Employment Protection Legislation Impacts on Capital and Skills Composition

Gilbert Cette*, Jimmy Lopez and Jacques Mairesse*****

Abstract – The article investigates the effects of Employment Protection Legislation (EPL) on capital and skills according to the intensity of international competition. Grounded on a panel data sample for 14 OECD countries and 18 industries from 1988 to 2007, and a difference-in-difference approach, we find that strengthening EPL: (i) leads to a capital-labour substitution in favour of non ICT non R&D capital to the detriment of employment, this effect being mitigated in industries highly exposed to international competition; (ii) lowers ICT capital and, even more severely, R&D capital relatively to other capital components; and (iii) works at the relative disadvantage of low-skilled workers. Strengthening EPL can therefore be an impediment to organizational and so technological change and risk taking on globalized markets. An illustrative simulation suggests that structural reforms weakening EPL could have a significant favorable impact on firms' ICT and R&D investment and on hiring low-skilled workers.

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Reminder:

The opinions and analyses in this article are those of the author(s) and do not necessarily reflect their institution's or Insee's views.

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Numerous economic studies have been devoted to exploring the impact of labour market regulations on firms' behavior. Many of them relied on the Employment Protection Legislation (EPL) indicators of OECD on procedures and costs involved in dismissing individuals or groups of workers and in hiring workers on fixed-term or temporary work agency contracts. Among them, several studies also focused on the effects of EPL on firms' innovation as proxied by patents and/or its effects on various measures of firms' productivity.[1] Much fewer studies have investigated the impacts of labour regulations on specific production factors. Some have considered the impact of labour regulations on the overall capital-to-labour ratio (or capital intensity), and have found apparently conflicting results such as Autor *et al.* (2007), Calgagnini *et al.* (2014), Cingano *et al.* (2010 and 2014), Janiak & Wasmer (2014). Others have studied the impact of EPL on Information and Communication Technology (ICT) capital (Aghion *et al.,* 2009; Cette & Lopez, 2012; Guerrieri *et al.,* 2011), but none, to our knowledge, on Research and Development (R&D) capital.[2]

R&D and ICT investments have become major determinants of economic growth and productivity, and are vital at the firm level to maintain competitiveness vis-a-vis firms from both developed countries and developing countries, notably through the supply of lower-skilled and less costly labour. The originality of our study is to investigate the effects of EPL on four capital and three labour skill components, precisely construction, non-ICT, ICT and R&D capital components on the one hand, and low, medium- and high-skill labour components on the other hand. Our paper has also the advantage of being grounded on a large country-industry panel dataset of 14 OECD countries, 18 manufacturing and market service industries, over the 20 years from 1988 to 2007. It relies on the implementation of a difference-in-difference econometric approach (with country*industry and country*year interacted fixed effects).

Our main estimation results show that strengthening EPL leads to a capital-to-labour substitution in favour of non-ICT non-R&D capital. However, this strengthening lowers both ICT capital and, even more severely, R&D capital relatively to non-ICT and non-R&D capital. This strenghtening also works at the relative disadvantage of the employment of low-skill workers with respect to high-skill workers. These results confirm that firms consider that the strengthening of EPL involves significant adjustment costs for labour and indirectly capital, and can be an impediment to organizational change and to risk taking.[3] Taking into account the intensity of international competition on our results, through the interaction of EPL and an indicator of industry exposure to external trade, shows that the EPL differential impact tend to diminish with increased openness for R&D capital and high-skill labour, but not for ICT capital.

An illustrative policy simulation based on our results suggests that structural reforms lowering EPL to the "lightest labour regulation practice", defined as the level of EPL in the USA, could have in the medium-long term a favorable impact of about 30% on R&D capital intensity in average, and of about 10% on unskilled employment in average. Thus, EPL reforms may also contribute to maintain OECD countries' national competitiveness in the face of increasing international competition.

Our paper proceeds as follows. The two next sections respectivily explain our choice of model specification and present our data. The two following sections show and comment first our main econometric results, then propose, based on these results, a policy simulation of the impacts on capital and skill composition of a structural reform consisting in adopting the lightest labour regulation practice observed in the USA. We summarize our findings in the final section.

Model Specification

Employment Protection Legislation (EPL) may impact specific production factors and their combination in various ways: through observed labour cost, adjustment costs, efficiency and risk characteristics, directly and indirectly. In this paper, we investigate the overall, direct and indirect impacts of EPL on major production factors. We distinguish four components of capital: non-residential construction, non-ICT, ICT and R&D, and three

1. *See for instance Acharya* et al. *(2013); Bassanini* et al. *(2009); Cette* et al. *(2016); Conti & Sulis (2016); Griffith & Macartney (2014); Micco & Pages (2006), which find detrimental impacts of labour regulations on patents, Total Factor Productivity level or growth.*
2. *Appendix 1 provides a short review of the papers investigating the impact of labour regulations on on overall capital, ICT capital or patents referred to here.*
3. *This interpretation is also confirmed by Bartelsman* et al. *(2016) results which show that high-risk industries are smaller in countries with high EPL and by Conti and Sulis (2016) findings which suggest a detrimental impact of EPL on high-technology adoption.*

skill components of labour: high, medium and low-skilled employment. We expect that EPL would influence these seven production factors differently.

We expect two opposite effects of EPL concerning capital intensity. Due to its influence on labour adjustment cost, an increase in EPL should have a similar positive impact on capital intensity as an increase in the observed labour costs. However, if market constraints prevent the implementation of an optimal labour organization, thus reducing the efficiency of advanced technologies, an increase in EPL could also have a negative impact on capital intensity. This should be particularly the case for ICT capital which requires stronger labour reorganization and flexibility. This should be even more so for R&D capital which is very risky and requires higher labour flexibility. Moreover, internal R&D expenses consist largely of labour costs, so R&D capital user cost would tend to increase in line with the labour costs and the a priori positive impact of EPL due to labour adjustment cost would be small. On the whole, one should expect that the negative impact of EPL on R&D would be even much stronger than on ICT.

EPL differential impacts on employment skill composition depend largely on the differences in the labour adjustment costs between the three different skill levels. We thus expect that an increase in EPL should have a higher negative impact on the employment of low-skill workers, and hence should translate on a higher positive impact on the share of employment to total employment for high-skill workers.

In addition to these direct effects of EPL on each production factors, we may expect also indirect effects to the extent that complementarities between them are different. For instance, if high-skill employment is complementary to capital intensity, EPL may influence the capital demand through high-skill employment. Our empirical investigation is not able to tackle this issue as it would require to estimate a more general or structural model with an equation for each production factor as a different left hand-side variable, as we do here, but with also the other production factors as the right hand-side variables. This model will be much more complicated to estimate consistently (on this issue see Appendix 3). We privilege here a more reasonable and less ambitious model specification which must be viewed as a reduced form model allowing estimating the total impact of EPL on each production factor, but not disentangling between the direct and indirect channels.

The model we consider corresponds to one equation for each production factor (with small letters for logarithms):[4]

$$\left(x_f - l\right)_{cit} = \alpha_f - s_f \cdot \left(c_f - w\right)_{cit} + \beta_f \cdot \lambda_i \cdot \mathrm{EPL}_{ct} + \eta_{f,ci} + \eta_{f,ct} + \epsilon_{f,cit} \quad (1)$$

where f is an index denoting the seven different factors of production; c, i, t are the country, industry and time indices; X_f and C_f stand for the quantity and unit user cost of production factor f, L for total employment, W for the average labour compensation, λ_i for an industry specific characteristic (see below), and EPL the OECD indicator of Employment Protection Legislation. The coefficients to be estimated are α_f, s_f and β_f. Country*industry and country*year fixed effects $\eta_{f,ci}$ and $\eta_{f,ct}$ are also included in addition to the usual idiosyncratic error or residual term $\epsilon_{f,cit}$.

We introduce country*industry $\eta_{f,ci}$ and country*year $\eta_{f,ct}$ fixed effects to prevent from various sources of endogeneity, such as reverse causality and omission bias stemming from the fact that national governments would reform their employment legislation in view of their country changing economic situation. We thus rely on a difference-in-difference type of approach, allowing us to estimate consistently the various differences between the main coefficients of interest: $(\beta_f - \beta_{f'})$ for all distinct f and f'. To identify the effects of EPL, which is collinear to country*year fixed effects, we allow EPL effects to depend on an industry specific characteristic λ_i, measuring an intensity of use of labour. In our main specification, λ_i is proxied by the industry labour share over production in the USA in 2000, which we can view as a rather 'natural' reference, since USA is in our sample the country with the lowest EPL values.

The *a priori* expectations we suggested in the beginning of this section on the relative size of the impacts of EPL (precisely the elasticities of $\lambda_i \cdot \mathrm{EPL}_{ct}$) are well confirmed by our estimation results. We find that the two elasticities β_f are positive for the non-ICT capital equipment and non-residential capital construction intensities, the one for R&D capital intensity is negative and

4. A more formal presentation of the model can be found in the Online complement.

significantly higher, while the one for the ICT capital intensity is in between. We find similarly that the elasticity β_f for the share of high-skilled employment is positive and the one for the share of low-skilled employment is negative.

We also consider a variant of relation (1) taking into account that national firms exposed to international competition have to face higher demand variability and higher risks. We do so by including as an additional explanatory variable the product interaction of EPL with the level of openness to external trade:

$$\left(x_f - l\right)_{cit} = \alpha_f - s_f \cdot \left(c_f - w\right)_{cit} + \beta_f \cdot \lambda_i \cdot \mathrm{EPL}_{ct} + \mu_f \cdot Openess_i \cdot \mathrm{EPL}_{ct} + \eta_{f,ci} + \eta_{f,ct} + \epsilon_{f,cit} \quad (2)$$

where $Openess_i$ is the average level of openness of industry i to external trade observed in the US. This level of openness corresponds to the sum of exports and imports in product i divided by twice the production of industry i.[5]

Data

Our study sample is an unbalanced country-industry panel dataset of 3,625 observations. It covers 14 countries: Australia, Austria, Czech Republic, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Spain, Sweden, the United Kingdom and the United States for 18 manufacturing, network and service industries from 1988 to 2007.[6] Six industries (almost) do not invest in R&D and are excluded from the R&D intensity estimation sample; our estimation results are robust when the estimation sample include these industries, (see Appendix 2). Our study sample is reduced to 3,200 observations from 1988 to 2005 when we use data on wages by skill. Detailed descriptive analysis of data are presented on web supplementary material.

To estimate relation (1) we need data on capital stocks and their user cost, on employment by skill level and a measure of EPL. We compute capital using the so-called permanent inventory method $X_{f,t} = \left(1 - \delta_f\right) \cdot X_{f,t-1} + I_{f,t-1}$, where I_f corresponds to the investment in factor f, using the EU-KLEMS investment data, OECD ANBERD R&D expenses and the following depreciation rates δ_f: non-residential structures, 5%; non-ICT equipment, 10%; ICT equipment, 20%; R&D, 25%. We compute the user-cost of capital according to Jorgenson (1963) formula: $C_{f,t} = P_{f,t-1} \cdot \left(\delta_f + \Delta \ln\left(P_{f,t}\right) + r_t\right)$, where P_f is the investment price of factor f and r the long-term interest rate.[7] We measure total employment as the number of persons employed, using the OECD STAN database, and EU-KLEMS data on hours worked for the share of employment by skill level.

Finally, our analysis uses the OECD EPL indicator, which is the most frequently used in the empirical literature on the impacts of labour market regulations on capital intensity, productivity and growth. Based on detailed information on laws, rules and market settings, this indicator measures the procedures and cost involved in dismissing individual workers with regular contracts and regulations on temporary contracts, including regulations on fixed-term and temporary work agency contracts. The scale of the OECD EPL indicator is 0-6, with 0 for the most flexible country labour market (see OECD Employment Outlook 2013 for more information). The OECD EPL indicator experienced large decreases over our sample period in some previously highly-regulated countries (see the supplementary web material).

Main Results

Table 1 gives the main relation (1) estimate results. The estimated elasticities of capital intensity with respect to its unit user cost of production factor f relative to wage are always negative, as expected, and significant. These elasticities are quite similar for the different capital components, within the interval -0.61 (for non-ICT equipment, column (2)) to -0.37 (for construction, column (3)). The

*5. As we introduced industry and country*year fixed effects in the estimated specifications, we do not add to these specifications each of the interacted variables (λ_i, $Openess_i$ and EPL_{ct}) separately. Data on industry labour share over production (λ) and on openness to external trade (Openess) are available over time and country and these variables may have an interesting impact on capital and skill composition. However, these two country*industry*year variables may be strongly endogeneous, because of omission bias but also of reverse causality, as capital and skills may influence compensation and trade. Therefore, we only use the average US values in order to prevent from endogeneity bias and estimate the differential impact of EPL.*

6. These industries are (ISIC Rev. 3 codes in brackets): food products (15-16), textiles (17-19), wood products (20), paper (21-22), chemicals products (23-25), non-metallic mineral products (26), metal products (27-28), machinery not elsewhere classified (29), electrical equipment (30-33), transport equipment (34-35), manufacturing not elsewhere classified (36-37), energy* (40-41), construction* (45), retail distribution*(50-52), hotels & restaurants* (55), transport & communication (60-64), banking services* (65-67) and professional services (72-74). The six industries with a "*" almost do not invest in R&D.*

7. Investment prices are from EU-KLEMS, but in order to improve comparability we have assumed, as suggested by Schreyer (2000), and as we have done in numerous studies, that for ICT investments in hardware, software and telecommunications equipment the ratio of investment prices to the GDP prices is the same for all countries as for in the USA, since the USA is the country that uses most systematically hedonic methods during the study period. Because of the lack of specific price information for R&D, we have used as a proxy the manufacturing production deflator.

corresponding elasticities are lower (in absolute value) for the two skill components of employment: -0.23 (high-skilled, column (6)) and -0.21 (low-skilled, column (7)). In other words, the price sensitivity is higher for capital intensity than for the share of employment by skill.

The estimated coefficients of the differential impacts of EPL differ among factors and have the expected signs. Concerning non-ICT non R&D equipment and constructions (columns (2) and (3)) they are positive and significant, respectively 0.17 and 0.12 (only at a level of confidence for constructions). Concerning the two high-quality capital components they are negative, non-significant for ICT (column (4)), and very significant and high for R&D: -1.10 (column (5)). These results suggest that the impact of labour regulations on the non-ICT and non-R&D capital-to-labour ratio is qualitatively similar to that of a change in the labour cost. More importantly, they suggest that labour regulations have a detrimental impact on capital quality, i.e. the share of R&D and ICT in total capital, in industries using labour intensively relatively to the other industries. Investment in high-quality capital is more risky in terms of results than investment in lower quality capital, and firms would take this risk less often as their labour force adaptability decrease. These results are consistent with those of Conti and Sulis (2016) and of Bartelsman *et al.* (2016), which suggest a detrimental impact of EPL on high-technology adoption and on growth of high-risk industries, respectively.[8]

It is noteworthy to stress that the estimated coefficient of the impact of EPL on total capital elasticity is positive but small and non-significant (column (1)). This elasticity is consistent with those obtained for the different capital components, which implies that it could be positive or negative, depending on the share of high-quality capital components (ICT and R&D) in total capital. These results are original and more detailed than the previous empirical ones from Autor *et al.* (2007) or Cingano *et al.* (2010) and (2014) who find positive or negative impacts of EPL on the capital-to-labour ratio. This divergence in our estimates and theirs may reflect differences in the capital share of high-quality capital components in their estimation samples.

The estimated coefficients of the impact of EPL also differ for the two shares of employment skill levels: positive and significant of 0.35 for the share of high-skilled employment (column (6)) and negative and significant of -0.22 for that of low-skilled employment (column (7)). This suggests that labour regulations are particularly detrimental to low-skilled employment, which is an interesting and original paradox as one of the main goals of labour regulations is usually to protect low-skilled workers. These regulations seem to frighten employers, who consider that they lead to an increase in labour costs with a negative impact on low-skilled employment. The positive impact on the share of high-skilled employment supports the idea of Janiak and Wasmer (2014) that stronger labour regulations impact positively the capital-to-labour

8. To illustrate the consequences of these results in terms of Total Factor Productivity (TFP), we may use a growth accounting analysis. We still assume a Cobb-Douglas production function and calibrate the value added elasticity vis-à-vis the production factors by the average factor cost shares in total cost in 2005 (these values are: 10.5% for non-ICT equipments, 5.2% for constructions, 2.6% for ICT capital and also 2.6% for R&D capital). According to this calibration and Table 1 estimation results, a one unit increase of "EPL impact" would induce a 0.6% reduction of TFP through capital composition. Note that in the presence of strong positive R&D and/or ICT externalities, this negative impact on TFP would be much higher.

Tableau 1
EPL Impact on Capital and Skill Composition, Depending on Labor Intensity of Use

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dep. Var.	Total Cap. Intensity (log)	Capital intensity (log)				Employment share (log)	
		Non-ICT	Cons.	ICT	R&D	High-skilled	Low-skilled
Relative cost ($c_f - w$)	-0.449*** [0.0310]	-0.606*** [0.0400]	-0.369*** [0.0432]	-0.477*** [0.0226]	-0.474*** [0.144]	-0.233*** [0.0537]	-0.212*** [0.0317]
EPL impact (λ_i·EPL)	0.0474 [0.0557]	0.176*** [0.0595]	0.122* [0.0642]	-0.0738 [0.0914]	-1.106*** [0.249]	0.347*** [0.0682]	-0.219*** [0.0428]
Observations	3,625	3,625	3,625	3,625	2,537	3,200	3,200
R-squared	0.799	0.751	0.662	0.942	0.684	0.792	0.900
rmse	0.0965	0.104	0.112	0.159	0.273	0.111	0.0685

Included fixed effects: country, industry, year, country*industry and country*year. Robust standard errors in brackets: *** p<0.01, ** p<0.05, * p<0.1.
Sources: OECD ANBERD, EPL and STAN databases; EUKLEMS database; authors' calculations.

ratio and, due to the complementarity between capital and high-skilled workers, the share of these high-skilled workers in total employment. Our results, however, are more detailed. Higher labour regulations have no clear impact on the ICT capital-to-labour ratio and a negative and large one on the R&D capital-to-labour ratio.

We have carried out a number of robustness checks which are presented in Appendix 2. The elasticities of substitution between factors may be significantly biased because of the difficulties of measuring well the corresponding user costs variables and may be very sensitive to our choice of measuring the intensity of use of labour by the 2000 USA industry labour share over production. When we constrain the elasticities of substitution between factors to be all equal to one, which is the extreme case of an underlying Cobb-Douglas production function, the EPL impact elasticity estimates β_f on capital intensity and on labour shares by skill do not appear qualitatively different from those of Table 1, as can be seen in Table A2-1. When we multiply EPL by a binary indicator of industry layoff propensity, rather than by the labour intensity, the qualitative differences between the EPL impact elasticity estimates β_f remain mostly confirmed, as recorded in Table A2-2. Our conclusions on the differential EPL impact elasticities are also not affected when we slightly modify the contours of our study sample as shown in Tables A2-3 and A2-4.

As we already stressed, there are certainly complementarities between the production factors, but we do not investigate the impact of each factor on the others because of the endogeneity issue that this would induce. Table 1 estimates thus correspond to a reduced form model of the impact of EPL. In other words, the estimated effect of EPL on a production factor may correspond to a direct impact on this specific factor demand and/or to an indirect impact coming through the impact of EPL on another complementary factor. Appendix 3 presents an attempt to take into account such production factor complementarity.

To take into account that international competition may require a higher capacity for adaptation from firms and industries, Table 2 presents in a similar format as Table 1 our estimation results of relation (2), which includes the interaction of EPL and the US industry trade openness indicator in relation (1). We see that the impact of EPL is changed in an interesting way. The higher the exposure to external trade, the higher EPL impact is detrimental to ICT intensity, with now a statisticaly significant coefficient. The negative impact of EPL on R&D intensity is unchanged, whereas the positive effects on construction and non-ICT equipment appear smaller with trade openness, reducing only slightly the differential impact of EPL on R&D capital relatively to non-ICT non-R&D capital. It appears also that the positive impact of EPL on the share of high-skilled workers and the negative impact on the share of low-skill workers are slightly smaller with trade openness. These last results may be explained by the complementarity of skills with ICT capital (as investigated in Appendix 3). Indeed, ICT implementation requires skilled workers, so by reducing ICT investment EPL reduces also the

Tableau 2
EPL Impact Depending on Labor Intensity of Use and Trade Openness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dep. Var.	Total Cap. Intensity (log)	Capital intensity (log)				Employment share (log)	
		Non-ICT	Cons.	ICT	R&D	High-skilled	Low-skilled
Relative cost ($c_f - w$)	-0.441*** [0.0308]	-0.587*** [0.0403]	-0.350*** [0.0435]	-0.475*** [0.0226]	-0.460*** [0.146]	-0.227*** [0.0536]	-0.202*** [0.0318]
EPL impact ($\lambda_i \cdot$EPL)	-0.00771 [0.0560]	0.142** [0.0601]	0.0885 [0.0648]	-0.118 [0.0923]	-1.096*** [0.250]	0.315*** [0.0689]	-0.199*** [0.0431]
EPLxOpenness ($\text{Openess}_i \cdot$EPL)	-0.110*** [0.0170]	-0.0662*** [0.0184]	-0.0662*** [0.0199]	-0.0908*** [0.0281]	-0.0374 [0.0583]	-0.0659*** [0.0210]	0.0476*** [0.0129]
Observations	3,625	3,625	3,625	3,625	2,537	3,200	3,200
R-squared	0.801	0.752	0.664	0.942	0.684	0.793	0.901
rmse	0.0959	0.103	0.112	0.159	0.273	0.111	0.0683

Included fixed effects: country, industry, year, country*industry and country*year. Robust standard errors in brackets: *** p<0.01, ** p<0.05, * p<0.1.
Sources: OECD ANBERD, EPL and STAN databases; EUKLEMS database; authors' calculations.

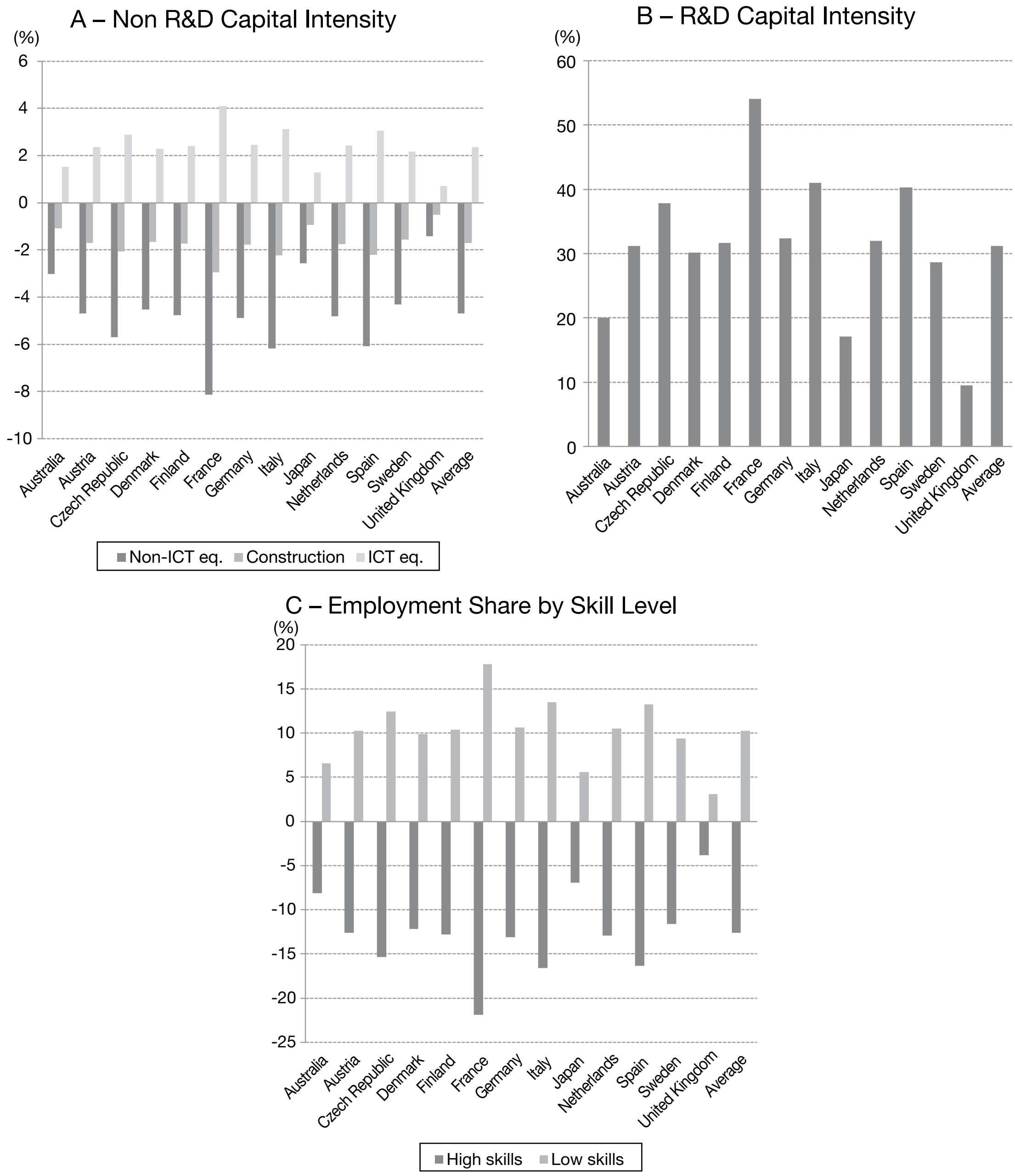
demand for skilled workers in industries with high trade openness.

Simulation

To illustrate the meaning and potential implication of our results, we simulate what could be the impact of having for all countries in our study sample the same EPL than in the USA in 2013. The USA is the country with the lightest level of regulation according to the OECD EPL indicator and 2013 is the most recent year the EPL indicator was available to us. The adoption of USA EPL level would require very large scale structural reforms of labour markets in several countries, in particular France and Italy. The implementation of such drastic reforms would be very difficult and cannot be considered politically or socially desirable realistic.

The potential impacts of adopting the USA EPL are calculated at the industry level using our main estimates (given in Table 1) and then

Figure I
Long-Term Impact of Adopting the USA EPL



Sources: OECD ANBERD, EPL and STAN databases; EUKLEMS database; authors' calculations.

aggregated at the country level using the 2000 USA industry shares in the whole economy for each production factor.[9] The country level impacts thus depend, for each factor, on the corresponding EPL gaps with the US. They can be viewed as long-term impacts, after dynamic adjustments which are not specified and simulated. The results of our simulation are shown in Figures I-A, B and C. They are the following:

- Overall the impacts are always the largest in France, followed by Italy, Spain and the Czech Republic, which are the four countries with the highest EPL level. They are always the smallest in the UK, the least regulated country after the USA;

- The capital-labour ratio would decrease from 1.4% to 8.1% for non-ICT equipment and from 0.5% to 3.0% for construction (Figure I-A). Conversely, it would increase from 0.7% to 4.1% for ICTs (Figure I-A) and from 9.5% to 54.1% for R&D (Figure I-B). This large impact for R&D must be related to the fact that R&D only accounts on average for 9.7% of the capital stock in industries where R&D capital is not negligible, and 7.1% in all industries;

- The labour shares increase from 3.1% to 17.8% for low-skilled employment and decrease from 3.8% to 21.9% for high-skilled employment (Figure I-C).

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The main results of our difference-in-difference approach using a large and original unbalanced country-industry panel dataset can be summarized as follows: 1) non-ICT and non-R&D capital intensity increases overall with EPL; 2) ICT capital intensity is not significantly impacted by EPL; 3) R&D capital intensity decreases with EPL; and 4) the share for high-skilled workers in total employment increases with EPL, while it decreases for low-skilled workers; 5) the higher the exposition to international trade openness, the more EPL is detrimental on non-R&D capital intensities; 6) the positive impact of EPL on the share of high-skilled workers diminishes with trade openness. These results support overall the fact that firms consider an increase in EPL to be a rise in labour costs, which implies a capital-to-labour substitution impact hindering sophisticated technologies and detrimental to unskilled workers.

The finding that labour regulations are particularly detrimental to low-skilled employment, is an interesting paradox, since one of the main goals of labour regulations is to protect low-skilled workers. These regulations seem to frighten employers, who tend to see them as a labour cost increase, which explains their negative impact on low-skilled employment. It support the idea by Janiak and Wasmer (2014) that higher labour regulations increase the capital-to-labour ratio and, due to the complementarity between capital and high-skilled workers, the share of the latter in total employment. But our results provide more details about this channel: this added capital is not the most sophisticated one, from higher labour regulations, the ICT capital to labour ratio does not significantly change and the R&D capital to labour ratio even decreases hugely.

From these results, the proposed simulations suggest that structural reforms that reduce EPL could have a favorable impact on R&D investment and would be helpful for unskilled employment. The simulated impact of a decrease in EPL to the US level appears large for several countries. But this decrease in EPL would require a very ambitious reform plan in these countries, and the simulated impact is a long-term one. This confirms that the potential gains from the implementation of ambitious labour market plans could be sizeable. ☐

9. To compute these effects from our difference-in-difference approach, we assume that EPL changes would have no impact on industries with employment close to 0.

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APPENDIX 1

INVESTIGATING THE IMPACT OF LABOUR PROTECTION LEGISLATION ON TOTAL AND ICT CAPITAL: COMPLEMENTARY LITERATURE REVIEW

Several papers investigate the impact of labour regulations on a few production factors, although not on variety of them. This appendix presents briefly this literature.

The empirical literature on the impact of labour market regulations on total capital intensity provides different results. Author *et al.* (2007) use a large US establishment-level dataset (of more than 120,000 observations) and show that the adoption of unfair-dismissal protection by state courts in the US from 1970 to 1999 reduced employment flows and firm entry rates, reduced TFP and increased the capital-to-labour ratio and labour productivity. Their interpretation of these results is that an increase in employment protection corresponds to an increase in labour adjustment costs. Higher labour adjustment costs result in a decrease in TFP as well as an increase in the capital-to-labour. This capital deepening effect dominates the TFP effect and so labour productivity increases. Cingano *et al.* (2014) use a large Italian firm-level dataset (of more than 25,000 observations) and show that the implementation, in 1990, of a reform that introduced unfair-dismissal costs for firms below 15 employees had increased in these firms the capital-to-labour ratio, particularly in labour-intensive firms. But in a previous study carried out using a large panel of European firms, Cingano *et al.* (2010) had found a negative impact of EPL on the capital-to-labour ratio, and Calcagnini *et al.* (2014) also found a negative empirical relation between EPL and investment dynamics using a small European firm-level dataset (2,600 firms in 10 European countries). For Cingano *et al.* (2014), these differences in the results of their two studies *"may be reconciled by adopting the view, proposed by Janiak and Wasmer (2014)"*. Indeed, Janiak and Wasmer (2014) observe at the country level an inverted U-shape relationship between employment protection legislation, measured by the usual OECD indicator of EPL , and the capital-to labour ratio. Their interpretation, using a theoretical model, is that two opposite effects are at play: a higher EPL decreases profits and consequently investment, explaining the negative correlation between EPL and capital intensity, but it also has a positive effect on human capital accumulation which is complementary to capital, explaining the positive correlation. The last effect dominates at low level of EPL and the first effect at high level of EPL. This interpretation based on complementarity is supported by Cingano *et al.* (2014): according to their estimation results, the adoption of unfair-dismissal protection had increased the share of high-tenured workers with high-specific human capital who are likely to be complementary with capital investments. These various results underline the importance of investigating simultaneously capital intensity and workers' skill composition. But in modern economies, capital quality is also essential.

Cette and Lopez (2012) propose a survey of the literature on the influence of labour market regulations on capital quality in terms of ICT or the share ICT in the capital stock. Their estimates using a country panel dataset show that labour regulations, measured by the usual EPL indicator, have a negative impact on ICT and on the share of ICT in capital, like previous studies (among others, see Aghion *et al.*, 2009, or Guerrieri *et al.,* 2011). They also show the favorable impact on ICT diffusion of post-secondary education among the working age population and the detrimental impact of product market rigidities. These results suggest that an efficient use of ICT requires a higher degree of skilled labour than in other technologies and firm reorganisations which can be constrained by strict labour market regulations.

To our knowledge, there are no studies focusing on the impact of labour market regulations on R&D spending. But some previous papers deal with the similar topic of the impact of labour market regulations on innovation measured by the patenting behavior. Griffith and Macartney (2014) give a survey of this literature and show, from an original large dataset of big European firms, that EPL has two types of effect on innovation: a higher EPL increases job security and hence worker investment in innovative activity but, at the same time, it reduces investment in activities that are likely to require adjustment, including technologically advanced innovation.

APPENDIX 2

SENSITIVITY ANALYSIS

This appendix presents the different robustness checks that we have been able to carry out.

First of all, all the estimated coefficients of relative cost differ significantly from the Cobb-Douglas unitary elasticity, which suggests that our unconstrained specification is preferable. We cannot exclude the fact that estimates of relative cost elasticities lower than one (in absolute value) could partly reflect the impact of relative cost measurement errors. Therefore, we also estimate relation (1) with an elasticity of substitution equal to -1 and the estimated coefficients of impact of EPL are robust to this constraint, as shown in Table A2-1. The only change is that the impact of EPL coefficient for low-skilled employment becomes non-significant (column (7)) but as the coefficient remains positive and significant for high-skilled employment (column (6)), a rise in the impact of EPL still increases the share of high-skilled labour relative to low-skilled employment.

Tableau A2-1
Relation (1) Estimate Results When the Elasticity of Substitution Parameters are Constrained to -1

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Factor	Total Cap.	Non-ICT eq.	Cons.	ICT	R&D	High-skilled	Low-skilled
Relative cost ($c_f - w$)	-1 [0]	-1 [0]	-1 [0]	-1 [0]	-1 [0]	-1 [0]	-1 [0]
EPL impact ($\lambda_i \cdot$EPL)	0.157*** [0.0580]	0.209*** [0.0603]	0.176*** [0.0662]	0.0453 [0.0987]	-1.061*** [0.250]	0.268*** [0.0705]	0.0115 [0.0462]
Observations	3,625	3,625	3,625	3,625	2,537	3,200	3,200
R-squared	0.122	0.146	0.141	0.175	0.125	0.266	0.204
rmse	0.101	0.105	0.115	0.172	0.274	0.115	0.0757

Included fixed effects: country, industry, year, country*industry and country*year. Robust standard errors in brackets: *** p<0.01, ** p<0.05, * p<0.1.
Sources: OECD ANBERD, EPL and STAN databases; EUKLEMS database; authors' calculations.

Another question relates to the measure of the industry-specific characteristic (λ_i), which is equal to the industry *i* labour share in the USA in 2000 for Table 1 estimates. Alternatively, we can also test whether EPL is more binding in industries which require more labour flexibility. As suggested by Bassanini and Duval (2006), we use the layoff propensity as an indicator of the labour flexibility need. This indicator appears to be quite volatile over time, and for this reason we measure the industry-specific characteristic (λ_i), by a simple fixed effect: λ_i = 1 in the half industries with the highest layoff propensity in the US in 2000 (textiles, wood products, non-metallic mineral products, metal products, machinery not elsewhere classified, electrical equipment, manufacturing not elsewhere classified, construction, transport & communication), and λ_i = 0 in other industries.

The estimate results appear robust to this choice, as shown in Table A2-2. The only changes are that the EPL impact coefficient becomes non-significant for construction (column (3)) and low-skilled (column (7)) but we retain the contrast between a positive and significant EPL impact coefficient for non-ICT equipment (column (2), a non-significant coefficient for ICT (column (4)) and a negative and significant coefficient for R&D (column (5)). We also find that a rise in the impact of EPL increases the share of high-skill labour (column (6)).

Finally, we investigate the estimation result sensitivity to our choices of estimation sample. Indeed, our main estimations use different estimation samples: industries almost not investing in R&D are excluded when estimating the R&D demand and data on years 2006 and 2007 are not available for the employment demand by skill. Tables A2-3 and A2-4 show the robustness of our estimation results to these sample choices.

Tableau A2-2
Relation (1) Estimate Results When the Industry Characteristic (λ_i) is the Layoff Propensity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Factor	Total Cap.	Non-ICT eq.	Cons.	ICT	R&D	High-skilled	Low-skilled
Relative cost ($c_f - w$)	-0.446*** [0.0308]	-0.604*** [0.0400]	-0.364*** [0.0432]	-0.476*** [0.0228]	-0.476*** [0.145]	-0.258*** [0.0537]	-0.247*** [0.0311]
EPL impact ($\lambda_i \cdot$EPL)	0.0220** [0.0105]	0.0329*** [0.0112]	-0.00369 [0.0121]	0.0128 [0.0174]	-0.0953** [0.0372]	0.0270** [0.0129]	-0.00367 [0.00795]
Observations	3,625	3,625	3,625	3,625	2,537	3,200	3,200
R-squared	0.799	0.751	0.662	0.942	0.682	0.791	0.899
rmse	0.0965	0.104	0.112	0.159	0.274	0.112	0.0688

Included fixed effects: country, industry, year, country*industry and country*year. Robust standard errors in brackets: *** p<0.01, ** p<0.05, * p<0.1. The industry characteristic λ_i equal 1 for industries with high layoff propensities (ISIC code Rev. 3: 17-19, 20, 26, 27-28, 29, 30-33, 36-37, 45, 60-64) and 0 otherwise.
Sources: OECD ANBERD, EPL and STAN databases; EUKLEMS database; authors' calculations.

Tableau A2-3
Relation (1) Estimate Results for R&D Intensity When all Industries are Included in the Sample

	(1)	(2)
Factor	R&D	
Sample	R&D industries	All industries
Relative cost ($c_f - w$)	-0.474*** [0.144]	-0.761*** [0.143]
EPL impact (λ_i·EPL)	-1.106*** [0.249]	-1.956*** [0.215]
Observations	2,537	3,555
R-squared	0.684	0.562
rmse	0.273	0.363

Included fixed effects: country, industry, year, country*industry and country*year. Robust standard errors in brackets: *** p<0.01, ** p<0.05, * p<0.1.
Sources: OECD ANBERD, EPL and STAN databases; EUKLEMS database; authors' calculations.

Tableau A2-4
Relation (1) Estimate Results When the Estimation Samples is Reduced to Data available on Skills

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Factor	Total Cap.	Non-ICT eq.	Cons.	ICT	R&D	High-skilled	Low-skilled
Relative cost ($c_f - w$)	-0.457*** [0.0331]	-0.586*** [0.0424]	-0.364*** [0.0445]	-0.438*** [0.0237]	-0.402*** [0.149]	-0.233*** [0.0537]	-0.212*** [0.0317]
EPL impact (λ_i·EPL)	0.0363 [0.0559]	0.180*** [0.0605]	0.0657 [0.0636]	-0.103 [0.0938]	-1.019*** [0.247]	0.347*** [0.0682]	-0.219*** [0.0428]
Observations	3,200	3,200	3,200	3,200	2,247	3,200	3,200
R-squared	0.801	0.748	0.685	0.940	0.681	0.792	0.900
rmse	0.0910	0.0990	0.104	0.154	0.256	0.111	0.0685

Included fixed effects: country, industry, year, country*industry and country*year. Robust standard errors in brackets: *** p<0.01, ** p<0.05, * p<0.1.
Sources: OECD ANBERD, EPL and STAN databases; EUKLEMS database; authors' calculations.

APPENDIX 3

FACTOR COMPLEMENTARITY

Our main specifications does not take into account production factors complementarity, thus we are not able to disentangle the direct effect of EPL on a production factor from the indirect effect on this factor caused by changes in other complementary factors. We consider this issue in this Appendix.

All factors may have some degree of complementarity, but because of multicollinearity we investigate only the complementarity of production factors with respectively High-skill employment and ICT diffusion. High-skill employment may be an important factor of ICT diffusion as well as R&D expenses and ICT investment may change significantly the organization of the production process. Table A3-1 and A3-2 presents the estimations results. The estimated coefficient of EPL-impact are robust to the inclusion of these explanatory variables. We find a positive and equivalent relation of High-skill employment share and ICT capital intensity with every capital intensity, except a much more stronger relation between High-Skill employment share and R&D. However, it is important to note that because of High-skill employment and ICT capital intensity endogeneity these estimates are biased. In other words, taking into account of the production factor complementarity in order to distinguish between the direct and indirect effects of EPL on each production factors would require to estimate a simultaneous equation model with endogenous explanatory variables, which is beyond what we can do with our data. Indeed, it would require not only to find exogenous instruments for each production factor but also strong instruments which in particular will not suffer too much from multicollinearity with relatively low time dimension and variability.

Tableau A3-1
Relation (1) Estimate Results Introducing High skilled Employment Share as Explanatory Variable

	(1)	(2)	(3)	(4)	(5)
Factor	Total Cap.	Non-ICT	Cons.	ICT	R&D
Relative cost ($c_f - w$)	-0.445*** [0.0329]	-0.572*** [0.0419]	-0.355*** [0.0444]	-0.431*** [0.0237]	-0.391*** [0.147]
High skilled emp. share	0.108*** [0.0153]	0.140*** [0.0166]	0.0848*** [0.0176]	0.108*** [0.0261]	0.498*** [0.0594]
EPL impact (λ_i·EPL)	-0.00590 [0.0557]	0.127** [0.0601]	0.0335 [0.0637]	-0.144 [0.0941]	-1.227*** [0.244]
Observations	3,200	3,200	3,200	3,200	2,247
R-squared	0.804	0.755	0.688	0.940	0.693
rmse	0.0902	0.0977	0.104	0.153	0.251

Included fixed effects: country, industry, year, country*industry and country*year. Robust standard errors in brackets: *** p<0.01, ** p<0.05, * p<0.1.
Sources: OECD ANBERD, EPL and STAN databases; EUKLEMS database; authors' calculations.

Tableau A3-2
Relation (1) Estimate Results Introducing ICT Capital Intensity as Explanatory Variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Factor	Total Cap.	Non-ICT eq.	Cons.	ICT	R&D	High-skilled	Low-skilled
Relative cost ($c_f - w$)	-0.428*** [0.0272]	-0.414*** [0.0362]	-0.261*** [0.0427]	-0.477*** [0.0226]	-0.272* [0.149]	-0.211*** [0.0537]	-0.209*** [0.0317]
ICT capital intensity	0.273*** [0.00885]	0.283*** [0.00980]	0.159*** [0.0115]		0.198*** [0.0395]	0.0636*** [0.0130]	-0.0227*** [0.00798]
EPL impact (λ_i·EPL)	0.0931* [0.0489]	0.211*** [0.0529]	0.142** [0.0623]	-0.0738 [0.0914]	-1.173*** [0.248]	0.361*** [0.0680]	-0.224*** [0.0428]
Observations	3,625	3,625	3,625	3,625	2,537	3,200	3,200
R-squared	0.845	0.803	0.682	0.942	0.688	0.794	0.901
rmse	0.0847	0.0921	0.108	0.159	0.272	0.111	0.0684

Included fixed effects: country, industry, year, country*industry and country*year. Robust standard errors in brackets: *** p<0.01, ** p<0.05, * p<0.1.
Sources: OECD ANBERD, EPL and STAN databases; EUKLEMS database; authors' calculations.

SURE ESTIMATIONS

Table A4 presents SURE estimates in order to discuss the interdependence between production factors. The SURE estimator allows taking into account of the correlation of the residuals across equations, thus increasing the efficiency of our estimates. The covariance matrix of residuals of the SURE estimation shows that physical capital intensities are strongly correlated, confirming Table A3-2 estimation results. More importantly, the estimated coefficients of EPL-impact are robust to this sensitivity analysis.

Tableau A4
Relation (1) Estimate Using the SURE Estimation Method

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Capital intensity (log)				Employment share (log)	
	Non-ICT eq.	Cons.	ICT	R&D	High-skilled	Low-skilled
Relative cost ($c_f - w$)	-0.512*** [0.0340]	-0.303*** [0.0393]	-0.442*** [0.0191]	-0.212** [0.0861]	-0.147*** [0.0449]	-0.175*** [0.0264]
EPL impact ($\lambda_i \cdot$EPL)	0.172*** [0.0562]	0.0871 [0.0598]	-0.0850 [0.0864]	-0.518*** [0.127]	0.329*** [0.0593]	-0.206*** [0.0373]
Observations	3,625	3,625	3,625	2,537	3,200	3,200
Log-likelihood	17,072					
Correlation matrix of residuals						
Non-ICT eq.	1					
Cons.	0.52	1				
ICT	0.48	0.28	1			
R&D	0.07	0.12	0.09	1		
High-skilled	0.15	0.08	0.07	0.12	1	
Low-skilled	-0.09	-0.08	-0.03	0.02	-0.09	1

Included fixed effects: country, industry, year, country*industry and country*year. Robust standard errors in brackets: *** p<0.01, ** p<0.05, * p<0.1.
Sources: OECD ANBERD, EPL and STAN databases; EUKLEMS database; authors' calculations.