NBER WORKING PAPER SERIES

LABOUR MARKET REGULATIONS AND CAPITAL INTENSITY

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Working Paper 22603
http://www.nber.org/papers/w22603

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 2016

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NBER Working Paper No. 22603
September 2016
JEL No. C23,E22,E24,L50,O30,O43,O47

ABSTRACT

On the basis of a country*industry unbalanced panel data sample for 14 OECD countries and 18 industries covering the years 1988 to 2007, this study proposes an econometric investigation of the effects of the OECD Employment Protection Legislation (EPL) indicator on capital intensity for four capital components, and on the share of employment for two skill components. Our results relying on a difference-in-difference approach are the following: i) positive and significant effects for non-ICT physical capital intensity and the share of high-skilled employment; ii) non-significant effects for ICT capital intensity; and (iii) negative and significant effects for R&D capital intensity and the share of low-skilled employment. These results suggest that firms consider that the strengthening of Employment Protection Legislation is equivalent to a rise in the cost of labor, resulting in capital-to-labor substitution in favor of non-ICT capital and working at the disadvantage of low-skill relatively to high-skill workers. They indicate to the contrary that structural reforms for more labor flexibility weakening this legislation could have a favorable impact on firms' R&D investment and their hiring of low-skill workers.

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1. Introduction

Numerous papers have been devoted to exploring the impact of labour market regulations on innovation and productivity (see among others: Acharya, Baghai and Subramanian, 2013; Bassanini, Nunziata and Venn, 2009; Cette, Lopez and Mairesse, 2016; Conti and Sulis, 2016; Griffith and Macartney, 2014; Micco and Pages, 2006). They usually find a detrimental impact of regulations on patents, TFP level or TFP growth. Fewer papers have been devoted to exploring the impact of labour regulations on the combination of production factors, although the latter are essential for anticipating the many effects of labour market reforms. Some of these papers investigate the impact of labour regulations on total capital intensity, i.e. the total capital-to-labour ratio, yielding opposite results (see Autor *et al.* 2007, Calgagnini *et al.* 2014, Cingano *et al.* 2010 and 2014, Janiak and Wasmer 2014).[1] Other papers investigate the impact on capital quality in terms of ICT intensity, showing a negative impact of EPL on ICT intensity (see, for instance, Aghion *et al.* 2009, Cette and Lopez 2012, Guerrieri *et al.* 2011).[2] Most of these papers show complementarities between capital accumulation and skills, but none investigates all the different effects of labour regulations on the combination of production factors.

The originality of our paper is to study the effects of labour market regulations on capital intensity, capital quality and the share of employment by skill level using a symmetric approach for each factor using a single original large database: a country-industry panel dataset of 14 OECD countries, 18 manufacturing and market service industries, over the 20 years from 1988 to 2007. Another original contribution is the use of a difference-in-difference approach: we investigate whether the impact of EPL is growing with the intensity of use of labour input (Cette, Lopez and Mairesse, 2016, uses a similar approach to estimate the impact of labour and product market regulations on productivity). Our main estimation results show an EPL effect: i) positive for non-ICT physical capital intensity and the share of high-skilled employment; ii) non-significant for ICT capital intensity; and (iii) negative for R&D capital intensity and the share of low-skilled employment. These results suggest that an increase in EPL would be considered by firms to be a rise in the cost of labour, with a physical capital to labour substitution impact in favour of more non-sophisticated technologies and would be particularly detrimental to unskilled workers. Moreover, it confirms that R&D activities require labour flexibility. According to simulations based on these results, structural reforms that lowered EPL to the "lightest practice", i.e. to the US EPL level, would have a favourable impact on R&D capital intensity and would be helpful for unskilled employment (30% and 10% increases on average, respectively).

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1 Autor *et al.* (2007) show that the adoption of wrongful-discharge protection by state courts in the US from 1970 to 1999 increased the capital-to-labour ratio and Cingano *et al.* (2014) show that the implementation in Italy in 1990 of a reform that introduced unjust-dismissal costs for firms below 15 employees had increased in these firms the capital-to-labour ratio. But using a panel of European firms, Cingano *et al*. (2010) and Calcagnini *et al.* (2014) had found a negative impact of EPL on the capital-to-labour ratio and on investment dynamics respectively. These results may be reconciled by idea of Janiak and Wasmer (2014) of an inverted U-shape relationship between the employment protection legislation and the capital-to-labour ratio: at a low (high) EPL level, a positive (negative) correlation appears between EPL and capital intensity.

2 To our knowledge, there are no studies focusing on the impact of labour market regulations on R&D spending, but some previous papers have dealt with the similar topic of the impact of labour market regulations on patenting behavior. Griffith and Macartney (2014) give a survey of this literature and show an ambiguous relationship between EPL and innovation.

The paper proceeds as follows: Section 2 presents a brief literature review, Section 3 and 4 give the model and data. Section 5 shows the main econometric results and Section 6 proposes, from these results, a simulation of the impact on capital intensity of structural reforms consisting in adopting the best labour regulation practices. Section 6 concludes.

2. Literature review

There are no papers on the impact of labour market regulations on all production factors, but there are a few papers that investigate the impact of labour regulations on some production factors. This section 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 physical 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 physical 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 investment 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 investment 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 favourable 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 behaviour. 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.

3. The model

The estimated specification of the impact of Employment Protection Legislation (EPL) on production factor combination is derived from firm maximisation, assuming perfect markets for products but not for labour, of the following profit function (individual and time indices are omitted in order to lighten the equations):

$$\pi = P.Q - \sum_f C_f X_f - \sum_{f \in \{H,M,L\}} \mu_f(X_f)$$

With π the firm profit, *P* the value added price, *Q* the value added quantity, C_f and X_f the unit user cost and quantity of production factor *f*. We distinguish seven different production factors *f*: ICT capital, R&D capital, non-ICT capital equipment (i.e. non-ICT and non-R&D equipment), non-residential capital construction, High (H), Medium (M) and Low (L) -skilled employment. μ_f is the adjustment cost of labour factor *f*, $f \in \{H, M, L\}$, growing with the level of employment.

We assume a Constant Elasticity of Substitution (CES) production function:

$$Q = A.\left[\sum_f \left(\theta_f^{1/s}.X_f^{\frac{s-1}{s}}\right)\right]^{\frac{s}{s-1}}$$

Where *A* is the disembodied technical change, *s* the elasticity of substitution and θ_f the factor share coefficient of production factor *f* (or factor *f* efficiency).

Therefore, the first order conditions of profit maximisation lead to:

$$\frac{C_f^*.X_f}{P.Q} = \theta_f.A^{s-1}.\left(\frac{C_f^*}{P}\right)^{-(s-1)} \Rightarrow \frac{X_f}{E} = \frac{\theta_f}{\theta_E}.\left(\frac{C_f^*}{W^*}\right)^{-s} \quad \forall f$$

With $C_f^* = C_f$ for the capital factors and $C_f^* = C_f + \frac{\partial \mu_f}{\partial X_f}$ for the labour factors, $\frac{\partial \mu_f}{\partial X_f}$ the marginal labour adjustment cost, $E = H + M + L$ total employment, θ_E the factor share coefficient of total employment and W^* the average labour cost per worker, taking into account of the marginal adjustment cost of labour.[3]

Beyond its impact on observed labour costs (C_f, $f \in \{H, M, L\}$, and W), EPL may influence the production factor combination through its impact on marginal labour adjustment costs ($\partial \mu_f / \partial X_f$) and labour organisation, thus affecting factor efficiency (θ_f). Concerning physical capital, we expect two different effects of EPL. Due to its influence on labour adjustment costs, an increase in EPL may have the same impact on physical capital intensity as an increase in the observed labour cost, thus EPL would have a positive impact on physical capital intensity (X_f / E). However, if the lack of labour flexibility reduces the relative factor efficiency of a capital factor (θ_f / θ_E), EPL would have a negative impact on capital intensity. This negative impact may be particularly large for ICT as it requires stronger labour reorganisation and flexibility. Therefore, we expect that the positive impact of EPL to dominate for non-ICT physical capital, whereas the impact on ICT is more ambiguous. Concerning the impact of EPL on R&D, it is important to note that: (i) R&D is more risky than the other investments, in terms of results, and requires higher labour flexibility; and (ii) R&D expenses are mainly labour costs, so the R&D user cost may increase in line with the labour cost. This last remark suggests that the positive impact of EPL on R&D intensity would be small. Thus, we expect that the impact of EPL on R&D intensity would be negative. Finally, the impact of EPL on the share of employment by skill level depends notably on the differences of EPL effects on labour adjustment costs. When a job is impacted by a negative productivity shock, the opportunity cost to remain in this job is lower for low-skilled workers as they suffer from the highest unemployment level. Hence, with strict EPL it would be particularly difficult for firms to adjust their low-skilled employment level in response to productivity shocks (i.e. the marginal labour adjustment cost would be high). As the ease to find another job increases with the skill level, the impact of EPL on the adjustment cost should decrease with the skill level, so we expect EPL to have a negative impact on the share of low-skilled employment and a positive impact on that of high-skilled employment.

In order to estimate these effects of EPL on capital intensities and employment shares, we assume linear relationships of EPL with the marginal labour adjustment cost ($\partial \mu_f / \partial X_f$) and factor efficiency (θ_f). Our main estimated specification (table 1) assumes also that: (i) the elasticity of substitution may differ between factors, which is consistent with various degrees of complementarity/substitutability between factors, notably a possible complementarity between high-skilled workers and capital;[4] and (ii) the

[3] Total employment E is introduced in order to take into account of industry sizes. It also makes it possible to focus on the capital available per worker and share of employment by skill level.

[4] The estimation results are robust to various constrained values of the elasticity of substitution, notably when $s = 1$, as it would be with a Cobb-Douglas production function specification.

impact of EPL depends on the intensity of use of labour, measured by the industry *i* labour share over production in the USA in 2000. Rearranging the terms of the equations, the estimated specifications are (with small letters for logarithms):

$$(x_f - l)_{cit} = \alpha_f - s_f.(c_f - w)_{cit} + \beta_f.\lambda_i.EPL_{ct} + \eta_{f,ci} + \eta_{f,ct} + \epsilon_{f,cit} \tag{1}$$

Where *c*, *i*, *t* are the country, industry and time indices, λ_i industry specific characteristics, EPL the OECD indicator of Employment Protection Legislation, $\eta_{f,ci}$ and $\eta_{f,ci}$ the fixed effects, and $\epsilon_{f,cit}$ the residual terms. The variable $\lambda_i.EPL_{ct}$ is called further EPL impact.

Relation (1) presents a difference-in-difference approach to estimate the effects of EPL. The introduction of several fixed effects, notably the country*year fixed effects, prevents various sources of endogeneity such as reverse causality and omission bias which could stem from governments modifying their EPL depending on the economic situation. This specification allows us to investigate whether the impact of EPL increases with the intensity of use of labour (the results are robust to another industry characteristic, see Appendix B). The above-mentioned EPL effect expectations result in the following values of the coefficient β_f: positive for the non-ICT capital intensities and the share of high-skilled employment, negative for the R&D intensity and the share of low-skilled employment and ambiguous for the ICT intensity. Of course, these expectations lead to an ambiguous impact of EPL on the total capital intensity.

4. Data

Our study sample is an unbalanced country-industry panel dataset of 3,625 observations from 1988 to 2007. 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) and 18 manufacturing, network and service industries.[5] Six industries (almost) do not invest in R&D and are excluded from the R&D intensity estimation sample (estimation results are robust when the estimation sample include these industries, see Appendix B). Appendix A presents the descriptive analysis of data.

Relation (1) estimations require data on capital stocks and their user cost, employment by skill level and a measure of EPL. We compute capital using the permanent inventory method $X_{f,t} = (1 - \delta_f).X_{f,t-1} + I_{f,t-1}$, where I_f corresponds to the investment in factor *f*, using the EU-KLEMS physical 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

[5] 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.

to the Jorgenson (1963) formula: $C_{f,t} = P_{f,t-1}.\left(\delta_f. + \Delta ln\left(P_{f,t}\right) + r_t\right)$, where P_f is the investment price of factor f and r the long-term interest rate.[6] 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. 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 (see OECD Employment Outlook 2013 for more information).

5. Main estimation results

Table 1 gives the main relation (1) estimate results.[7]

The estimated coefficients of relative cost are always negative, as expected, and significant. Concerning capital components, they are quite similar and within the interval -0.61 (for non-ICT equipment, column [2]) to -0.37 (for construction, column [3]), whereas they 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 level, maybe because of the significant inertia of human capital accumulation.

The estimated coefficients of *the* impact of EPL differ among factors and have the expected signs. Concerning non-ICT physical capital components (non-ICT equipment, column [2], and constructions, column [3]) they are positive and significant (but only at a 0.1 threshold for constructions). This means that, for these two components, more labour regulations increase the capital-to-labour ratio. This result suggests that the impact of labour regulations on the non-ICT physical capital-to-labour ratio is qualitatively similar to that of a change in the labour cost. Concerning the two high-quality capital components, the estimated coefficients of the impact of EPL is negative, non-significant for ICT (column [4]), and significant for R&D (column [5]), so labour regulations have a detrimental impact on high-quality capital components. 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 labour regulations increase. These results are consistent with those of Conti and Sulis (2016) which suggest a detrimental impact of EPL on high technology adoption.

The estimated coefficient of *the* impact of EPL on the total capital stock is positive but small and non-significant (column [1]). This estimated coefficient is consistent with those obtained on the different capital components, which means that this elasticity could be positive or negative, depending on the

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6 Physical investment prices are from EU-KLEMS, but in order to improve comparability we have assumed, as suggested by Shreyer (2000) and have done so after in numerous studies, that for the 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 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.

7 Table 1 does not show the estimation results for share of medium-skilled employment. We do not find any statistically significant impact of EPL on the share of medium-skilled employment, but this result is not meaningful as medium-skilled employment accounts for the majority of total employment.

share of high-quality capital components (ICT and R&D) in the 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) which find positive or negative impacts of EPL on the capitalto-labour ratio. This difference in results between this and previous studies may be explained by 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 for the share of high-skilled employment (column [6]) and negative for that of low-skilled employment (column [7]). This suggests that labour regulations are particularly detrimental to low-skilled employment, which is an interesting 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. From our knowledge of the literature, this result is also original. The positive impact on the share of high-skilled employment supports the idea of 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 these high-skilled workers in total employment. But our results give more detail on this channel: this added capital is not the most sophisticated one as, from higher labour regulations, the ICT capital-to-labour ratio does not significantly change and the R&D capital-to-labour ratio even decreases substantially.

TABLE 1 ABOUT HERE

Different robustness checks have been carried out and are presented in Appendix B. We first analyse the sensitivity of the estimation results to the two assumptions already mentioned for Table 1: (i) the elasticity of substitution may differ between factors, which is consistent with various degrees of complementarity/substitutability between factors; and (ii) the impact of EPL depends of the intensity of the use of labour. The estimation results are robust to different alternatives to these two assumptions. Indeed, when we constrain the elasticity of substitution to a same value, notably the Cobb-Douglas unitary elasticity, as presented in Table B1, or when we use other industry characteristics, for instance the industry layoff propensity suggested by Bassanini and Duval (2006), as presented in Table B2, the coefficients of *the* impact of EPL are similar to Table 1 estimates. The estimate results are also robust to various other sensitivity analyses: (i) the change of the employment measurement in the capital intensity ratio, using medium-skilled employment instead of total employment (see Table B3); (ii) various estimate samples (see Table B4 and B5); and (iii) the removal, in the dataset, of any country, any industry and any year. [8]

6. <u>Simulation</u>

To illustrate the meaning of our results, we compute from them and for all countries in our dataset the impact of the adoption of the US 2013 EPL level, the US being the country with the lightest level of regulation according to the OECD EPL indictor and 2013 being the last year the EPL indicator was available. The adoption of this US EPL level would require very largescale labour market structural reforms in some countries, such as France and Italy. So this simulation cannot be considered politically and socially realistic in a short time. But considering the favourable impact of labour market reforms on

[8] The corresponding estimate result Tables can be obtained on request to the authors.

productivity and growth (see numerous papers including Cette, Lopez and Mairesse, 2016) these reforms could be considered a long-term political goal.

The impact of structural reforms is calculated at the industry level using the main estimate results (given in Table 1) for our 18 sample industries, then these effects are aggregated at the national level using the 2000 US industry share in the whole economy for each factor. The country level impact depends, for each variable, on the EPL gap with the US. It corresponds to a long-term impact, after dynamic adjustments not evaluated here. The results of this simulation are the following:

- The impact is always the largest in France, followed by Italy, Spain and the Czech Republic; these four countries suffer from the highest EPL level. At the other end of the scale, it is always the smallest in the UK which appears to be the least regulated country after the US.
- 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 (Chart 1-A). Conversely, it would increase from 0.7% to 4.1% for ICTs (Chart 1-A) and from 9.5% to 54.1% for R&D (Chart 1-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 investment is not negligible, and 7.1% in all industries.
- The proportion of the share of low-skilled employment increases from 3.1% to 17.8% and the proportion of the share of high-skilled employment decreases from 3.8% to 21.9% (Chart 1-C).

7. Concluding remarks

The main results of our difference-in-difference approach using a large and original unbalanced country-industry panel dataset are that: i) non-ICT physical capital intensity increases overall with EPL; ii) ICT capital intensity is not significantly impacted by EPL; iii) R&D capital intensity decreases with EPL; and iv) the share of high- (low-) skilled workers in total employment increases (decreases) with EPL. These results support the fact that an increase in EPL would be considered by firms to be a rise in labour costs, with a capital-to-labour substitution impact in favour of more non-sophisticated technologies and would be particularly detrimental to unskilled workers.

It appears that labour regulations are particularly detrimental to low-skilled employment, which is an interesting paradox as one of the main goals of labour regulations is to protect low-skilled workers. These regulations seem to frighten employers, who see them as a labour cost increase with consequently a negative impact on low-skilled employment. From our knowledge of the literature, this result is original. It supports 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 favourable 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 programme 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 programmes could be sizeable.

REFERENCES

Acharya, Viral, Ramin Baghai and Krishnamurthy Subramanian (2013): “Labour Laws and Innovation”, The Journal of Law and Economics, 56 (4), pp. 997-1037

Aghion, Philippe, Philippe Askenazy, Renaud Bourlès, Gilbert Cette and Nicolas Dromel (2009): “Education, Market Rigidities and Growth”, Economics Letters, 102 (1), pp. 62-65.

Autor, David, William Kerr and Adriana Krukler (2007): “Does employment protection reduce productivity? Evidence from US States”, The Economic Journal, 117, June pp. F189-F217.

Bassanini, Andrea and Romain Duval (2006): “Employment Patterns in OECD Countries: Reassessing the role of Policies and Institutions”, OECD working Paper, DELSA/ELSA/WD/SEM(2006)4, 9 Jun.

Bassanini, Andrea, Luca Nunziata and Danielle Venn (2009): “Job protection legislation and productivity growth in OECD countries”, Economic Policy, 24 (4), pp. 349-402

Calcagnini, Giorgio, Annalisa Ferrondo and Germana Giombini (2014): “Does employment protection legislation affect firm investment? The European case”, Economic Modelling, 36, pp. 658-665.

Cette, Gilbert, and Jimmy Lopez (2012): “ICT demand behaviour: an international comparison.” *Economics of Innovation and New Technology* 21 (4), pp. 397-410.

Cette, Gilbert, Jimmy Lopez and Jacques Mairesse (2016): “Market Regulations, Prices, and Productivity”, American Economic Review, Papers & Proceedings 2016, 106(5), pp. 104–108.

Cingano, Federico, Marco Leonardi, Julian Messina and Giovanni Pica (2010): “The effect of employment protection legislation and financial market imperfections on investment: evidence from a firm-level panel of EU countries”, Economic Policy, vol. 25(61), pp. 117-163.

Cingano, Federico, Marco Leonardi, Julian Messina and Giovanni Pica (2014): “Employment protection legislation, capital investment and access to credit: Evidence from Italy”, The Economic Journal, early view.

Conti, Maurizio, and Giovanni Sulis (2016): “Human capital, employment protection and growth in Europe”, Journal of Comparative Economics, 44, pp. 213-230

Griffith, Rachel and Gareth Macartney (2014): “Employment protection legislation, multinational firms, and innovation”, The Review of Economics and Statistics, 96(1), March, pp. 135-150.

Guerrieri, Paolo, Matteo Luciani, and Valentina Meliciani (2011): “The determinants of investment in information and communication technologies”, Economics of Innovation and New Technology 20 (4), pp. 387-403.

Janiak, Alexandre and Etienne Wasmer (2014): “Employment protection and capital-labour ratios”, SciencesPo, LIEPP Working Paper, n° 33, July.

Jorgenson, Dale (1963) “Capital Theory and Investment Behavior,” American Economic Review, Vol. 53, No. 2, pp. 47-259.

Micco, Alejandro, and Carmen Pages (2006): “The Economic Effects of Employment Protection: Evidence from International Industry-Level Data”, IZA Discussion Papers 2433.

OECD (2013): “Employment Outlook”.

Schreyer, Paul (2000): “The Contribution of Information and Communication Technology to Output Growth: A Study on the G7 Countries”, OECD Science, Technology and Industry Working, Papers 2000/2, OECD.

TABLE and CHARTS

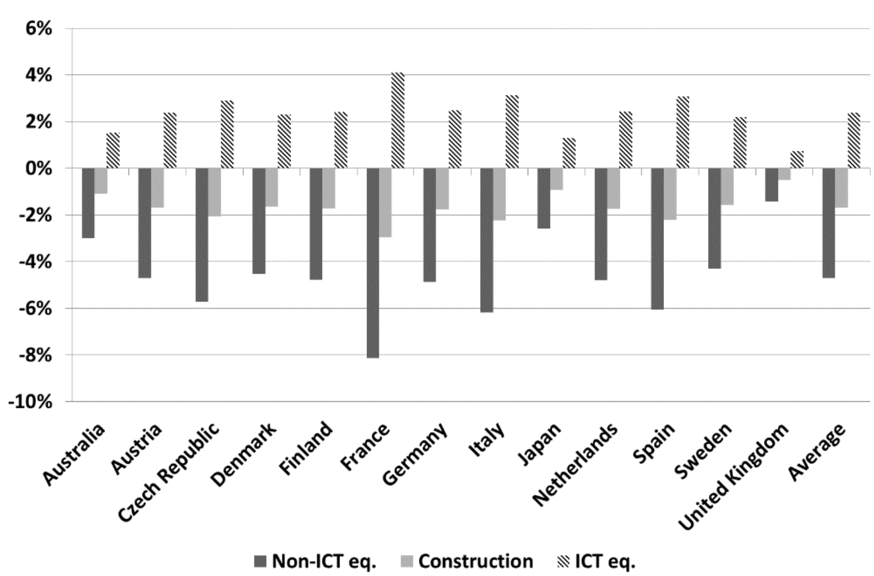
Table 1: EPL impact on capital intensity ($x_f - l$)

Factor	(1) Total Cap.	(2) Non-ICT	(3) Cons.	(4) ICT	(5) R&D	(6) High-skilled	(7) Low-skilled
Relative cost	-0.449***	-0.606***	-0.369***	-0.477***	-0.474***	-0.233***	-0.212***
($c_f - w$)	[0.0310]	[0.0400]	[0.0432]	[0.0226]	[0.144]	[0.0537]	[0.0317]
EPL impact	0.0474	0.176***	0.122*	-0.0738	-1.106***	0.347***	-0.219***
($\lambda_i.EPL$)	[0.0557]	[0.0595]	[0.0642]	[0.0914]	[0.249]	[0.0682]	[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

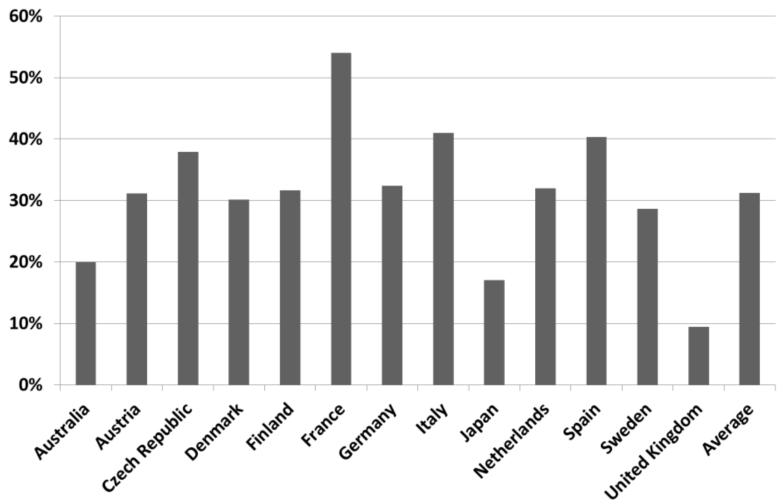
Included fixed effects: country, industry, year, country*industry and country*year.
Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1.

Chart 1: Long-term impact of adopting the US EPL

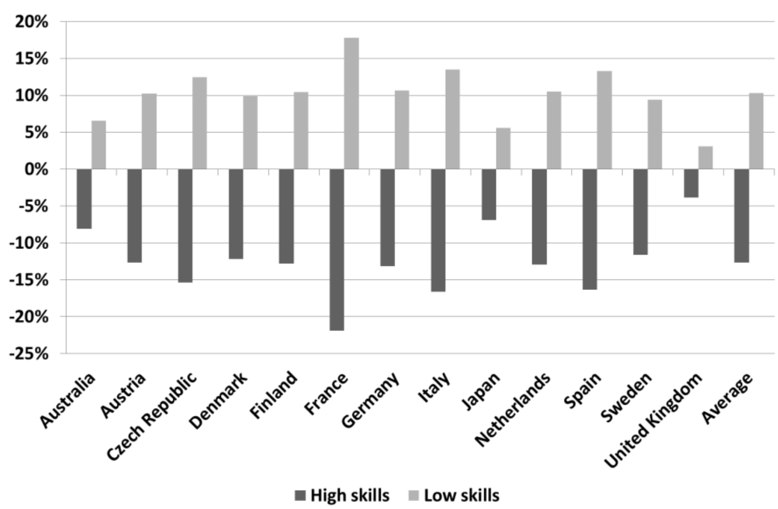
A: Physical capital intensity



B: R&D capital intensity



C: Employment share by skill level



APPENDICES

Appendix A: Descriptive analysis

Table A1 and A2 present means, standard-errors and the main quantiles of the distribution of our principal variables in level and in growth respectively, while Chart A1 to A4 present country sample averages of our main variables, showing large country differences.[9]

As regards hours worked, the share of medium-skilled employment is on average the largest, i.e. more than 60%, whereas the average share of high-skilled employment is only 11% (Table A1). But these shares differ significantly across countries: the higher proportions are observed (on average over the 2000-2006 period) in the US (21%) and in Germany (25%) (Chart A3). It is also interesting to note the large decreases in the OECD EPL indicator from 1994 to 2006 in some previously highly-regulated countries, such as Denmark, Finland and Netherlands (Chart A4). In 2006, the level of labour market regulations (EPL) is the lowest in the US and the highest in France and Italy.

Table A3 presents the variance analysis of equation (1) variables. It shows that for most of our variables a large part of their variances is accounted for by the fixed effects. Apart from the EPL, the three single fixed effects (country, industry and years) together explain at least 64% of the variability of each variable, and even more than 90% for the capital intensity indicators (column [1]). And the three potential crossed fixed effects (country*industry, country*year, industry*year) explain at least 76% of the residual variability, and even often more than 90%. Therefore, our main specification does not introduce the industry*year fixed effects, but includes the country*industry, country*year fixed effects in order to prevent various sources of endogeneity.

[9] As first years and the last year observations are not always available, these charts present the values from 1994 to 2006 to ensure country comparability.

Table A1: Summary of the main variables – level

Statistics		Mean	Std. err.	D1	Q1	Median	Q3	D9	Obs
Capital intensity	Total capital	13.658	19.848	3.010	4.650	7.740	13.137	22.760	3625
	Non-ICT eq.	5.558	6.382	1.463	2.229	3.832	6.043	9.844	3625
	Cons.	6.653	14.422	0.869	1.541	2.560	4.756	9.607	3625
	ICT	0.605	0.810	0.072	0.139	0.299	0.698	1.598	3625
	R&D	1.152	1.987	0.046	0.109	0.341	1.196	3.599	2537
Empl. Share	High-skilled	0.110	0.093	0.021	0.044	0.077	0.151	0.247	3200
	Med.-skilled	0.625	0.185	0.353	0.517	0.642	0.723	0.856	3200
	Low-skilled	0.265	0.183	0.047	0.134	0.239	0.351	0.517	3200
Relative cost	Total capital	0.057	0.023	0.033	0.041	0.053	0.068	0.088	3625
	Non-ICT eq.	0.059	0.029	0.032	0.041	0.053	0.069	0.092	3625
	Cons.	0.035	0.017	0.019	0.024	0.032	0.043	0.056	3625
	ICT	0.199	0.157	0.068	0.093	0.149	0.254	0.392	3625
	R&D	0.110	0.040	0.069	0.083	0.103	0.127	0.162	2537
	High-skilled	1.608	0.340	1.246	1.385	1.569	1.799	2.039	3200
	Med.-skilled	0.991	0.084	0.901	0.946	0.997	1.039	1.089	3200
	Low-skilled	0.769	0.145	0.606	0.702	0.779	0.873	0.923	3200
EPL impact		0.589	0.346	0.110	0.344	0.563	0.794	1.039	3625

The total capital mean differs from the sum of the different asset means because the R&D mean is calculated on the subsample of industries investing significantly in R&D

Table A2: : Summary of the main variables – growth

Statistics		Mean	Std. err.	D1	Q1	Median	Q3	D9	Obs
Capital intensity	Total capital	3.32%	4.36%	-1.43%	0.56%	2.84%	5.59%	8.57%	3625
	Non-ICT eq.	3.03%	4.69%	-2.28%	0.03%	2.64%	5.57%	8.78%	3625
	Cons.	2.26%	4.86%	-3.10%	-0.72%	1.75%	4.73%	8.06%	3625
	ICT	11.10%	8.54%	1.62%	5.70%	10.21%	15.34%	21.61%	3625
	R&D	7.78%	9.83%	-2.04%	2.23%	6.51%	12.03%	19.14%	2537
Empl. share	High-skilled	3.82%	9.35%	-3.62%	0.24%	3.17%	6.97%	13.06%	3200
	Med.-skilled	1.07%	3.00%	-1.19%	-0.15%	0.65%	1.84%	3.59%	3200
	Low-skilled	-3.60%	6.73%	-9.26%	-6.09%	-3.27%	-1.02%	1.62%	3200
Relative cost	Total capital	-3.86%	4.30%	-9.13%	-6.34%	-3.65%	-1.30%	1.02%	3625
	Non-ICT eq.	-3.92%	4.32%	-9.38%	-6.51%	-3.78%	-1.24%	1.31%	3625
	Cons.	-4.58%	9.59%	-12.19%	-8.11%	-4.33%	-0.99%	2.93%	3625
	ICT	-10.05%	9.50%	-19.65%	-14.26%	-9.58%	-5.84%	-1.75%	3625
	R&D	-3.29%	3.82%	-8.03%	-5.53%	-3.01%	-1.07%	0.90%	2537
	High-skilled	-0.45%	3.72%	-4.07%	-1.90%	-0.46%	0.95%	2.96%	3200
	Med.-skilled	-0.33%	1.40%	-1.62%	-0.79%	-0.20%	0.17%	0.92%	3200
	Low-skilled	-0.85%	3.94%	-4.14%	-1.66%	-0.45%	0.41%	1.93%	3200
EPL impact		-0.81%	4.01%	0.00%	0.00%	0.00%	0.00%	0.00%	3625

Table A3: Variance analysis of the estimate variables

		First step R^2	Second step R^2			Obs.
Fixed effects:		[1] country, industry, year	[2] country*indus.	[3] country*indus., country*year	[4] country*indus., country*year, industry*year	
Capital intensity	Total capital	0.9743	0.8510	0.8935	0.9295	3625
	Non-ICT eq.	0.9635	0.8766	0.9132	0.9350	3625
	Cons.	0.9596	0.8818	0.9205	0.9470	3625
	ICT	0.9550	0.7865	0.8692	0.8933	3625
	R&D	0.9225	0.9210	0.9300	0.9517	2537
Empl. share	High-skilled	0.8602	0.8518	0.9081	0.9299	3200
	Med.-skilled	0.8853	0.6961	0.8994	0.9397	3200
	Low-skilled	0.9363	0.8472	0.9453	0.9563	3200
Relative cost	Total capital	0.8508	0.7280	0.8842	0.9064	3625
	Non-ICT eq.	0.8683	0.6916	0.9194	0.9359	3625
	Cons.	0.8112	0.4199	0.9522	0.9620	3625
	ICT	0.9030	0.5087	0.6912	0.7686	3625
	R&D	0.8716	0.9098	0.9709	0.9768	2537
	High-skilled	0.7824	0.7208	0.8534	0.8714	3200
	Med.-skilled	0.7875	0.7929	0.8541	0.8723	3200
	Low-skilled	0.6478	0.7864	0.9350	0.9426	3200
EPL impact		0.0207	0.8870	0.8895	0.9324	3625

This Table summarises the results of an analysis of variance for all the variables in our analysis in terms of separate country, industry and year effects as well as a sequence of two-way interacted effects. Column [1] documents the variability of the variables lost in terms of "first step" R^2 when we include in the regressions of our model the three one-way fixed effects separately, as a basic control for the usual sources of specification errors. The three following columns [2], [3] and [4] document what is the additional variability lost (within the first step residual variability) in terms of "second step" R^2 when we also include interacted two-way effects, in order to control for other potential sources of specification errors.

Chart A1: Non-ICT physical capital intensity – country sample average
(thousands of constant 2000 US $ per worker)

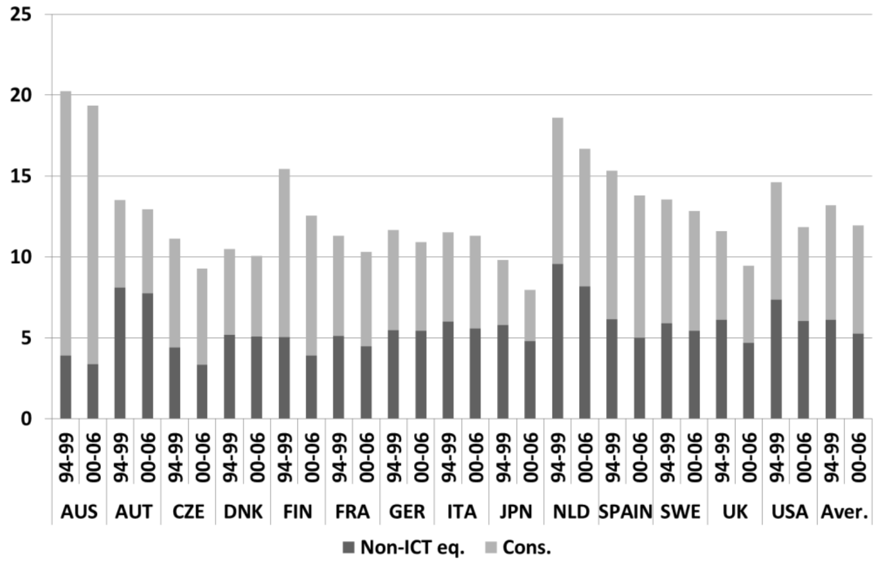


Chart A2: ICT and R&D capital intensity – country sample average
(thousands of constant 2000 US $ per worker)

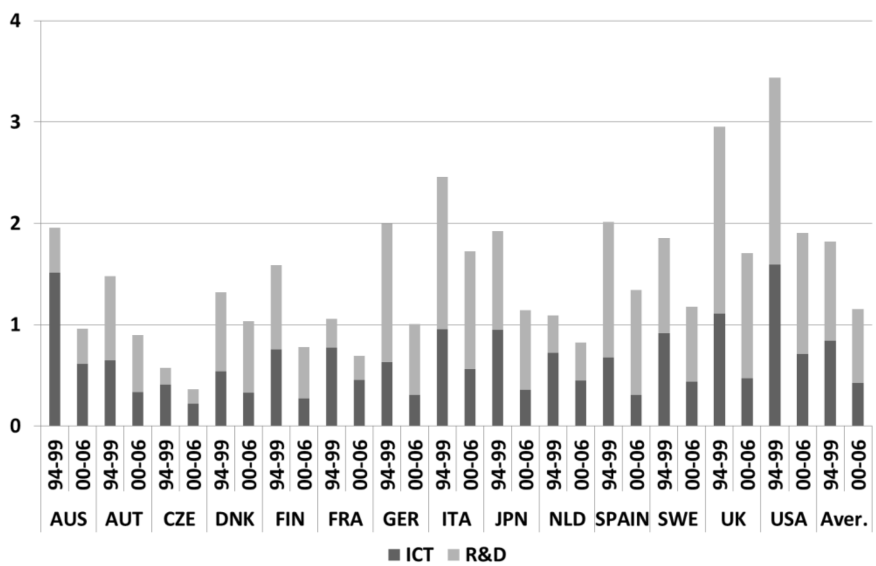


Chart A3: Employment share by skill level – country sample average

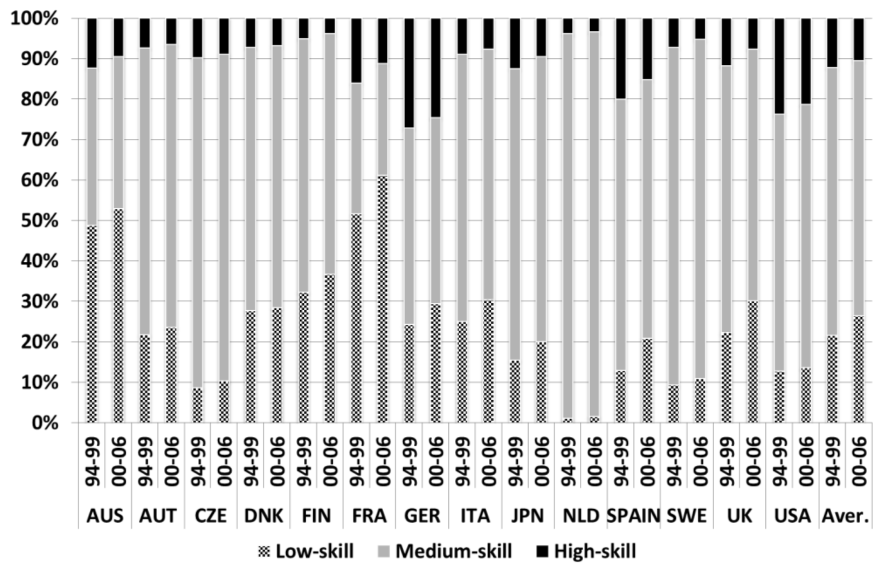
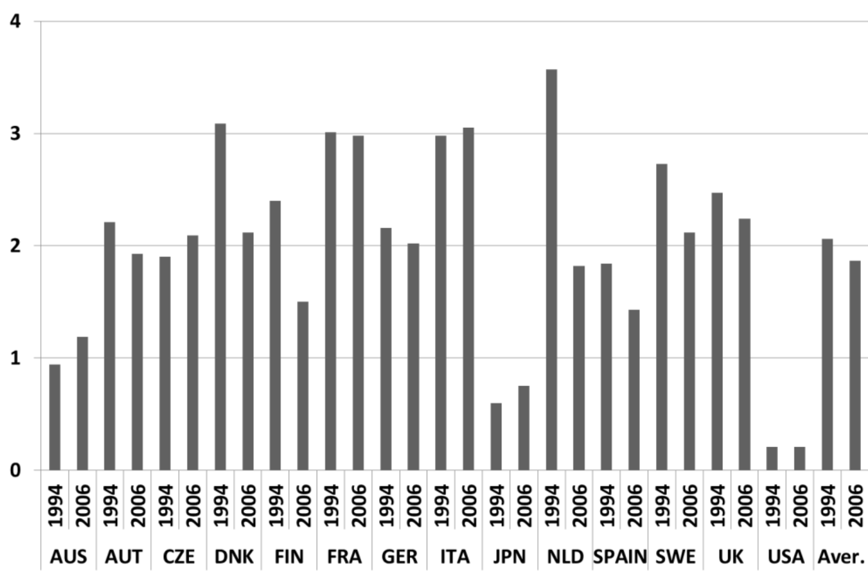


Chart A4: OECD Employment Protection Legislation indicator (EPL)
(scale 0-6, 0 for the most flexible country labour market)



Appendix B: Sensitivity analysis

This appendix presents the different robustness checks that have been carried 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 B1. 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.

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, and λ_i = 0 in other industries.[10] The estimate results appear robust to this choice, as shown in Table B2. 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).

Estimate results are also robust to several other sensitivity analyses, notably the change of the measurement in the capital intensity ratio, using medium-skilled employment instead of total employment (see Table B3). Estimate results presented in Table 1 use specific estimate samples for R&D intensity, column (5), and for the share of employment by skill level, column (6) and (7). For R&D intensity, industries that almost do not invest in R&D are excluded, but Table B4 shows that the negative impact of the relative cost and EPL are robust to the inclusion of all the industries in the estimate sample. For skills, the estimate samples are smaller than for the other assets because of data availability. When this smaller estimate sample is used for the other assets, the estimate results are quite similar, as shown in Table B5. The only exception is that the impact of EPL on construction capital would be smaller and no longer statistically significant. Finally, estimate results are also robust to the removal, in the dataset, of any country, any industry and any year.[11]

[10] The high layoff propensity industries (with $\lambda_i = 1$) are: textiles (17-19), wood products (20), non-metallic mineral products (26), metal products (27-28), machinery not elsewhere classified (29), electrical equipment (30-33), manufacturing not elsewhere classified (36-37), construction (45), transport & communication (60-64).

[11] The corresponding estimate result Tables can be obtained on request to the authors.

Table B1
Relation (1) estimate results when the elasticity of substitution parameters are constrained to -1

Factor	(1) Total Cap.	(2) Non-ICT eq.	(3) Cons.	(4) ICT	(5) R&D	(6) High-skilled	(7) Low-skilled
Relative cost	-1	-1	-1	-1	-1	-1	-1
$(c_f - w)$	[0]	[0]	[0]	[0]	[0]	[0]	[0]
EPL impact	0.157***	0.209***	0.176***	0.0453	-1.061***	0.268***	0.0115
$(\lambda_i . EPL)$	[0.0580]	[0.0603]	[0.0662]	[0.0987]	[0.250]	[0.0705]	[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
Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1

Table B2
Relation (1) estimate results when the industry characteristic (λ_i) is the layoff propensity

Factor	(1) Total Cap.	(2) Non-ICT eq.	(3) Cons.	(4) ICT	(5) R&D	(6) High-skilled	(7) Low-skilled
Relative cost	-0.446***	-0.604***	-0.364***	-0.476***	-0.476***	-0.258***	-0.247***
$(c_f - w)$	[0.0308]	[0.0400]	[0.0432]	[0.0228]	[0.145]	[0.0537]	[0.0311]
EPL impact	0.0220**	0.0329***	-0.00369	0.0128	-0.0953**	0.0270**	-0.00367
$(\lambda_i . EPL)$	[0.0105]	[0.0112]	[0.0121]	[0.0174]	[0.0372]	[0.0129]	[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
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

Table B3:
Relation (1) estimate results when the reference is medium-skilled employment ($x_f - l_M$)

Factor	(1) Total Cap.	(2) Non-ICT eq.	(3) Cons.	(4) ICT	(5) R&D	(6) High-skilled	(7) Low-skilled
Relative cost	-0.346***	-0.468***	-0.259***	-0.435***	-0.166	0.0231	-0.258***
($c_f - w$)	[0.0378]	[0.0472]	[0.0458]	[0.0239]	[0.147]	[0.0490]	[0.0330]
EPL impact	0.0601	0.214***	0.102	-0.0598	-1.221***	0.420***	-0.161***
($\lambda_i . EPL$)	[0.0646]	[0.0684]	[0.0664]	[0.0956]	[0.249]	[0.0719]	[0.0480]
Observations	3,200	3,200	3,200	3,200	2,247	3,200	3,200
R-squared	0.626	0.562	0.502	0.927	0.598	0.653	0.923
rmse	0.105	0.112	0.109	0.157	0.258	0.117	0.0772

Included fixed effects: country, industry, year, country*industry and country*year
Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1

Table B4:
Relation (1) estimate results for R&D intensities when all industries are included in the sample

	(1)	(2)
Factor	R&D	
Sample	R&D industries	All industries
Relative cost	-0.474***	-0.761***
($c_f - w$)	[0.144]	[0.143]
EPL impact	-1.106***	-1.956***
($\lambda_i . EPL$)	[0.249]	[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
Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1

Table B5:
Relation (1) estimate results when the estimation samples is reduced to data available on skills

Factor	(1) Total Cap.	(2) Non-ICT eq.	(3) Cons.	(4) ICT	(5) R&D	(6) High-skilled	(7) Low-skilled
Relative cost	-0.457***	-0.586***	-0.364***	-0.438***	-0.402***	-0.233***	-0.212***
$(c_f - w)$	[0.0331]	[0.0424]	[0.0445]	[0.0237]	[0.149]	[0.0537]	[0.0317]
EPL impact	0.0363	0.180***	0.0657	-0.103	-1.019***	0.347***	-0.219***
$(\lambda_i . EPL)$	[0.0559]	[0.0605]	[0.0636]	[0.0938]	[0.247]	[0.0682]	[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
Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1