_{us}
Food Products, Beverages And Tobacco	15-16	0.15	2.83	0.74	0.22
Textiles, Textile Products, Leather And Footwear	17-19	0.17	6.58	0.66	0.07
Chemicals And Chemical Products	24	0.14	3.09	0.79	0.32
Rubber And Plastics Products	25	0.13	4.88	0.79	0.10
Other Non-Metallic Mineral Products	26	0.17	4.85	0.79	0.06
Basic Metals And Fabricated Metal Products	27-28	0.17	5.64	0.79	0.22
Machinery, Nec	29	0.13	5.42	0.84	0.18
Electrical And Optical Equipment	30-33	0.18	8.12	0.80	0.44
Other Instruments	34-35	0.19	4.53	0.82	0.29
Manufacturing Nec; Recycling	36-37	0.26	5.95	0.74	0.08

Source: Bassanini *et al*. (2009) and own calculations based on data from the EU KLEMS Database.

Tables 5: Innovation Intensity and Employment Protection Legislation, Baseline Model

	EPL	EPLR	EPLT	EPLR, EPLT
	(1)	(2)	(3)	(4)
$jr_{us,j} * EPL_{it-1}$	-0.343***			
	(0.106)			
$jr_{us,j} * \Delta EPL_{it}$	1.108			
	(1.586)			
$jr_{us,j} * EPLR_{it-1}$		-0.177		-0.018
		(0.123)		(0.131)
$jr_{us,j} * \Delta EPLR_{it}$		-1.912		-2.455
		(2.319)		(2.309)
$jr_{us,j} * EPLT_{it-1}$			-0.250***	-0.252***
			(0.068)	(0.072)
$jr_{us,j} * \Delta EPLT_{it}$			1.112	1.272
			(0.921)	(0.934)
Country * Time Fixed Effects	yes	yes	yes	yes
Industry * Time Fixed Effects	yes	yes	yes	yes
Country-Industry Groups	180	180	180	180
Observations	1620	1620	1620	1620
Adjusted R^2	0.747	0.746	0.748	0.747
Economic Significance of EPL Job Reallocation Interaction				
25th- 75th percentile	-1.72	-0.89	-1.91	
10th - 90th percentile	-9.21	-3.26	-10.99	

Notes: The estimates were obtained with an OLS estimator. Robust standard errors are shown in parentheses. *,**,*** denote significant at the 10%, 5% and 1% level, respectively. Detailed definitions of variables and data sources are given in Table A1.

Table 6: Innovation Intensity and Employment Protection Legislation: Additional Controls

	EPL	EPLR	EPLT	EPLR, EPLT
	(1)	(2)	(3)	(4)
$jr_{us,j} * EPL_{it-1}$	-0.595***			
	(0.113)			
$jr_{us,j} * \Delta EPL_{it}$	0.251			
	(1.541)			
$jr_{us,j} * EPLR_{it-1}$		-0.312**		-0.004
		(0.144)		(0.152)
$jr_{us,j} * \Delta EPLR_{it}$		-0.495		-0.595
		(2.546)		(2.363)
$jr_{us,j} * EPLT_{it-1}$			-0.424***	-0.425***
			(0.069)	(0.073)
$jr_{us,j} * \Delta EPLT_{it}$			0.122	0.142
			(0.885)	(0.889)
$ky_{us,j} * KY_{it-1}$	0.057***	0.058***	0.058***	0.058***
	(0.004)	(0.004)	(0.004)	(0.004)
$\mathrm{hc}_{us,j} * HCAP_{it-1}$	0.020***	0.019***	0.020***	0.020***
	(0.002)	(0.002)	(0.002)	(0.002)
dtf_{ijt-1}	0.011	0.010	0.021	0.021
	(0.021)	(0.023)	(0.020)	(0.022)
$impcomp_{ijt-1}$	0.192***	0.184***	0.200***	0.200***
	(0.045)	(0.046)	(0.046)	(0.047)
pmr_{ijt-1}	-1.290***	-1.172***	-1.379***	-1.381***
	(0.341)	(0.359)	(0.340)	(0.347)
Country * Time Fixed Effects	yes	yes	yes	yes
Industry * Time Fixed Effects	yes	yes	yes	yes
Country-Industry Groups	170	170	170	170
Observations	1530	1530	1530	1530
Adjusted R^2	0.809	0.806	0.810	0.810

Notes: The estimates were obtained with an OLS estimator. Robust standard errors are shown in parentheses. *,**,*** denote significant at the 10%, 5% and 1% level, respectively. Detailed definitions of variables and data sources are given in Table A1.

Table 7: Innovation Intensity and EPL (Overall EPL Index): Controls for Labour Market Institutions

	Union Density	Tax Wedge	Gross Unempl. Benefit	Net Unempl. Benefit	Wage Coordina-tion	Wage Centralisa-tion	Labour Market Activation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$jr_{us,j} * EPL_{it-1}$	-0.569***	-0.511***	-0.370***	-0.543***	-0.692***	-0.722***	-0.480***
	(0.154)	(0.159)	(0.132)	(0.128)	(0.142)	(0.142)	(0.146)
$jr_{us,j} * \Delta EPL_{it}$	0.707	0.764	0.258	0.427	0.414	-1.017	0.667
	(1.517)	(1.594)	(1.495)	(1.530)	(1.429)	(1.503)	(1.659)
$ky_{us,j} * KY_{it-1}$	0.046***	0.047***	0.053***	0.053***	0.053***	0.052***	0.052***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$\mathrm{hc}_{us,j} * HCAP_{it-1}$	0.024***	0.027***	0.021***	0.020***	0.020***	0.020***	0.020***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
dtf_{ijt-1}	0.092***	0.074***	0.027	0.027	0.029	0.034	0.022
	(0.021)	(0.022)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
$impcomp_{ijt-1}$	0.327***	0.342***	0.162***	0.164***	0.168***	0.170***	0.152***
	(0.035)	(0.035)	(0.047)	(0.047)	(0.046)	(0.047)	(0.049)
pmr_{ijt-1}	-0.697	-0.636	-0.699	-0.658	-0.668	-0.459	-1.007
	(0.663)	(0.683)	(0.642)	(0.646)	(0.663)	(0.650)	(0.741)
$jr_{us,j} * LMI_{it-1}$	0.004	0.016	-0.034***	-0.025*	0.328**	0.408***	-0.183
	(0.007)	(0.013)	(0.010)	(0.014)	(0.137)	(0.144)	(0.200)
$jr_{us,j} * \Delta LMI_{it}$	10.526	0.016*	-1.822***	0.199	-2.380	6.065	0.587
	(12.569)	(0.061)	(0.513)	(0.552)	(3.391)	(4.881)	(1.105)
Country *Time Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Industry *Time Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Country-Industry Groups	150	140	160	160	160	160	150
Observations	1350	1260	1440	1440	1440	1440	1350
Adjusted R^2	0.826	0.808	0.812	0.811	0.812	0.812	0.808

Notes: The estimates were obtained with an OLS estimator. Robust standard errors are shown in parentheses. *,**,*** denote significant at the 10%, 5% and 1% level, respectively. Detailed definitions of variables and data sources are given in Table A1.

Table 8: Innovation Intensity and Employment Protection (EPLR and EPLT): Controls for Labour Market Institutions

	Union Density	Tax Wedge	Gross Unempl. Benefit	Net Unempl. Benefit	Wage Coordina-tion	Wage Centralisa-tion	Labour Market Activation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$jr_{us,j} * EPLR_{it-1}$	0.141	- 0.286*	0.091	-0.006	-0.194	-0.315	-0.027
	(0.163)	(0.172)	(0.169)	(0.162)	(0.171)	(0.194)	(0.188)
$jr_{us,j} * \Delta EPLR_{it}$	-0.554	-2.855	-0.610	-0.624	-0.650	-0.635	-0.441
	(2.336)	(4.440)	(2.519)	(2.415)	(2.355)	(2.240)	(2.487)
$jr_{us,j} * EPLT_{it-1}$	-0.487***	-0.530***	-0.319***	-0.400***	-0.412***	-0.376***	-0.378***
	(0.085)	(0.091)	(0.082)	(0.077)	(0.079)	(0.076)	(0.119)
$jr_{us,j} * \Delta EPLT_{it}$	0.221	0.270	0.119	0.200	0.314	-0.500	0.331
	(0.834)	(0.830)	(0.835)	(0.880)	(0.831)	(0.894)	(0.951)
$ky_{us,j} * KY_{it-1}$	0.046***	0.047***	0.053***	0.053***	0.053***	0.052***	0.052***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$\mathrm{hc}_{us,j} * HCAP_{it-1}$	0.024***	0.027***	0.020***	0.020***	0.020***	0.020***	0.020***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
dtf_{ijt-1}	0.105***	0.094***	0.034	0.034	0.033	0.035	0.028
	(0.022)	(0.023)	(0.025)	(0.025)	(0.025)	(0.025)	(0.026)
$impcomp_{ijt-1}$	0.343***	0.364***	0.170***	0.171***	0.172***	0.171***	0.159***
	(0.035)	(0.036)	(0.048)	(0.048)	(0.048)	(0.048)	(0.050)
pmr_{ijt-1}	-0.791	-0.706	-0.756	-0.713	-0.710	-0.477	-1.004
	(0.673)	(0.685)	(0.649)	(0.654)	(0.672)	(0.666)	(0.742)
$jr_{us,j} * LMI_{it-1}$	0.005	0.024*	-0.037***	-0.027*	0.301**	0.392**	-0.139
	(0.007)	(0.012)	(0.010)	(0.014)	(0.140)	(0.165)	(0.204)
$jr_{us,j} * \Delta LMI_{it}$	6.532	0.164**	-1.392***	0.275	-1.383	5.833	0.670
	(13.233)	(0.064)	(0.537)	(0.532)	(3.468)	(4.911)	(1.113)
Country * Time Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Industry * Time Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Country-Industry Groups	150	140	160	160	160	160	150
Observations	1350	1260	1440	1440	1440	1440	1530
Adjusted R^2	0.827	0.827	0.813	0.811	0.812	0.812	0.813

Notes: The estimates were obtained with an OLS estimator. Robust standard errors are shown in parentheses. *,**,*** denote significant at the 10%, 5% and 1% level, respectively. Detailed definitions of variables and data sources are given in Table A1.

Table 9: Innovation Intensity and Employment Protection: Alternative EPL Measure

	Baseline Model	Augmented Model	Union Density	Tax Wedge	Gross Unempl. Benefit	Net Unempl. Benefit	Wage Coordina-tion	Wage Centralisa-tion	Labour Market Activation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$jr_{us,j} * EPL_{it-1}$	-0.318**	-0.533***	-0.374**	-0.467**	-0.397***	-0.611***	-0.603***	-0.700***	-0.433**
	(0.127)	(0.142)	(0.164)	(0.195)	(0.148)	(0.149)	(0.148)	(0.149)	(0.183)
$jr_{us,j} * \Delta EPL_{it}$	-0.657	-1.229	-1.070	-4.475**	-0.544	-1.610	-1.154	-1.423	-1.157
	(1.386)	(1.438)	(1.527)	(2.204)	(1.293)	(1.444)	(1.484)	(1.478)	(1.455)
$ky_{us,j} * KY_{it-1}$		0.053***	0.047***	0.047***	0.053***	0.054***	0.054***	0.053***	0.052***
		(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$\mathrm{hc}_{us,j} * HCAP_{it-1}$		0.020***	0.023***	0.026***	0.021***	0.020***	0.020***	0.020***	0.019***
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
dtf_{ijt-1}		0.027	0.096***	0.079***	0.026	0.027	0.030	0.034	0.024
		(0.024)	(0.021)	(0.023)	(0.024)	(0.024)	(0.024)	(0.024)	(0.025)
$impcomp_{ijt-1}$		0.166***	0.325***	0.345***	0.161***	0.162***	0.167***	0.169***	0.151***
		(0.047)	(0.034)	(0.035)	(0.046)	(0.047)	(0.047)	(0.046)	(0.049)
pmr_{ijt-1}		-0.822	-0.822	-0.749	-0.759	-0.750	-0.802	-0.620	-1.170
		(0.664)	(0.661)	(0.683)	(0.639)	(0.647)	(0.664)	(0.655)	(0.740)
$jr_{us,j} * LMI_{it-1}$			0.002	0.014	-0.041***	-0.035**	0.195	0.342**	-0.277
			(0.007)	(0.013)	(0.009)	(0.014)	(0.131)	(0.143)	(0.200)
$jr_{us,j} * \Delta LMI_{it}$			-2.242	0.130*	-1.903***	0.256	-4.120	6.166	-0.046
			(12.306)	(0.066)	(0.542)	(0.546)	(3.621)	(4.573)	(1.106)
Country * Time Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry * Time Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-Industry Groups	160	160	150	140	160	160	160	160	150
Observations	1440	1440	1350	1260	1440	1440	1440	1440	1350
Adjusted R^2	0.765	0.810	0.825	0.824	0.812	0.810	0.810	0.811	0.807

Notes: The estimates were obtained with an OLS estimator. Robust standard errors are shown in parentheses. *,**,*** denote significant at the 10%, 5% and 1% level, respectively. Detailed definitions of variables and data sources are given in Table A1.

Table 10: Innovation Intensity and EPL: Model Specifications with Industry Layoff Rates

	Baseline Model	Augmented Model	Union Density	Tax Wedge	Gross Unempl. Benefit	Net Unempl. Benefit	Wage Coordination	Wage Centralisation	Labour Market Activation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(7)
$lr_{us,j} * EPL_{it-1}$	-0.019***	-0.020***	-0.023***	-0.026***	-0.014***	-0.019***	-0.021***	-0.020***	-0.019***
	(0.005)	(0.004)	(0.006)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)
$lr_{us,j} * \Delta EPL_{it}$	-0.045	-0.034	-0.017	-0.018	-0.040	-0.040	-0.052	-0.117**	-0.021
	(0.069)	(0.064)	(0.063)	(0.067)	(0.058)	(0.059)	(0.054)	(0.055)	(0.067)
$ky_{us,j} * KY_{it-1}$		0.057***	0.046***	0.046***	0.053***	0.053***	0.052***	0.052***	0.051***
		(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$\mathrm{hc}_{us,j} * HCAP_{it-1}$		0.019***	0.023***	0.026***	0.020***	0.019***	0.019***	0.019***	0.019***
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
dtf_{ijt-1}		0.027	0.101***	0.086***	0.038*	0.039*	0.044**	0.044**	0.044**
		(0.020)	(0.020)	(0.021)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
$impcomp_{ijt-1}$		0.173***	0.307***	0.329***	0.173***	0.165***	0.152***	0.153***	0.135***
		(0.045)	(0.036)	(0.038)	(0.050)	(0.049)	(0.046)	(0.048)	(0.049)
pmr_{ijt-1}		-1.118***	-1.329**	-0.921	-1.094*	-1.142*	-1.058*	-1.103*	-1.203*
		(0.333)	(0.632)	(0.658)	(0.592)	(0.599)	(0.623)	(0.603)	(0.702)
$lr_{us,j} * LMI_{it-1}$			-0.000	0.001**	-0.001***	-0.001**	0.005	-0.000	0.012
			(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.004)	(0.008)
$lr_{us,j} * \Delta LMI_{it}$			0.657	0.001	-0.075***	-0.020	-0.165	0.357**	-0.008
			(0.403)	(0.002)	(0.022)	(0.018)	(0.126)	(0.156)	(0.045)
Country * Time Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry * Time Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-Industry Groups	180	170	150	140	160	160	160	160	150
Observations	1620	1530	1350	1260	1440	1440	1440	1440	1350
Adjusted R^2	0.752	0.812	0.832	0.830	0.816	0.815	0.814	0.815	0.811

Notes: The estimates were obtained with an OLS estimator. Robust standard errors are shown in parentheses. *,**,*** denote significant at the 10%, 5% and 1% level, respectively. Detailed definitions of variables and data sources are given in Table A1.

Table 11: Innovation Intensity and Employment Protection (EPLR and EPLT): Model Specifications with Industry Layoff Rates

	Baseline Model	Augmented Model	Union Density	Tax Wedge	Gross Unempl. Benefit	Net Unempl. Benefit	Wage Coordination	Wage Centralisation	Labour Market Activation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$lr_{us,j} * EPLR_{it-1}$	-0.004	-0.008	-0.010	-0.010	-0.006	-0.007	-0.012**	-0.009	-0.011*
	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
$lr_{us,j} * \Delta EPLR_{it}$	-0.014	0.026	0.011	0.004	0.018	0.019	0.023	0.022	0.016
	(0.081)	(0.074)	(0.083)	(0.150)	(0.078)	(0.078)	(0.076)	(0.078)	(0.079)
$lr_{us,j} * EPLT_{it-1}$	-0.012***	-0.011***	-0.012***	-0.015***	-0.007**	-0.010***	-0.010***	-0.011***	-0.009**
	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
$lr_{us,j} * \Delta EPLT_{it}$	-0.034	-0.033	-0.018	-0.021	-0.035	-0.036	-0.044	-0.084***	-0.022
	(0.042)	(0.037)	(0.035)	(0.035)	(0.033)	(0.033)	(0.030)	(0.029)	(0.038)
$ky_{us,j} * KY_{it-1}$		0.057***	0.046***	0.046***	0.053***	0.053***	0.052***	0.052***	0.051***
		(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$\mathrm{hc}_{us,j} * HCAP_{it-1}$		0.019***	0.022***	0.026***	0.020***	0.019***	0.019***	0.019***	0.019***
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
dtf_{ijt-1}		0.028	0.101***	0.087***	0.039*	0.040*	0.044**	0.045**	0.043**
		(0.020)	(0.020)	(0.021)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
$impcomp_{ijt-1}$		0.169***	0.304***	0.323***	0.171***	0.161***	0.150***	0.148***	0.134***
		(0.045)	(0.037)	(0.038)	(0.050)	(0.049)	(0.047)	(0.048)	(0.049)
pmr_{ijt-1}		-1.096***	-1.328**	-0.888	-1.094*	-1.140*	-1.052*	-1.096*	-1.223*
		(0.330)	(0.632)	(0.661)	(0.593)	(0.599)	(0.625)	(0.605)	(0.702)
$lr_{us,j} * LMI_{it-1}$			-0.000	0.001**	-0.001***	-0.001**	0.005	-0.000	0.011
			(0.000)	(0.000)	(0.000)	(0.001)	(0.004)	(0.005)	(0.008)
$lr_{us,j} * \Delta LMI_{it}$			0.640	0.002	-0.074***	-0.019	-0.191	0.384**	-0.010
			(0.408)	(0.002)	(0.024)	(0.018)	(0.132)	(0.155)	(0.045)
Country * Time Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry * Time Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-Industry Groups	180	170	150	140	160	160	160	160	150
Observations	1620	1530	1350	1260	1440	1440	1440	1440	1350
Adjusted R^2	0.752	0.812	0.832	0.830	0.816	0.815	0.814	0.815	0.820

Notes: The estimates were obtained with an OLS estimator. Robust standard errors are shown in parentheses. *,**,*** denote significant at the 10%, 5% and 1% level, respectively. Detailed definitions of variables and data sources are given in Table A1.

Table A1: Definitions of Variables and Data Sources

Name	Description	Source	Notes
Country- Industry Variables			
Innovation Intensity, *INNO*	The natural logarithm of one plus the ratio of patents (fractionally assigned) to total hours worked in each year.	EU KLEMS, Linked Data 2008 Release.	As noted on website, the patent data is based on the NBER database updated by Bronwyn Hall and the database refers to patents granted by USPTO until 2002. Data is available annually from 1970 to 1999 for 26 countries. For description of data refer to O'Mahony et al (2008). http://www.euklems.net/
Distance to the Technology Frontier, *dtf*	The natural logarithm of the industry's labour productivity (i.e. gross value added to total hours worked by employees) divided by labour productivity in the country-industry with the highest value in each year (i.e. industry at the technology frontier).	EU KLEMS, Basic files	
Import Penetration, *impcomp*	Total imports divided by the sum of gross output minus exports plus imports.	1. OECD STAN Database for Structural Analysis (ISIC Rev. 3)	Production data begins in 1990, Export and import data only available from 1994 onwards for Rep of Korea. The 1998 value for Ireland is an extremely large outlier and is replaced with the average of its values for 1997 and 1999.
Product Market Regulation Index, *pmr*	An index which measures the potential direct and indirect costs of product market regulation on manufacturing sectors of the economy.	Nickell (2006) The CEP – OECD Institutions Data Set (1960-2004). Centre for Economic Performance, LSE.	
Industry Variables			
Job Reallocation Rates*, jr*	The sum of absolute values of the job destruction and job creation rates in each US industry averaged over the period 1990-1999.	EU KLEMS	
Layoff Rates, *lr*	Average percentage ratio of annual recorded layoffs to wage and salary employment in each US industry over the period 2001-2003.	Data are taken from Bassanini et al. (2009). The variable is constructed based on data from a number of sources; CPS Displaced Workers Supplement, EU KLEMS.	
Physical Capital Intensity, *ky*	Average real fixed capital assets as a share of real gross value added in each US industry over the period 1990-1999.	EU KLEMS	
Human Capital Intensity, *hc*	Average share of hours worked by high and medium skilled employees per total hours worked in each US industry over the period 1990-1999.	EU KLEMS	

Table A1 (continued): Definitions of Variables and Data Sources

Name	Description	Source	Notes
Country Level Variables			
Employment Protection Variables: Overall *EPL*, Regular *EPLR*, Temporary *EPLT*	Indicators which measure the strictness of employment protection legislation for overall, regular and temporary employment. Variables evaluate the strictness of employment protection on a scale of 0 to 6.	OECD (2010), "Employment Protection Legislation: Strictness of employment protection legislation: collective dismissals", OECD Employment and Labour Market Statistics (database).	
EPL alternative	Indicator which measure the strictness of employment protection legislation. The series uses the OECD methodology and ranges from 0 to 5.	Nickell (2006), The CEP – OECD Institutions Data Set (1960-2004). Centre for Economic Performance, LSE. Original Source: Allard (2005a).	
Union density	Number of workers covered by collective agreements normalised by employment	Nickell (2006), The CEP – OECD Institutions Data Set (1960-2004). Centre for Economic Performance, LSE	This series was constructed as an interpolation of both data series collected by Ochel (2001) and union coverage series collected by OECD (2004). We interpolated the series differently to the series in CEP – OECD Institutions Data Set. i.e. Data is available periodically, our data is interpolated yearly between points of the average of two series, but unlike the CEP-OECD interpolated series when the observation of either series is missing we use the previous observation to calculate the average before interpolating. Data not available for Ireland and Greece in dataset.
Tax Wedge	Tax Wedge is equal to the sum of the employment tax rate, the direct tax rate and the indirect tax rate.	Nickell (2006), The CEP – OECD Institutions Data Set (1960-2004). Centre for Economic Performance, LSE.	Data not available for Australia, Ireland and Greece in dataset.
Gross Unemployment Benefit	Benefit Duration is defined as the average unemployment benefit across the first five years of unemployment for three family situations and two money levels taken from www.oecd.org/els/social/workincentives and interpolated.	Nickell (2006), The CEP – OECD Institutions Data Set (1960-2004). Centre for Economic Performance, LSE. Original Source: OECD	Complete data series not available for Ireland and Greece in dataset.
Net Unemployment Benefit	An alternative indicator for unemployment benefits which combines the amount of the subsidy with their tax treatment, their duration and the conditions that must be met in order to collect them.	Nickell (2006), The CEP – OECD Institutions Data Set (1960-2004). Centre for Economic Performance, LSE. Original Source: Allard (2005b)	Data not available for Greece in dataset.

Table A1 (continued): Definitions of Variables and Data Sources

Name	Description	Source	Notes
Wage Coordination	Index of bargaining coordination which ranges from 1 to 5. The series is increasing in the degree of coordination in the bargaining process on the employers' as well as the unions' side.	Nickell (2006), The CEP – OECD Institutions Data Set (1960-2004). Centre for Economic Performance, LSE, Original Source: OECD (2004), Table 3.5	Data not available for Greece in dataset.
Wage Centralisation	Index of bargaining centralisation which ranges from 1 to 5. The series is increasing in the degree of centralization.	Nickell (2006), The CEP – OECD Institutions Data Set (1960-2004). Centre for Economic Performance, LSE. Original Source: OECD (2004), Table 3.5	Data not available for Greece in dataset.
Labour Market Activation Polices	Expenditure on Active Labour Market Policies as a percentage of GDP	Nickell (2006), The CEP – OECD Institutions Data Set (1960-2004). Centre for Economic Performance, LSE. Data for 1980, 1989, 1993 and 1998 taken from OECD (2001), Table 1.5 and interpolated. Original Source: OECD (2001),	Complete data series not available for Italy, Greece in dataset.
Physical Capital to GDP Ratio, *KY*	Variable is defined as the ratio of physical capital stock to GDP. Both variables are expressed at constant prices.	OECD (2012), "OECD Economic Outlook No. 91", OECD Economic Outlook: Statistics and Projections (database)	We replaced data for Germany in 1990 with 1991 value. Also for Greece, missing data from 1990-1993 is replaced with its 1994 value.
Human Capital Index, *HC*	Country level Human Capital Index.	OECD (2012), "OECD Economic Outlook No. 91", OECD Economic Outlook: Statistics and Projections (database) To access the Economic Outlook data select Economic Indicators, then Outlook version, followed by Supply Block.	We replaced data for Germany in 1990 with 1991 value. Also missing data from 1990-1993 is replaced with its 1994 value.

Table A2: Summary Statistics of the Explanatory Variables, 1991-1999

Variable Name	Obs.	Mean	Std. Dev.	Min	Max
Ln Patent Intensity	1620	0.35	0.39	0.00	1.62
Ln Distance to Technological Frontier	1620	-0.82	0.6	-2.47	0.00
Import Competition	1530	0.47	0.32	0.04	1.46
Industry Regulation Impact Index	1530	0.12	0.03	0.06	0.2
Union density	135	74.2	22.41	19.80	98.50
Δ Union density	135	0.00	0.01	-0.05	0.01
Tax wedge	135	54.0	11.64	33.40	85.60
Δ Tax wedge	135	0.51	2.50	-9.74	7.74
Gross Unemployment Benefit	144	31.3	12.66	2.50	64.90
Δ Gross Unemploymnet Benefit	144	0.02	0.13	-0.14	1.35
Net Unemployment Benefit	144	15.6	8.37	0.80	42.10
Δ Net Unemployment Benefit	144	0.00	0.18	-0.91	1.35
Wage Coordination	144	3.27	1.17	1.00	5.00
Δ Wage Coordination	144	0.00	0.04	0.00	0.29
Wage Centralisation	144	2.65	1.11	1.00	5.00
Δ Wage Centralisation	144	0.00	0.03	-0.41	0.00
Labour Market Activation Policy Expenditure	135	1.07	0.62	0.09	2.97
Δ Labour Market Activation Policy Expenditure	135	0.01	0.09	-0.20	0.51
Human Capital Index	162	3.12	0.45	1.92	3.74
EPL	162	2.31	0.99	0.60	3.85
EPR	162	2.28	0.86	0.95	4.33
EPT	162	2.36	1.50	0.25	5.38
ΔEPL	162	-0.02	0.07	-0.38	0.01
ΔEPR	162	0.00	0.04	-0.31	0.04
ΔEPT	162	-0.03	0.13	-0.69	0.00

Year	Number	Title/Author(s) ESRI Authors/Co-authors *Italicised*
2012		
	444	Distance Effects, Social Class and the Decision to Participate in Higher Education in Ireland John Cullinan, Darragh Flannery, *Sharon Walsh* and *Selina McCoy*
	443	Sentencing in Criminal Cartel Cases in Ireland: the Duffy Judgment *Paul K. Gorecki and Sarah Maxwell*
	442	Currency intervention and the global portfolio balance effect: Japanese lessons *Petra Gerlach-Kristen, Robert N McCauley and Kazuo Ueda*
	441	Regulating Small Public Service Vehicles in Ireland: Is There a Problem of Oversupply? *Paul K. Gorecki*
	440	Combining Public Sector and Economic Reform *Frances Ruane*
	439	The Effect of Real Exchange Rate Changes on Labour Productivity Growth *Gavin Murphy* and *Iulia Siedschlag*
	438	Consumption in Ireland: Evidence from the Household Budget Survey *Petra Gerlach-Kristen*
	437	Simulating Demand for Electrical Vehicles using Revealed Preference Data *Áine Driscoll, Seán Lyons*, Franco Mariuzzo, and Richard S.J. Tol
	436	The Costs of Working in Ireland Niamh Crilly, *Anne Pentecost* and Richard S.J. Tol
	435	Choice, Price and Service Characteristics in the Irish Broadband Market *Seán Lyons* and *Michael Savage*
	434	International Migration in Ireland, 2011 *Philip J. O'Connell, Corona Joyce* and *Mairéad Finn*
	433	The Potential for Segmentation of the Retail Market for Electricity in Ireland *Marie Hyland, Eimear Leahy* and Richard S.J. Tol
	432	Timing and Determinants of Local Residential Broadband Adoption: Evidence from Ireland *Seán Lyons*

For earlier *Working Papers* see
http://www.esri.ie/publications/search_for_a_working_pape/search_results/index.xml