Sunk Capital, Unions and the Hold-Up Problem: Theory and Evidence from Cross-Country Sectoral Data*

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Abstract

In this paper we study the hold-up problem by considering the effect of union bargaining power on the level of investment per worker across sectors characterised by different levels of sunk capital investment. We develop a search and matching model with heterogeneous sectors and ex-post collective wage bargaining and test the predictions of the model using a difference-in-difference approach on manufacturing sector data in a set of OECD countries during the period 1980-2000. We find that union power reduces investment per worker particularly in sunk capital intensive industries. We refine our empirical analysis showing that the underlying hold-up problem is exacerbated when strikes are not regulated after a collective contract is signed and there is no arbitration, while the presence of social pacts may sustain cooperative equilibria that alleviate the hold-up problem. Our results are robust to a series of controls and possible endogeneity of union power.

Keywords: Hold-Up, Unions, Sunk Investments, Search and Matching, Difference-in-Difference, Sectors.

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1 Introduction

How relevant are contractual incompleteness and labour market institutions in shaping firms' incentives to invest? What are the channels through which such institutions influence physical capital accumulation? What is the role of the degree of sunkness and the timing of investments by firms? In this paper we try to answer the above questions by focusing on the relation between sunk capital, union bargaining power and the underlying hold-up problem. We construct a search and matching model with sunk investment and ex-post collective wage negotiations in order to study the effects of union bargaining power on investment per worker. We then bring the model to the data by evaluating the quantitative effect of coverage of union bargaining agreements on the levels of investment per worker across manufacturing sectors in a set of OECD countries during the period 1980-2000.

We show that higher union power has a relatively stronger negative effect on investment in sectors with a larger proportion of sunk physical capital. The reason rests on the classic concept of hold-up as analysed by Grout (1984): in a setting in which firms make their investment decisions before the wage negotiation takes place, a rise in union bargaining power increases the quasi-rents workers receive (via higher wages) without paying any capital cost. Anticipating this, firms decide to invest less.

We further develop the basic intuition of Grout (1984) in a matching model with capital investment: in particular, we extend the model proposed by Acemoglu and Shimer (1999) by allowing for different sunk capital intensities across sectors. In our model, the degree of sunkness is captured by the amount of capital that firms cannot re-let when there is no production. We show that stronger union bargaining power translates into relatively lower rates of investment per worker in sunk capital intensive sectors. The intuition is the following: union power pushes unemployed workers to search for jobs in the sectors where the hold-up problem is more relevant and wages are expected to be higher. Moreover, a more powerful union generally dampens vacancy creation (as expected profits are lower), but in the sectors with a larger share of sunk capital, where the increase in job applications reduces the expected duration of a vacancy and the opportunity costs of idle capital equipment, this happens to a lesser extent. In order to ensure that not all unemployed workers stop applying for their jobs, firms in the low sunk capital sectors react by reducing capital investment less than those operating in high sunk capital industries.

We test the theoretical predictions of the model using the difference-in-difference approach proposed by Rajan and Zingales (1998). In particular, we interact an indicator of union power at the country level (proxied by the coverage of union bargaining agreements) with a sectoral measure of sunk capital intensity, which is invariant across countries and is derived from US industry data. The latter is defined, following Balasubramanian and Sivadasan (2009), as one minus the share of used capital investment in total capital investment outlays at the industry level.

Our main empirical results suggest that higher union power is associated to lower levels of investment per worker. In particular, our set of estimates imply an investment differential of about 13% between a sector at the 75^{th} percentile (Transport equipment) and one at the 25^{th} percentile of the sunk capital intensity distribution (Leather products) in a country at the 25^{th} percentile of the union coverage distribution (such as the United Kingdom) compared to a country at the 75^{th} percentile of union coverage (such as Spain). These results are robust to a large battery of sensitivity checks. First, we consider various measures of union power, and R&D intensity as an alternative proxy for the degree of sunk capital in each industry. Second, we include interactions of sunk capital intensity with country level variables potentially correlated with union coverage as well as interactions of union coverage with other industry characteristics potentially correlated with the share of sunk capital. Finally, we find that the effect of union coverage in sunk capital intensive sectors is larger in those countries where strikes are not regulated and arbitration is not legally binding. Moreover, the negative effect of unions is not statistically significant in the case of countries where the government routinely involves the confederations of unions and employers in the main economic policy decisions by means of "social pacts".

The paper relates to several strands of literature. It is part of the literature on the hold-up problem with relation-specific investments and contractual incompleteness, in which under-investment occurs if contracts cannot be enforced (Williamson, 1985; Grossman and Hart, 1986; Hart and Moore, 1999).[1] In a labour market environment, Grout (1984) shows that, in the presence of rent sharing, irreversibility of capital investments and the structure of wage bargaining reduce investments. Indeed, when long term contracts are not binding and capital

[1] General equilibrium effects of specificity are studied by Caballero and Hammour (1998), who analyse how the market system provides an inefficient solution to the unresolved microeconomic contracting problems. More recently, Acemoglu et al (2007) show that contractual incompleteness favours the adoption of less advanced technologies, thus shaping the pattern of endogenous comparative advantage. See also Nunn (2007).

investment is sunk, unions have the ex-post incentive to appropriate quasi-rents, undermining firms' incentives to invest. This intuition is discussed with reference to the UK Trade Union Immunity Laws, which prevented firms from suing a trade union that ex-post breached a labour agreement.[2] More recently, in an insightful and thorough paper, Card et al (2014) propose a two-period model showing that the hold-up problem is likely to be mitigated if there is a credible threat of liquidation by the firm in the second period. Using a matched employer-employee dataset for the manufacturing sector of the Veneto region in Italy, they test the predictions of the model and find evidence that workers appropriate rents but after deducting the full cost of capital, suggesting that investment might be at its efficient level, even if the precision of their estimates does not allow them to exclude modest degrees of hold-up.

Another strand of literature related to our paper analyses the hold-up problem by focusing explicitly on the effect of unions on investment. Using data on US manufacturing companies, Hirsch (1991) and Cavanaugh (1998) find a substantial negative impact of unionisation on investment.[3] In turn, the evidence provided by Addison et al (2007) on German establishments suggests that the presence of works councils has no effect on physical capital accumulation. Such contrasting evidence is also confirmed by Menezes-Filho and Van Reenen (2003) in their review of the effects of unions on R&D investment.

Our study is also related to the literature on the relationship between union power, the structure of wage bargaining and macroeconomic outcomes (Cuckierman and Lippi, 1999). Finally, this paper is connected to recent studies on the cross-country effects of labour market regulations and institutions.[4]

This article contributes to the literature in four main directions. First, we generalise the search and matching model of Acemoglu and Shimer (1999) by allowing for different

[2] A large body of research has studied how agents may prevent the occurrence of hold-up even in the case of incomplete contracts (Hart and Moore, 1988; Malcomson, 1997). However, the possibility of renegotiation or unions' lack of commitment to future wages may hinder the ability of contractual arrangements to mitigate the hold-up problem (Krusell and Rudanko, 2012). The purpose of this paper is not to enter such a debate. In the theoretical part, we assume the existence of several obstacles that prevent contracting from eliminating the hold-up problem. In the empirical part we try to explore whether good labour relationships in general and long term relationships in particular might mitigate the hold-up problem.

[3] Hirsch (2004) reviews the literature on the effects of trade unions on investment, profitability and employment and finds that, at least for the US and Canada, investment levels are generally lower in unionised firms. See Lee and Mas (2013) for a recent study on the effect of unionisation on the equity value of US firms.

[4] In this setting, Fiori et al (2012) find that bargaining power of unions has negative employment effects in OECD countries, while Murtin et al (2014) explore the effects of the extension of collective wage bargaining on unemployment. In turn, using a sample of firms for a group of EU countries, Cingano et al (2010) show that EPL reduces investment per worker especially in high reallocation sectors, while Conti and Sulis (2015) find a larger negative effect on value added and productivity growth in high skill intensive sectors.

extents of sunk capital across sectors of the economy. In such a framework, we show that, by influencing vacancy creation and capital investment, workers' mobility is a key factor in the analysis of the relative importance of the hold-up problem across different sectors. In second place, by using a difference-in-difference approach, we also perform a direct test of the most important theoretical mechanism through which unions can negatively affect investment, namely the hold-up problem arising from the interplay between contractual incompleteness and sunk capital investments. Third, ours is the first paper, to our knowledge, that investigates the effects of unions on investment using a cross-country cross-industry consistent source of data. Finally, we explore the possibility that the relevance of the hold-up problem is influenced by features of the industrial relations system that have somewhat been neglected in the previous literature, such as the regulation of strikes and the quality of labour relations.

The rest of the paper is organised as follows. In section 2 we develop the theoretical model and derive its main empirical implications. In sections 3 and 4 we present the data and the estimation method respectively, while in section 5 we discuss the results. Section 6 concludes.

2 The Model

2.1 Production and Matching Technology

We consider a continuous-time model with a continuum of infinitely-lived and risk-neutral workers with perfect foresight and a common discount rate r. The economy is composed by one final consumption good Y, whose price is normalised to 1, and two intermediate goods.[5] The final good production function takes a CES form:

$$Y = \left[Y_a^{\frac{\sigma-1}{\sigma}} + Y_b^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{1}$$

in which Y_a (Y_b) is the amount of the intermediate good a (b) used in the production process of the final good while $\sigma > 1$ allows for a situation in which one of the intermediate goods is equal to zero. Since we assume perfect competition in both intermediate and final good markets, cost minimisation in the final good sector leads to the following inverse demand function for

[5] Unlike Acemoglu and Shimer (1999) we consider a two-sector model because it allows us to study the labour supply response to a change in union bargaining power and the associated impact on the allocation of workers across sectors. Such characterisation also chimes well with our empirical analysis.

each intermediate good:

$$p_{Y_i} \equiv \frac{\partial Y}{\partial Y_i} = \left(\frac{Y_i}{Y}\right)^{-\frac{1}{\sigma}}; \text{ for } i \in \{a, b\}. \tag{2}$$

Following the standard search and matching framework (Pissarides, 2000), we assume that, in each intermediate sector, a firm is composed of a single (filled or vacant) job. Before meeting the workers, firms in sector i have to choose a certain level of capital investment k_i, whose price p is determined in the international market. So a hold-up problem arises because firms must choose k_i before the wage negotiation takes place.

We also assume that a firm in sector i can re-let a share $1-\gamma_i$ of investment (with $0 < \gamma_i < 1$, for $i \in \{a, b\}$) as long as the job vacancy remains idle. Each worker produces y_i units of the intermediate good via a technology $y_i = f(k_i) = k_i^\alpha$ with $i \in \{a, b\}$.

The labour force is normalised to 1. There are frictions in the labour market. In any intermediate sector $i \in \{a, b\}$, a matching function yields the measure of matches for certain values of unemployed searching for a job in that sector, u_i, and vacancies v_i: $m_i = m(v_i, u_i)$. The function $m(.,.)$ has constant returns to scale and is increasing and concave in each argument. Labour market tightness in sector i is defined as $\theta_i \equiv v_i/u_i$, for $i \in \{a, b\}$. A vacancy is filled according to a Poisson process with rate $q(\theta_i) \equiv m_i/v_i$, $q'(\theta_i) < 0$. A job-seeker moves into employment at rate $\theta_i \cdot q(\theta_i) \equiv m_i/u_i$, increasing in θ_i.[6] Following most of the literature, we consider a Cobb-Douglas technology for the matching function: $m_i = u_i^\eta v_i^{1-\eta}$.[7] At an exogenous rate s, investment k_i breaks down and the worker loses the job.

We assume that unemployed workers are able to direct their search towards either sector, and a no arbitrage condition discussed below ensures that there is no expected gain in choosing either option. Therefore, if λ denotes the endogenous share of unemployed workers searching for a job in sector a, we can derive the steady state level of employment in the two sectors:

$$e_a = \frac{\lambda\theta_a q(\theta_a)}{s + \lambda\theta_a q(\theta_a) + (1-\lambda)\theta_b q(\theta_b)} \tag{3}$$

$$e_b = \frac{(1-\lambda)\theta_b q(\theta_b)}{s + \lambda\theta_a q(\theta_a) + (1-\lambda)\theta_b q(\theta_b)} \tag{4}$$

[6] Moreover, it is assumed that $\lim_{\theta_i \to 0} q(\theta_i) = +\infty$, $\lim_{\theta_i \to +\infty} q(\theta_i) = 0$, $\lim_{\theta_i \to 0} \theta_i q(\theta_i) = 0$, and $\lim_{\theta_i \to +\infty} \theta_i q(\theta_i) = +\infty$.

[7] Our results apply to more general functional forms. In Appendix D5 available online, we also look at the case of different matching elasticities across sectors. We refer to that Appendix for details.

in which e_a and e_b respectively denote the level of employment in sector a and in sector b. Therefore the amount of the intermediate goods produced in the economy is $Y_i = e_i \cdot y_i$.

2.2 Investment Decision and Free-Entry Condition

The expected discounted value of a filled job verifies the following Bellman equation:

$$r\Pi_i^E(k_i) = p_{Y_i} \cdot k_i^{\alpha} - w(k_i) - p \cdot k_i - s\Pi_i^E(k_i) \tag{5}$$

for $i = \{a, b\}$. The equation above says that the firm's revenues are equal to the amount of the intermediate good produced (multiplied by its price p_{Y_i}) net of the real wage $w(k_i)$ and the rental cost of investment that the firm must pay. At a rate s, the equipment is destroyed and the firm exits the market. The expected discounted value of a firm with a job vacancy reads as:

$$r\Pi_i^V = \max_{k_i} -\gamma_i p \cdot k_i + q(\theta_i) \left[\Pi_i^E(k_i) - \Pi_i^V \right] - s\Pi_i^V \tag{6}$$

for $i = \{a, b\}$. The firm's problem is to choose the optimal level of capital investment that maximises $r\Pi_i^V$.[8]

Since $1 - \gamma_i$ is the fraction of the equipment that firms with a vacant position can re-let or dispose for in other ways in order to cover their cost, $\gamma_i p \cdot k_i$ is the flow cost of investment incurred when firms are searching for a worker. In this sense, the parameter γ_i measures the extent of sunkness of investment. In order to single out more starkly the impact of irreversible investment in our model, we impose $\gamma_a > \gamma_b$ as the only technological difference between the two sectors.[9]

Inserting the expression for $r\Pi_i^E(k_i)$ in equation (5) into equation (6) and computing the first order condition we get:

$$\frac{p_{Y_i}\alpha \cdot k_i^{\alpha-1} - w'(k_i) - p}{r + s} = \frac{\gamma_i p}{q(\theta_i)} \qquad \text{for } i \in \{a, b\}. \tag{7}$$

At the equilibrium, the expected marginal cost of capital when the vacancy is idle must be

[8] Note that our model cannot be interpreted as one with differential vacancy costs across sectors. This is because firms incurr a cost $p \cdot k_i$ when the vacancy is idle and when it is filled.

[9] Note that, as in Acemoglu and Shimer (1999), the model abstracts from time-to-build considerations and there is instantaneous capital adjustment. This formulation is coherent with the regression analysis in the empirical part, where the dependent variable is the level of investment per worker. In Appendix D2 available online we show that the main results of the model hold even in case of capital accumulation over time.

equal to its expected marginal revenues, net of labour and capital costs.

There is free-entry of vacancies. Firms enter the labour market as long as expected profits are nonnegative: $\Pi_i^V = 0$. From equation (6) this implies:

$$\Pi_i^E(k_i) = \frac{\gamma_i \, p \cdot k_i}{q(\theta_i)} \qquad \text{for } i \in \{a, b\}. \tag{8}$$

Then, rearranging equations (5) and (6) in order to get rid of $\Pi_i^E(k_i)$ and Π_i^V yields:

$$\frac{p_{Y_i} k_i^{\alpha} - w(k_i) - p\, k_i}{r + s} = \frac{\gamma_i p \cdot k_i}{q(\theta_i)} \quad \text{for } i \in \{a, b\}. \tag{9}$$

Equation (9) says that the expected cost of filling a vacancy is equal to the expected revenues obtained from a job. Note that the parameter γ_i increases the expected cost of filling a vacancy.

2.3 Workers' Preferences and Wage Bargaining

The expected discounted utilities of an employed and an unemployed worker in sector $i \in \{a, b\}$ are respectively:

$$r J_i^E = w(k_i) + s \left[J_i^U - J_i^E \right] , \tag{10}$$

$$r J_i^U = \theta_i q(\theta_i) \left[J_i^E - J_i^U \right] . \tag{11}$$

The interpretation of these Bellman equations is standard. Being employed (respectively, unemployed) is equivalent to holding an asset that yields an instantaneous utility equal to the wage $w(k_i)$ (resp., zero) and the capital gain in case the worker becomes unemployed (resp., gets a job) multiplied by the corresponding entry rate.[10]

Since unemployed workers are free to search for a job in either sector, a no arbitrage condition must ensure that the expected utility of being unemployed is the same across sectors:[11]

$$r J_a^U = r J_b^U . \tag{12}$$

[10] For simplicity we assume there are neither unemployment benefits nor home production in this economy. In online Appendix D3 we show that a model with positive home production delivers the same results of our baseline framework.

[11] Since the expected utility J^U is invariant across sectors, we will suppress the subscript i henceforth.

Since our main interest is the effect of union power on investment, we do not consider the individual bargaining process that is common in standard search and matching models (see Pissarides, 2000); we instead impose a collective bargaining process where, in each sector, unions and firms' representatives negotiate over wage levels.[12]

To model unions' preferences, we consider a utilitarian case. In particular, firms in sector i have a utility equal to $e_i \cdot \Pi_i^E(k_i)$, i.e. the expected revenues of each single firm multiplied by the number of firms with a filled job in the market. In addition, there is a union which cares about the sum of the utilities of its members. For simplicity, we also assume that the union represents the entire workforce in that sector: therefore, the utility of the union when bargaining in sector i is equal to $e_i \cdot J_i^E + u_i \cdot J^U$, for $i \in \{a, b\}$.

Wages are determined by bilateral generalised axiomatic Nash bargaining that takes the following form:

$$w(k_i) = \text{argmax} \left[e_i \cdot J_i^E + u_i \cdot J^U - (e_i + u_i) \cdot J^U \right]^{\beta} \cdot \left[e_i \cdot (\Pi_i^E(k_i) - \Pi_i^V) \right]^{1-\beta} \tag{13}$$

for $i \in \{a, b\}$, in which the parameter β represents the bargaining power of unions.[13] Here we can envisage two different cases. In the first scenario, unions of workers and firms choose the wage level by taking the level of employment as given; alternatively, unions also consider the negative effects of the wage on e_i. In Appendix A1, we show that both cases deliver the same results in terms of comparative statics. Therefore, in what follows we proceed with the simple model.

If the level of employment e_i is taken as given by unions, the F.O.C of the above maximization problem is:

$$\beta \cdot \left(\Pi_i^E(k_i) - \Pi_i^V \right) = (1 - \beta) \cdot \left(J_i^E - J^U \right) \quad \text{for } i \in \{a, b\}. \tag{14}$$

Using the Bellman equations for firms and workers (5), (6), (10) and (11), we get:

$$p_{Y_i} k_i^{\alpha} - w(k_i) = (1 - \beta) \left[p_{Y_i} k_i^{\alpha} - r J^U \right] + \beta \cdot p \cdot k_i \tag{15}$$

[12] We have also solved a model with large firms and individual intra-firm bargaining (Cahuc et al, 2008). Since the production technology exhibits constant returns to labour, such extension delivers the same results of our baseline model. We refer to online Appendix D6.

[13] In online Appendix D4 we present a model with different bargaining power across sectors. We refer to that Appendix for details.

for $i \in \{a, b\}$. Differentiating this equation with respect to k_i and plugging it into (7) yields:

$$\mathbb{G}_i(\theta_i, \theta_j, \lambda, k_i, k_j) \equiv (1-\beta)\, p_{Y_i} \cdot \alpha k_i^{\alpha-1} - p\frac{(r\,+\,s)\gamma_i + q(\theta_i)(1-\beta)}{q(\theta_i)} = 0 \tag{16}$$

for $i, j \in \{a, b\}$, $i \neq j$. The implicit function $\mathbb{G}_i(\theta_i, \theta_j,\, \lambda, k_i, k_j) = 0$ represents the firm's optimal choice of investment in sector i when the wage is determined by bilateral bargaining. Note that the endogenous variables θ_j, λ, and k_j appear in equation (16) via the price of the intermediate good p_{Y_i} (see equations (2), (3) and (4)). The first term in $\mathbb{G}_i(\theta_i, \theta_j,\, \lambda, k_i, k_j) = 0$ is the marginal gain of investment, which is decreasing in k_i, because the production function has diminishing returns to capital. The second term is the marginal cost of investment, which is increasing in θ_i, as a higher labour market tightness raises the expected duration of filling a vacancy. In turn, that implies more time with idle capital equipment. In equilibrium, marginal costs must be equal to marginal benefits, so an increase in θ_i must be accompanied by a lower k_i. Note also that the higher the fraction of sunk capital γ_i, the higher the marginal cost of investment.

Using the free entry condition (8), the Bellman equation for unemployed workers (11), and the Nash sharing rule (14), the no arbitrage condition (12) takes the following form:

$$rJ^U = \frac{\beta}{1-\beta} \cdot p \cdot \theta_a \cdot \gamma_a \cdot k_a = \frac{\beta}{1-\beta} \cdot p \cdot \theta_b \cdot \gamma_b \cdot k_b. \tag{17}$$

Rearranging we get:

$$\frac{k_b}{k_a} = \frac{\theta_a \cdot \gamma_a}{\theta_b \cdot \gamma_b}. \tag{18}$$

Equation (17) allows us to express the wage equation below without the term J^U:

$$w(k_i) = \beta \cdot [\, p_{Y_i} \cdot k_i^{\alpha} + p \cdot k_i\, (\gamma_i \cdot \theta_i - 1)] \qquad \text{for } i \in \{a, b\} \tag{19}$$

The expression in (19) is similar to the wage equation obtained in search and matching models with individual bargaining and no sunk capital investment. Workers receive a fraction β of the revenues earned by the intermediate firms plus an amount that positively depends on labour market tightness. Note also that the wage equation is increasing in γ_i: the closer γ_i is to 1, the bigger the hold-up problem faced by firms, as they have a greater fraction of capital investment that cannot be employed for alternative uses when production does not occur. In other words, a higher share of sunk investment weakens the firms bargaining position and, as a result, the wage tends to be higher.

Thanks to equation (19) the no arbitrage condition (18) can also be easily interpreted. It simply states that one sector cannot jointly combine a bigger share of sunk capital γ_i, a higher level of investment k_i, and a tighter labour market compared to the other sector. This is because this would imply both a higher real wage (via equation 19) and a lower expected duration of unemployment. Hence, no worker would search for a job in the other sector. Therefore, in equilibrium, the product of these three variables must be equal across sectors.

We substitute the RHS of (19) into (9) and rewrite the free entry zero profit condition as:

$$\frac{(1-\beta)\, p_{Y_i} k_i^{\alpha}}{[\,(r\,+\,s)\gamma_i\,+\,q(\theta_i)(1-\beta+\beta\gamma_i\theta_i)\,]}=\frac{p\cdot k_i}{q(\theta_i)} \tag{20}$$

for $i\in\{a,b\}$. Note that the effect of γ_i on the expected profits is negative.

2.4 Steady-State Equilibrium and Comparative Statics

Definition 1 *A steady state general equilibrium is defined as a vector* $[\lambda, k_i, \theta_i, e_i, w(k_i),\, p_{Y_i}]$ *for* $i\in\{a,b\}$ *and a value* Y *of the final good satisfying the following conditions: (i) the inverse demand functions (*2*); (ii) the steady state levels of employment (*3*) and (*4*); (iii) the implicit functions* $\mathbb{G}_i(\theta_i,\theta_j,\,\lambda,k_i,k_j)\,=\,0$*; (iv) the no arbitrage condition* (18)*; (v) the free entry zero profit conditions (*20*); (vi) the final consumption good production function (*1*).*

In Appendix A2 we show that a steady state equilibrium exists and is unique. Comparative statics delivers the following result:

Proposition 1 *If and only if* $\beta>\eta$*, an increase in the bargaining power of unions* β *reduces investment per worker* k_i*. The decrease is more pronounced in sector* a*, which has a higher fraction of sunk capital investment,* γ_a*.*

In formal terms, the Proposition means that:

$$0>\frac{dk_b}{d\beta}\frac{1}{k_b}>\frac{dk_a}{d\beta}\frac{1}{k_a}\iff\beta>\eta. \tag{21}$$

The proof is in Appendix A3, while here we simply provide an intuition. The proposition above tells that (i) investment decreases in both sectors after an increase in union bargaining power and that (ii) the decrease is larger in the sector characterised by a larger fraction of sunk capital. For both results to hold, the necessary and sufficient condition is $\beta > \eta$.[14] Let us focus on the first point. Consider equation $\mathbb{G}_i(\theta_i, \theta_j,\ \lambda, k_i, k_j) = 0$. A higher β has a direct negative effect on investment, as firms realise that they will get lower marginal revenues.[15] But there is a second, indirect, effect that goes in the opposite direction. Given the zero-profit condition (9), stronger union bargaining power also dampens vacancy creation, thus reducing labour market tightness θ_i. In turn, a lower θ_i decreases the marginal cost of capital, because vacancies are expected to be filled quicker and investment remains unproductive for less time.[16] The magnitude of this second effect is increasing in η, the elasticity of the expected duration of a vacancy, $1/q(\theta_i)$, with respect to θ_i. Intuitively, if η is high, the decrease in tightness might squeeze the expected duration of a vacancy to such an extent that firms might even decide to raise investment k_i when workers bargaining power goes up. Therefore, the condition $\beta > \eta$ ensures that the direct negative effect outweighs the indirect positive one and it is both a necessary and sufficient for k_i to be decreasing in β.

To understand point (ii), let us focus first on how a higher β affects θ_a and θ_b. Stronger union bargaining power has an impact on labour supply, pushing more unemployed workers to search for a job in sector a, that has a larger share of sunk investment. This is because the wage gains stemming from the hold-up problem are increasing with union bargaining power. In turn, an increase in the number of job seekers tends to reduce the expected duration of a vacancy in sector a, thereby mitigating the negative effect of a higher β on expected profits. Vacancy creation is expected to decrease less in sector a than in sector b. So the workers' reallocation effect pushes towards a larger reduction in labour market tightness in sector a compared to sector b, while firms' reaction in terms of vacancy posting goes in the opposite direction. In Appendix A3 we show that the inequality $0 > \frac{d\theta_a}{d\beta}\frac{1}{\theta_a} > \frac{d\theta_b}{d\beta}\frac{1}{\theta_b}$ holds, so the second effect prevails.

These changes in tightness affect investment via the non arbitrage condition (18). Indeed, one sector cannot experience a larger reduction in both investment and labour market tightness

[14]In the empirical literature the range of estimates for both η and β is quite large and a consensus is yet to emerge. Our reading of the literature is that a plausible range for β is 0.4-0.6 (see, for instance Dumont et al., 2012), but with non-negligible differences across countries, sectors and estimation methods. In turn, different studies conducted mostly for the US found that η generally varies between 0.2 and 0.5 (see for instance Hagedorn and Manovskii, 2008). As a result, we think that it is reasonable to assume that the condition underlying Proposition 1 may hold true.

[15]The derivative of $\mathbb{G}_i(\theta_i, \theta_j,\ \lambda, k_i, k_j) = 0$ with respect to β is negative, conditional on θ_i, θ_j and λ.

[16]The derivative of $\mathbb{G}_i(\theta_i, \theta_j,\ \lambda, k_i, k_j) = 0$ with respect to θ_i is positive, conditional on θ_j and λ.

compared to the other. If this was indeed the case, no worker would search for a job in the sector with a more pronounced decrease in both wages and in the job finding rate. Therefore the sector with a higher share of sunk capital, which is characterised by a smaller decrease in tightness, must exhibit a larger reduction in the rate of investment per worker.

It is important to stress that the results of Proposition 1 hold true even under the hypothesis of individual bargaining (see footnote 12). Since the aim of the paper is to study the effect of union power on investment, in the empirical part we separately identify the effect of collective versus individual negotiations. Finally, it is interesting to note that the results of Proposition 1 on investment also apply to labour productivity. We refer to Appendix A3 for details.

3 Data

3.1 Country-Industry Level

The source of data for our dependent variable is the "Trade, Production and Protection, 1976-2004" database by Nicita and Olarreaga (2007) originally based on the UNIDO dataset. From this data, we extract investment (gross fixed capital formation) per worker for a set of 11 OECD countries: Australia, Austria, Belgium, Finland, Greece, Italy, Japan, South Korea, Portugal, Spain and the United Kingdom. The sectoral level of aggregation is the ISIC Rev2 classification with 28 manufacturing sectors and, for most countries, information is available for the entire period 1980-2000.[17]

Since monetary variables in the UNIDO dataset are expressed in current prices, we have to use EUKLEMS (see Inklaar et al., 2008) country-sector deflators to obtain investment at constant prices. For most countries we recover this information at a level of sectoral aggregation of 13 manufacturing sectors. If they are not available in the EUKLEMS database, we obtain country-sector deflators for gross fixed capital formation from the OECD's STAN database (Austria and Belgium). In the case of Greece, Portugal and South Korea, lack of data forces us to use country level PPI from the manufacturing sector as a whole from the OECD. We also face a problem linked to currency conversions. Since the original data are expressed in US dollars, we convert the currency units into national currencies and then apply

[17] The time span covered by the UNIDO database does not allow us to include other OECD countries. We also checked investment data in the OECD STAN database, but the latter was either incomplete or had a higher level of aggregation than the UNIDO one.

purchasing power parities for GDP conversion factors (Penn World Table 7.1) to eliminate price variations. We report descriptive statistics for sectoral investment per worker in the first column of Table 1.

3.2 Industry Level

Our measure of sunk capital intensity at the industry level is derived from Balasubramanian and Sivadasan (2009), and it is only available for the US manufacturing sector. They define an index of capital resalability as the share of used capital investment in total capital investment outlays at the 4 digits SIC87 aggregate level for the years 1987 and 1992. The proposed index is a valid measure of physical capital resalability based on the supposition that in industries where capital expenditure is not firm-specific (and there is an active secondary market for physical capital), it is likely that used capital would account for a relatively higher share of total investment. Thus, they expect their capital resalability index to be an inverse measure of the degree of sunkness of investment across industries.

In Table 1, we report the main descriptive statistics for our measure of sunk capital intensity (which is an average of the 1987 and 1992 values reported in Balasubramanian and Sivadasan, 2009), where the latter is obtained after applying appropriate procedures for aggregation of data and conversion of sectors using different classification systems (see the Appendix B1 for details).[18] We also report descriptives for some additional sector-level control variables derived from US data that do not vary across countries in our sample: physical capital, external financial dependence, human capital and R&D intensity. As a measure of human capital intensity we use the variable proposed by Ciccone and Papaioannou (2009) and subsequently used in Conti and Sulis (2015).[19] Physical capital intensity is computed as the ratio between real gross capital stock and value added in the US in 1980 using data taken from the EUKLEMS. Our measure of R&D intensity is proxied by the ratio of R&D expenditure to value added in the US in 1990, using data taken from the OECD ANBERD database. Finally, external financial dependence for 1980 is directly derived from Rajan and Zingales (1998).

[18] It might be important to note that, while there is some variation in the industry relative levels of sunk capital intensity if the latter is measured either in 1987 or in 1992, the relatively high correlation coefficient (0.6) between the two measures allows us to exclude that our variable just captures idiosyncratic shocks: as a result, we are confident that our proxy correctly captures sector level differences in sunk capital intensity due to technological features.

[19] We calculate average years of schooling for each educational attainment in 1970. Then, for each sector, we calculate the share of employees in each educational attainment level and multiply this share by the average years of schooling calculated above.

Table 1: Descriptive Statistics: Main Sector Level Variables

Sector (ISIC Rev2 Classification)	Investment Worker Levels (Ln)	Sunk Capital Intensity	Physical Capital Intensity	External Financial Intensity	Human Capital Intensity	R&D Intensity .
Beverages	2.6756	0.9605	1.7444	0.0772	11.3830	0.0115
Fabricated metal products	1.5096	0.8867	1.2548	0.2371	11.8440	n.a.
Food products	2.0071	0.9376	1.3656	0.1368	11.3830	0.0115
Footwear, except rubber or plastic	0.5648	0.8766	0.4433	-0.0779	10.5209	0.0060
Furniture, except metal	1.2012	0.9040	0.7892	0.2357	11.5205	0.0163
Glass and products	2.2499	0.9706	1.9543	0.5285	11.4111	0.0202
Industrial chemicals	2.9710	0.9607	2.4068	0.2000	12.9635	0.1463
Iron and steel	2.5189	0.8700	2.1253	0.0871	11.4270	0.0202
Leather products	0.7945	0.8935	0.6374	-0.1400	10.5209	0.0060
Machinery, electric	1.8116	0.9309	0.9354	0.7675	12.4389	0.0749
Machinery, except electrical	1.4957	0.8930	0.9685	0.4453	11.8739	0.0295
Miscellaneous petroleum and coal products	2.1715	0.8923	1.1991	0.3341	13.1708	0.1042
Non-ferrous metals	2.5333	0.9186	2.0132	0.0055	11.4270	0.0202
Other chemicals	2.2232	0.9493	0.8002	0.2187	12.9635	0.1463
Other manufactured products	1.2832	0.9009	0.8782	0.4702	11.5205	0.0163
Other non-metallic mineral products	2.1317	0.9171	2.9001	0.0620	11.4111	0.0202
Paper and products	2.5333	0.9251	2.2146	0.1756	11.7346	0.0080
Petroleum refineries	3.7090	0.9744	2.5929	0.0420	13.1708	0.1042
Plastic products	2.0342	0.9353	1.8958	1.1401	11.7338	0.0267
Pottery, china, earthenware	1.3981	0.9436	0.9032	-0.1459	11.4111	0.0202
Printing and publishing	1.7292	0.9061	0.7850	0.2038	12.2466	0.0080
Professional and scientific equipment	1.4609	0.9169	0.6542	0.9610	12.6221	0.1233
Rubber products	1.7568	0.9255	1.7246	0.2265	11.7338	0.0267
Textiles	1.5006	0.9212	1.8065	0.4005	10.5165	0.0060
Tobacco	2.1776	0.9473	0.7304	-0.4512	11.2078	0.0115
Transport equipment	1.9131	0.9414	1.3201	0.3069	12.8481	0.0010
Wearing apparel, except footwear	0.3523	0.8967	0.4818	0.0286	10.5816	0.0060
Wood products, except furniture	1.5401	0.8582	1.6321	0.2840	10.6958	0.0428
Total	1.8590	0.9198	1.3985	0.2414	11.7244	0.0383

Notes: Investment per worker is the natural logarithm of the (deflated) average gross fixed capital formation per worker during the period 1980-2000. Sunk capital intensity is one minus the share of used capital investment in total capital investment outlays, US average 1987-1992. Physical capital intensity is the ratio between real gross capital stock and value added in the US in 1980. External financial intensity for 1980 is directly derived for the US from Rajan and Zingales (1998). Human capital intensity is calculated as average years of schooling of workers at the sectoral level in the US in 1970 (see Ciccone and Papaioannou, 2009). R&D intensity is the ratio of R&D expenditure to value added in US in 1990; data for Fabricated metal products is not available. See subsections 3.1 and 3.2 for further details.

3.3 Country Level

The main country level variables are reported in Table 2 as averages for the period 1980-2000. Our measure of union power is the adjusted coverage of bargaining union agreements, as proposed by Visser (2011). It is calculated as the number of employees covered by wage bargaining agreements as a proportion of all wage and salary earners in employment, with the right to bargaining, expressed as percentage, adjusted for the possibility that some sectors or occupations are excluded from the right to bargain. This indicator is the standard measure of union power and it is preferable to union density for a variety of reasons (see Checchi and Lucifora, 2002). The latter is calculated as net union membership as a proportion of wage and salary earners in employment and it is a measure of the demand for union representation that we use as a robustness check of our specification. As Table 2 shows, union coverage is persistently higher than union density and it ranges from around 11% in Korea to about 97% in Austria. In Europe, Scandinavian countries traditionally show very high values for both union density and coverage (above 70% and 80%, respectively), while Mediterranean countries have quite high excess coverage (difference between coverage and density, e.g., Spain has 84% and 14% respectively); finally, Anglo-Saxon countries have less unionised labour markets.[20] We refer to Appendix B3 for other country variables used in the empirical analysis.

4 Estimation and Identification

Our empirical framework – which directly stems from the main predictions of our theoretical model – is based on the difference-in-difference approach pioneered by Rajan and Zingales (1998) and subsequently employed in many other empirical applications (see Nunn, 2007). In order to evaluate whether union power tends to reduce the level of investment per worker, particularly in sunk capital intensive industries, we estimate different versions of the following baseline equation:

$$\ln k_{s,c} = \alpha(Sunk_s \times Union_c) + \phi W_s^{'} Z_c + \rho X_{s,c} + v_s + u_c + \varepsilon_{s,c} \tag{22}$$

where the dependent variable $\ln k_{s,c}$ is the average level of investment per worker in country c and sector s over the period 1980-2000; $Sunk_s$ is the sunk capital intensity of each industry

[20]For the US, union density is equal to 15%, while union coverage is 18%.

Table 2: Descriptive Statistics: Main Country Level Variables 1980-2000

Country	Union Coverage	Change Coverage	Union Density	Employment Protection	Rule Law	Bargaining Power	Fragment. Index	Quality Index
Australia	70.00	-41.18	38.48	1.06	7.30	4.90	1.20	5.80
Austria	97.08	3.68	46.43	2.17	8.00	5.50	1.00	7.60
Belgium	96.17	-1.03	53.18	2.73	7.80	5.20	2.30	5.20
Finland	85.04	16.88	74.09	2.16	6.80	6.00	1.95	7.10
Greece	68.00	-7.14	34.52	3.40	5.60	4.30	1.80	4.80
Italy	83.00	-5.88	40.43	3.02	5.70	4.60	3.01	5.00
Japan	23.40	-32.14	26.28	1.67	7.90	4.20	2.71	7.70
Portugal	77.14	24.29	34.40	3.83	8.00	3.80	1.50	6.30
South Korea	11.00	n.a.	13.84	2.38	6.50	4.60	n.a.	3.60
Spain	84.22	19.27	13.63	3.34	6.30	4.60	3.39	5.70
United Kingdom	46.63	-48.73	40.00	0.64	7.00	3.50	1.31	6.90
Total	67.43	-7.20	37.75	2.40	6.99	4.65	2.01	5.97

Notes: Union coverage is the average number of employees covered by wage bargaining agreements as a proportion of all wage and salary earners in employment over the period 1980-2000. Change coverage is the percentage difference of union coverage between 1980 and 2000. Union density is membership divided by wage and salary earners. Employment protection is an unweighted average of the OECD index for regular and temporary contracts. Rule of law is the structure and security of property rights index reported in the Economic Freedom of the World database. The fragmentation index is the effective number of confederations defined as the inverse of the Herfindahl index discounted to take into account the weight of smaller confederations. Quality index is a measure of the quality of labour relations from hostile to productive as reported by direct interviews with managers of firms. Bargaining power is an index obtained by direct interviews with managers of firms. For South Korea, Change coverage and Fragmentation Index are missing. See subsection 3.3 and Appendix B3 for more details and sources of data.

derived from US data; $Union_c$ defines different indicators of average union power at the country level over the sample period; $W_s^{\prime}Z_c$ are controls for other sector-country interactions; $X_{s,c}$ are other additional controls that vary both at sector and country level, while v_s, u_c and $\varepsilon_{s,c}$ are sector and country specific fixed effects and a conventional error term, respectively.[21]

A negative sign for the coefficient α of the interaction term $Sunk_s \times Union_c$ would indicate that countries in which unions are stronger tend to have lower levels of investment per worker, especially in industries with higher sunk capital. The identification assumption behind equation (22) is that union power is likely to be more binding in more sunk capital intensive sectors, where the hold up problem is likely to be more severe. This approach only allows us to identify differential effects between more and less sunk capital intensive industries. However, this differential provides us with some indication on the direction of the average effect of union power across all manufacturing industries, subject to the identification assumption that in less sunk capital intensive industries the effect of unions is of the same sign and smaller than in high sunk capital intensive industries or, alternatively, zero (Bassanini and Garnero, 2013). In other words, union power tends to reduce investment per worker disproportionately in sunk capital intensive industries.

One assumption of our identification strategy is that the degree of sunkness and our measures of union power are not correlated across sectors. In other words, we need to rule out the possibility that unions tend to concentrate in sectors in which the degree of sunk capital investment is larger. Information on unionisation rates at the sectoral level for the countries in our sample is not readily available, so in order to test this hypothesis we use US data and correlate the original measure of sunkness with sectoral data on union coverage and union density.[22] Reassuringly, results indicate a very low correlation between sunkness and union power (0.0797 for union coverage and 0.0827 for union density). Moreover, we compute the correlation coefficient between the change in sunkness over the period 1987-1992 and the change in union coverage over the corresponding period and we find a value of about -0.1, not significantly different from zero. In other words, the US data do not seem to lend much support to the hypothesis that unions tend to concentrate relatively more in sunk capital sectors, which

[21] Note that the presence of country and sector fixed effects does not allow us to include $Sunk_s$ and $Union_c$ as separate regressors.

[22] In particular, we aggregate the original measure of sunkness from 4 to 3 digits of the SIC87 classification using appropriate weights for shares of value added. Then we match these data with sectoral data on union coverage and union density for the year 1990 which are made available by B. Hirsch and D. Macpherson at the website www.unionstats.com. As the latter data uses the CIC classification in the Current Population Survey (CPS), to convert sectors we use routines from J. Haveman, which are available at his homepage.

in turn suggests that our measure of sunkness captures a technological characteristic of sectors and may not be related to union behaviour.

In equation (22) country fixed effects should control for any omitted variable at the country level that has the same effect on investment in all industries, such as the quality of institutions, macroeconomic conditions over the period, social norms, etc. In turn, industry dummies may capture differences in technologies or sector specific patterns of investment. Our regression specification takes also into account other possible determinants of investment by including the relevant country and sector interactions $W_s^{\prime}Z_c$, such as the country years of schooling and the sector human capital intensity; the country capital-output ratio and the sectoral physical capital intensity, the industry dependence on external finance and the country level of financial development. The inclusion of $W_s^{\prime}Z_c$ is important because there is evidence that countries with an abundant factor tend to specialise in industries that use intensively that factor. Controlling for the relevant country-industry interactions should allow us to take into account the possibility that W_s (e.g. the industry physical capital intensity) and $Sunk_s$ or Z_c (e.g. the country capital stock) and $Union_c$ are correlated: in this case, the omission of the relevant country-industry interactions would tend to bias the OLS estimates of the coefficient of interest α.

In order to consider the possibility that union behaviour might interact with some other industry characteristics, in some specifications we augment our regressions with interactions between $Union_c$ and sector level variables, such as R&D and physical capital intensity. But there might be other country-level variables, potentially correlated with $Union_c$, that interact with industry sunk capital intensity. Hence, in some regression specifications we also include additional interactions between $Sunk_s$ and country level variables such as various labour market institutions, rule of law, etc. Finally, we estimate a version of equation (22) in which we instrument $Union_c$ with variables related to the political history of each country, because there might be reasons to believe that causality might go in the other direction, namely from investment to union power (see below).

5 Results

5.1 Main Results

In Table 3 we start testing the main implication of our model, namely that the average level of investment per worker is especially reduced in high sunk capital industries in countries where labour unions have strong bargaining power. We proxy union power by the average percentage of employees covered by wage bargaining agreements over the sample period.

In column 1 we start with a baseline specification of equation (22), where we control for country and industry fixed effects and the relevant country-industry interactions contained in the matrix $W_s^{\prime}Z_c$, as discussed in the previous section. The coefficient of the interaction between the industry degree of sunkness and union coverage is negative and strongly statistically significant at 5% level. In particular, the coefficient of -0.079 implies an investment differential of about 13% between a sector at the 75^{th} percentile (Transport equipment) and one at the 25^{th} percentile of the sunk capital intensity distribution (Leather products) in a country at the 25^{th} percentile of the union coverage distribution (such as the United Kingdom) compared to a country at the 75^{th} percentile of union coverage (such as Spain).

In the next column we address possible endogeneity concerns of union coverage. First, there can be some country level omitted variables for which we do not control that might tend to affect the level of investment per worker, especially in high sunk capital industries. Alternatively, it might be argued that investment and union coverage are jointly determined if countries that tend to specialise in industries characterised by low levels of investment per worker and by a high fraction of sunk capital are also more likely to have stronger unions and, in particular, high coverage rates. In column 2 we report the result of an IV regression otherwise identical to that reported in column 1, where we instrument union coverage with a dummy equal to one for countries that had experienced a right-wing dictatorship spell before 1980 and zero otherwise, and with the average fraction of votes held by left wing parties at the government over the 1980-2000 period.[23] The rationale for these two instruments is that we expect right-wing dictatorships to have fought the development of the labour unions movement and a strong presence of left wing parties in the governments to favour the growth of labour unions (Fiori et al, 2012). The first stage regression, whose results are available

[23] The countries that experienced a dictatorship spell are Austria, Greece, Italy, Japan, Korea, Portugal and Spain.

Table 3: Baseline Model for Levels of Investment per Worker: Sectoral Controls

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln of Investment per Worker	OLS	IV	OLS	OLS	OLS	OLS	OLS	OLS
Sunk Capital Intensity ×	-0.0792**	-0.0887**	-0.0678*	-0.0677*	-0.0676**	-0.0614*	-0.0678*	-0.0815***
Union Coverage	(0.0336)	(0.0384)	(0.0370)	(0.0358)	(0.0326)	(0.0352)	(0.0357)	(0.0286)
R&D Intensity ×			-0.0394**					
Union Coverage			(0.0171)					
Physical Capital Intensity ×				-0.00262				
Union Coverage				(0.00212)				
Skill Intensity					0.0373***			
					(0.0122)			
Skill Intensity ×					-0.000427*			
Union Coverage					(0.000228)			
Job-to-Job Transition Rate						-0.1977**		
						(0.0861)		
Job-to-Job Transition Rate ×						0.00229**		
Union Coverage						(0.00104)		
Share Temporary Workers							-0.0354	
							(0.0596)	
Share Temporary Workers ×							0.000363	
Union Coverage							(0.000731)	
Subsidies Intensity								0.375
								(0.585)
Subsidies Intensity ×								-0.00298
Union Coverage								(0.00711)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	306	306	295	306	306	286	286	230
R-squared	0.817	0.817	0.819	0.819	0.822	0.797	0.791	0.861

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Controls are interactions between sectoral US human capital intensity and country level of schooling; sectoral US external financial intensity and country financial development, sectoral US physical capital intensity and country capital output ratio. Sunk capital intensity is one minus the share of used capital investment in total capital investment outlays in US. Union coverage is the share of covered workers over total employment. R&D intensity is R&D expenditure to value added in US. Physical capital intensity is the ratio between real gross capital stock and value added in the US. Skill intensity is the average share of hours of skilled workers over total hours at country-sector level. Job-to-job transition rate is number of job-to-job transitions divided by average employment at country-sector level. Share of temporary contracts is the share of workers on temporary contracts over total employment at country-sector level. Subsidies intensity is the ratio of "subsidies less taxes" on value added at country-sector level. See Table 1 and Appendix B2 for more details for the main set of controls and additional country-sector controls. In col. (2) we instrument union coverage with a dummy equal to one for countries that had experienced a right-wing dictatorship spell before 1980 and zero otherwise, and with the average fraction of votes held by left wing parties at the government over the 1980-2000 period.

from the authors upon request, confirms our expectations and suggests that our instruments are not weak and pass the Sargan test of instrument validity.[24] The second stage regression confirms that higher union coverage rates negatively affect the level of investment per worker, particularly in sunk intensive industries, with a slightly larger magnitude of the effect with respect to OLS estimates.

We augment our baseline regression with interactions between union coverage and sectoral characteristics in the remaining regressions of the Table. In column 3, we investigate whether stronger union power tends to affect investment, particularly in R&D intensive industries. We do this for two reasons. The first is that R&D expenditure is largely sunk and, therefore, to a certain extent, the industry R&D intensity might be considered as an alternative proxy of industry sunk capital intensity. The second is that there is empirical evidence that R&D intensive industries tend to be more volatile and that some labour market institutions tend to depress growth in volatile industries (Cuñat and Melitz, 2012). Given the positive correlation in our sample between R&D intensity and our measure of sunkness, we believe it is important to check that the negative interaction between sunk capital and union coverage is not simply capturing the negative effect of union coverage on investment rates in R&D intensive industries. Empirical results displayed in column 3 do not confirm that this is the case, as the sunk-union coverage interaction is always negative and statistically significant. Moreover, also the R&D-union coverage interaction is negative and statistically significant.[25] If we interpret the degree of R&D intensity as a different proxy for the importance of sunk capital, this result provides additional empirical evidence that union bargaining power might have negative effects in industries where sunk capital and the associated hold-up problem are more important.

In column 4 we include an interaction between the union coverage and the industry physical capital intensity. Controlling for this term is very important not only because the latter is positively correlated with the industry degree of sunkness, but also because our theoretical model predicts that it is the sunk nature of capital investments that generates the hold-up problem, and not the physical capital intensity per se. As the empirical results show, the interaction between union coverage and physical capital intensity is never significant while the magnitude of the sunk intensity-union coverage interaction barely changes.[26]

[24] The Kleibergen-Paap test statistics is 70.1; in turn, the Sargan test statistics is 0.285 (p value 0.59).

[25] See Menezes-Filho and Van Reenen (2003) for a survey of the empirical evidence on the effects of unionisation on R&D investments.

[26] It is possible to argue (Baldwin, 1983) that firms in high sunk cost industries might tend to increase debt as a sort of commitment device to be tough against unions. If this results in structurally higher dependence

In the next columns of Table 3, we extend the analysis in order to provide additional evidence that higher union coverage indeed exerts greater influence over investment in sunk capital intensive industries. For instance, as mentioned in the theoretical section of the paper, not only collective but also individual bargaining power might reduce investments relatively more in industries with a larger share of sunk capital. In other words, one might argue that our estimates could be capturing the joint effect of individual and collective bargaining power. If industry level differences in individual workers' bargaining power are correlated with the industry share of sunk capital, the coefficient of the interaction term between union coverage and the share of sunk capital might be biased. Moreover, the direction of the bias is not even clear a priori, because it depends not only on the correlation between the industry degree of sunkness and the level of individual bargaining power, but also on the effect of the latter on investment per worker.[27] For this reason, we verify that our regressions are indeed capturing the role played by collective bargaining, by augmenting our baseline regressions with various proxies of sector level individual bargaining power (see Appendix B2). In particular, in column 5 we use EUKLEMS data on the cross-country cross-industry share of hours of high skilled workers. We include that share alone (we can identify it because it varies across both industries and countries), and interacted with union coverage. The empirical results suggest the existence of a positive and significant correlation between the share of skilled workers and the level of investment per worker. In turn, the interaction between sunk capital and union coverage remains negative and statistically significant, while the interaction between skill intensity and coverage is negative.[28]

We further test the robustness of this result by including the job-to-job transition rate in column 6. Such additional control may be important, as there is an influential literature sug-

towards external finance in high sunk cost industries, then it might be important to control for an interaction between union coverage and an industry financial dependence. When we do so, the interaction of union coverage with the degree of industry sunkness remains negative and statistically significant. Results are available from the authors upon request.

[27] Note that the effect of individual bargaining power on investment is not a priori clear. For instance, if we proxy it with the share of high-skilled workers in an industry, the latter might negatively affect investments because higher individual bargaining power makes the hold-up problem more severe. However, in the presence of capital-skill complementarity, an higher share of skilled workers can lead to higher levels of investment via a higher marginal product of capital.

[28] In order to verify if the individual bargaining power has a different impact in sectors with different degrees of sunk capital, in regressions not reported, but available upon request, we drop the interaction between skill intensity and union coverage and include the interaction between skill and sunk capital intensities. Results confirm findings reported in column 3 and indicate that higher union power reduces levels of investment per worker particularly in sunk capital intensive industries. In turn, we do not find any statistically significant effect as far as individual bargaining power is concerned. We also run similar regressions using the two other alternative measures of individual bargaining power discussed below and results are confirmed.

gesting that voluntary mobility of workers is an important determinant of workers' bargaining power (Cahuc et al, 2006). Indeed, higher job to job transition rates may be associated to higher between firms competition for workers, thus higher workers bargaining power and a larger share of the match surplus accruing to them. Our results again confirm that countries with higher union power tend to exhibit lower levels of investment per worker particularly in sunk capital intensive industries. Note that jointly considering the level and interaction effects for the job-to-job transition rate, we find that higher individual bargaining power reduces physical capital investment per worker, but only in countries where union coverage is sufficiently low. This may be rationalised by noting that in countries with strong unions the extent of individual negotiations is more limited. In any case, the fact that the interaction between sunk intensity and coverage remains statistically significant suggests that our regressions are indeed capturing the effect of collective and not individual bargaining power.

It is interesting to note that differences in sectoral skill intensities could also reflect variation in the importance of screening costs across sectors. Moreover, as a matter of fact, it is possible that unions reduce investment particularly in sectors in which screening costs are high. This may be due to the fact that unions impose common procedures for hiring and firing and this has a relatively larger impact in sectors in which screening costs are more relevant.[29] In order to further elaborate on this important issue, we consider an alternative proxy for the importance of screening costs across sectors. In particular, in column 7 we use the fraction of temporary workers, the intuition being that in sectors in which screening costs are higher, firms might tend to use relatively more temporary contracts to learn about match quality (Faccini, 2014).[30] Results confirm those found in previous columns.[31]

Finally, we consider the possibility that, in some countries, possibly as a consequence of union's lobbying activity, some sectors are politically favoured through lower taxes and/or higher subsidies, as in the model of Restuccia and Rogerson (2008). For this reason, in column 8 we control for a country-sector measure of subsidy intensity: even in this case, our main results are confirmed.[32]

[29] Moreover, it cannot be a priori ruled out that "screening cost" intensity is correlated with sunk intensity.

[30] Similarly, the share of temporary contracts can also be considered as a possible (inverse) proxy for individual bargaining power in an industry.

[31] Finally, in regressions not reported, but available upon request, we experiment with the hiring rate (taken from Bassanini and Garnero, 2013) as an additional proxy for screening costs and individual bargaining power. We recognise that this proxy may be criticised on various grounds, such as its dependence on the business cycle: nevertheless results confirm those reported in Table 3.

[32] Card et al (2014) justify their finding of a modest degree of hold-up on the grounds that workers bargaining power is reduced if firms can credibly threat to relocate overseas. While it is difficult to have a good measure

5.2 Robustness

In Table 4 we consider different extensions as well as additional robustness checks to our baseline regression (see Appendix B3). We start by adding country level variables that might be plausibly thought to affect investment per worker particularly in sunk intensive industries.[33] First, in column 1 we take into account the effect of union density, which has often been treated as an alternative proxy to union coverage for the bargaining power of unions: the interaction term is largely insignificant, while the sunk intensity-union coverage interaction is remarkably stable.[34]

In column 2 we check the robustness of our results to the inclusion of wage bargaining levels: because previous literature has found that the effect of bargaining levels may be non-linear, we interact sunk capital intensity with two dummies for different levels of wage coordination, i.e., nation-wide and sectoral, firm level bargaining being the omitted category. While our coefficient is almost unaltered, these interactions turn out to be largely statistically insignificant. In column 3 we add an indicator of generosity of unemployment benefits and an OECD index of employment protection legislation (EPL) of both regular and temporary workers. These two variables capture sources of workers bargaining power that do not depend, at least directly, on the strength of the trade unions, the first because it affects the fall back position of workers in the bargaining process by raising their outside option, and the latter because it tends to insulate incumbent workers by raising labour adjustment costs (Fiori et al, 2012). Our coefficient of interest is still negative and largely statistically significant, while the interaction term between sunk capital and benefits coverage is positive. There might be different explanations for such positive effect: perhaps higher coverage of unemployment insurance increases the probability of finding a good match, thus increasing the level of productivity and ultimately

of an industry's relocation intensity, we think the degree of vertical integration (measured by the ratio between sectoral value added and gross output) might be a reasonable proxy. In fact, in sectors where production tends to be vertically integrated the scope for outsourcing and overseas relocation might be lower, *ceteris paribus*. We therefore augment our baseline regression with the interaction between the industry vertical integration intensity in the US and union coverage: this interaction is negative but not statistically significant; in turn, the coefficient of the sunk-coverage interaction is barely altered.

[33] As a preliminary robustness check, we alternatively include interactions of the share of sunk capital investment with the country human capital level, the capital to output ratio, the level of financial development and the country average unemployment rate over the period, and results are virtually unaltered. Regression results are omitted for reasons of space, but are available from the authors upon request.

[34] If we drop the sunk capital union coverage interaction from our baseline specification, the interaction of sunk capital and union density is negative and statistically significant. Following Murtin et al (2014), we also use excess union coverage as a measure of union power, i.e., the difference between coverage and density, and results are again confirmed, with an estimated interaction term equal to -0.071 (p-value 0.03).

Table 4: Robustness for Levels of Investment per Worker: Country Level Variables

Dependent Variable: Ln of Investment per Worker	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sunk Capital Intensity ×	-0.0749**	-0.0810**	-0.0962**	-0.1210***	-0.0864**	-0.0841**			
Union Coverage	(0.0332)	(0.0342)	(0.0431)	(0.0439)	(0.0340)	(0.0331)			
Sunk Capital Intensity ×	-0.0130								
Union Density	(0.0324)								
Sunk Capital Intensity ×		0.422							
High Wage Coordination		(2.616)							
Sunk Capital Intensity ×		0.236							
Med. Wage Coordination		(2.023)							
Sunk Capital Intensity ×			0.090*						
Unemployment Benefits			(0.051)						
Sunk Capital Intensity ×			-1.592*						
EPL			(0.851)						
Sunk Capital Intensity ×				0.0561					
Union Fragmentation				(0.719)					
Sunk Capital Intensity ×					0.830				
Labour Relations					(0.692)				
Sunk Capital Intensity ×						2.069**			
Rule of Law						(0.871)			
Sunk Capital Intensity ×							-1.523*		
Bargaining Power							(0.930)		
Sunk Capital Intensity ×								-0.0931***	
Change Union Coverage								(0.030)	
Sunk Capital Intensity ×									-0.0595
Union Density Manufact.									(0.042)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country and Sector Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	306	306	306	278	306	306	306	278	222
R-squared	0.817	0.817	0.820	0.808	0.818	0.821	0.813	0.805	0.794

Note: Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Controls, Sunk Capital and Union Coverage are described in Table 3. Wage coordination is an index of coordination of wage bargaining. Fragmented bargaining is the omitted category. Unemployment benefits is the gross replacement rate of benefits over wage. EPL, Union fragmentation, Labour relations, Rule of law, Bargaining power, Change coverage are defined in Table 2. Union density in manufacturing in the share of members over total employees in the sector as a whole. See Appendix B3 for sources and more details.

the level of investment. In turn, higher levels of employment protection reduce investment particularly in sunk capital intensive industries.

We now investigate the importance of other labour market variables in driving our results. In column 4, we add an interaction between sunkness and the degree of fragmentation of confederations of unions. In this case, we expect that in countries where union membership is not concentrated, unions that are in charge of negotiations will try to fully exploit their bargaining power because the chances to be replaced by other unions in the future are higher than in countries with a very concentrated union membership. As a result, the possibility of sustaining cooperative equilibria between firms and unions is expected to be lower. However, we do not find confirmation for this prediction in the data: in turn, the interaction between sunk capital intensity and coverage is negative, larger in magnitude, and statistically significant.

In column 5, we include a variable measuring the quality of labour relations (Mueller and Philippon, 2011), described in Appendix B3. The intuition for including this control is that in countries characterised by good labour relationships, the existence of high union coverage rates might not affect investments. However, when we control for the quality of labour relations we do not find confirmation of this effect, as the interaction between labour relations and sunkness is positive as expected (which means that countries with "bad" labour relations tend to display lower investment in sunk intensive industries) but also statistically insignificant at conventional levels of confidence; in turn, the sunk-union coverage interaction is always negative, statistically significant and with barely altered coefficients. We further probe the robustness of our main result by adding interactions of sunk capital intensity with an indicator of the rule of law. There is some evidence (column 6) that countries with a stronger rule of law tend to have a higher level of investment per worker in high sunk capital industries, probably reflecting the fact that a stronger rule of law might be associated to higher government commitment not to use taxation to expropriate investors of the quasi-rents generated by sunk investments.[35]

In the last three columns of the Table, we examine the robustness of our results to alternative measures of union power. In column 7 we measure union strength with the variable

[35] Countries with strong unions might have stronger incentives to attract foreign direct investments, as recently argued by Haufler and Mittermaier (2011). For this reason, in regressions not reported we include an interaction between FDI regulations and sunk capital intensity. The latter is negative and statistically significant. This can be explained by noting that in countries with strong FDI regulation, product market competition might be less intense: the associated increase in rents generates incentives for workers to be more aggressive, which in turn stifles firms' incentives to invest, particularly in sunk capital intensive industries.

"Bargaining Power" recently used by Mueller and Philippon (2011). The main attraction of using this variable is that it is an attempt to measure union bargaining power directly, at least as perceived by top managers (see Appendix B3). The interaction between sunkness and union bargaining power is negative and statistically significant at 10% confidence levels. In column 8 we allow for the possibility that what is important is not the level of union coverage per se, but rather its change over the period. Empirical results suggest that countries which experienced a larger increase in union coverage over the sample period had a lower level of investment per worker in high sunk capital industries.[36] Finally, in the last column of the Table, we measure union power using data for the manufacturing sector as a whole. Despite its limitations as a proxy for union bargaining power, we are forced to consider union density because consistent cross-country data on union coverage in the manufacturing sector are not available, to the best of our knowledge. Despite the substantial fall in observations (about 25%) due to missing data for Greece, Portugal and Korea, the magnitude of the interaction term is similar to those found in previous columns, even if it is just slightly imprecisely estimated.[37]

Before concluding this section we want to add two final points. First, we have not exploited the panel dimension of our dataset so far. This is because, by focusing on the long run effects of union power, we make it less likely that the empirical results are driven by short term dynamics related to business cycle effects. However, using the panel nature of our data allows us to exploit the substantial time variation in union power that occurred over the sample period in some countries. Therefore, in Appendix C1 we provide an additional robustness check by estimating a panel version of our baseline equation. Regression results, reported in Table A1, confirm the main prediction of our paper: higher union power reduces the level of investment particularly in sunk capital intensive industries.

Finally, in Appendix C2 we explore the effect of unions on labour productivity. We do this for two reasons. Firstly, in the case of labour productivity we have been able to find

[36] Until now we have measured union coverage as the average value over the entire sample period. However, it might be argued that the variation of union coverage might not be exogenous, as it could be driven also by other country-industry developments over the period: for this reason, we have also proxied union bargaining power with the value taken by union coverage as of 1980. Results, not reported but available upon request, confirm our baseline results and therefore suggest that measuring union coverage as either the mean or the beginning of the period value does not matter much.

[37] It is possible to argue that in countries where the firm size distribution is skewed towards small firms, unions may have lower influence (see Mueller and Philippon, 2011). Therefore, in order to rule out the possibility that the interaction of sunk capital and union power is capturing the effect of the firm size distribution, we augment our baseline regression with the share of small firms (1-19 employees) in manufacturing during the 90s, derived from the OECD. Our main results, available upon request, are confirmed.

information for a larger set of countries with a slightly different level of sectoral aggregation. Secondly, the negative effect of higher union power on the level of investment per worker, in our theoretical model, directly spills over on levels of labour productivity (see Appendix A3). Regression results displayed in Table A2 show that stronger union power also reduces the average level of labour productivity particularly in sunk capital intensive industries.

5.3 Refinements

So far we have presented empirical evidence showing that union bargaining power tends to reduce the level of investment per worker particularly in industries characterised by a relatively large fraction of sunk capital investment, as predicted by our theoretical model. However, it might be of some interest to assess whether the magnitude of this effect varies with some regulations that characterise the labour relations system across countries (see Appendix B3 for more details). For instance, in some countries the government has the power to impose compulsory arbitration among parties involved in a labour dispute, or at least mandatory conciliation procedures before a strike can occur. In other countries, unions are not allowed to strike if there is a collective agreement in place, or there is a waiting or notification period before a strike can take place. Thus, using information contained in Botero et al. (2004), we run a series of baseline regressions (corresponding to column 1 of Table 3) by splitting the sample across some of the country-level dimensions of labour relations we have just mentioned. Before turning to the discussion of the empirical results, it is however important to acknowledge that some regressions are based on few observations and therefore we should view these results as suggestive only.[38]

In the first two columns of Table 5 we split the sample by grouping the countries where the law forbids strikes when a collective agreement has been already signed. The existence of such a regulation is important because one could expect it to significantly alleviate the hold-up problem, because the possibility for unions to behave opportunistically might be significantly reduced. This is exactly what we find, as the effect of union coverage is about halved for the group of countries characterised by regulations that forbid strikes when a collective agreement is in place. Then we divide the sample according to whether there is a mandatory waiting period before a strike can take place. Econometric results show that higher union coverage

[38]Moreover, we do not explore the issue of why some regulations are in place in some countries but not in others.

Table 5: The Role of Strikes, Arbitration and Social Pacts: Levels of Investment per Worker

Dep. Var. Ln of Inv. Work.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Strikes After Contract		Waiting Period Strikes		Conciliation Procedures		Arbitration		Social Pact	
	Yes	No	No	Yes	No	Yes	No	Yes	No	Yes
Sunk Cap. Int. × Union Cov.	-0.158*	-0.0745**	-0.116**	-0.0528	-0.105**	-0.0259	-0.116**	0.000579	-0.0916**	0.0616
	(0.0895)	(0.0351)	(0.0529)	(0.0372)	(0.0473)	(0.0369)	(0.0449)	(0.0410)	(0.0368)	(0.146)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	56	250	166	140	194	112	222	84	196	110
R-squared	0.958	0.808	0.779	0.910	0.795	0.920	0.806	0.932	0.880	0.778

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Controls, Sunk Capital and Union Coverage are described in Table 3. See Appendix B3 for definitions of other variables. Countries where strikes were allowed after a collective contract was signed (column 1) were Italy and the UK. Countries where there was a mandatory waiting period (column 4) were Finland, Greece, Korea, Portugal and Spain. Countries with mandatory concliation procedures (column 6) were Australia, Finland, Korea and Spain. Countries with mandatory arbitration procedures (column 8) were Australia, Korea and Spain. Countries where firms and unions were involved in economic policy decisions (column 10) were Austria, Belgium, Finland and Portugal.

tends to significantly reduce investment per worker particularly in high sunk capital industries in countries where there is no waiting period, while the effect is negative but not statistically significant in countries where a notification or waiting period before a strike is compulsory. In subsequent columns, countries have instead been split according to whether there is a mandatory conciliation procedure: empirical results suggest that, in both country groups, union coverage negatively affects the level of investment per worker, but it is statistically significant only in countries where there is no mandatory conciliation procedure. The sample has been then divided according to whether there is a mandatory arbitration procedure and we find that the negative impact of union coverage is statistically significant only in countries where there is no mandatory arbitration, while for countries where there is a compulsory and binding arbitration, the impact of union coverage is statistically insignificant.

Finally, we examine, for each country, whether both unions and employers had been routinely involved in government decisions concerning social or economic policy issues (i.e., social pacts; see Visser, 2011) for the majority of years included in our sample period. In this case, our idea is that the government, by involving (always, or at least sometimes) unions and employers in economic policy decisions, creates a more cooperative framework between the parts and favours the sustainability of a cooperative equilibrium characterised by unions that refrain from exploiting their bargaining power. Our empirical results provide some favourable evidence for this hypothesis, as regression coefficients confirm that only in countries characterised by the absence of concertation, higher coverage ratios are associated to lower levels of investment per worker in sunk capital intensive industries.

6 Concluding Remarks

In this paper, we study the hold-up problem by considering the effect of union power on investment per worker in sectors with different levels of sunk capital investment. We develop a search and matching model with collective wage bargaining and, using a difference-in-difference approach, we provide robust evidence that union power reduces the levels of investment per worker relatively more in industries with higher shares of sunk physical capital investment. Moreover, we find that this negative effect might depend on some features of the labour relations system, such as the possibility of striking after a collective contract has been signed, or on the sustainability of cooperative equilibria between unions and firms.

Our results may be compared with those of Card et al (2014) who found that the hold-up problem is likely to be relatively minor (if not totally absent) in their matched employer-employees dataset in the Veneto region of Italy. There can be several reasons for this difference, ranging from the type of sample to the specification of the empirical model and time period. However, as acknowledged by the authors, the institutional setting and, in particular, the threat by firms to relocate their plants overseas, might have played an important role in alleviating the hold-up problem in their sample. Furthermore, the economic structure of Veneto is overwhelmingly based on small firms, where unions are traditionally weak: this is in part confirmed by the fact that during the period considered by Card et al (2014), union density in Veneto was lower and falling more rapidly than in Italy as a whole.

Overall, our results suggest that contractual incompleteness in labour relations and the resulting hold-up problem are relevant phenomena that might have sizeable effects on the investment levels. Moreover, there is some evidence that, by influencing the degree of contractual incompleteness, the system of industrial relations may play a role in determining the magnitude of the problem. However, at least two issues remain to be investigated: first, why some countries persist in adopting labour regulations that exacerbate the hold-up problem; second, how the type of contractual incompleteness analysed here drives the pattern of comparative advantage.

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Appendix A: Theory

A1. Alternative Wage Bargaining

In this Appendix we sketch a different setting for negotiation, in which unions take into account the effects of the wage on the level of employment in their sector. Under this scenario, the F.O.C. for the problem in (13) becomes:

$$(1-\beta)\cdot\frac{e_i-\frac{de_i}{dw(k_i)}\Pi_i^E(k_i)}{e_i\left(\Pi_i^E(k_i)\;-\;\Pi_i^V\right)}=\beta\cdot\frac{e_i+\frac{de_i}{dw(k_i)}\left(J_i^E\;-\;J^U\right)}{e_i\left(J_i^E\;-\;J^U\right)}\quad\text{for } i\in\{a,b\}. \tag{A1}$$

It is easy to see that equation $(A1)$ coincides with (14) if $\frac{de_i}{dw(k_i)}=0$. Such a derivative can be computed using equations (3), (4) and (9):

$$\frac{de_i}{dw(k_i)}=-\frac{1-\eta}{\eta}\frac{e_i\cdot q(\theta_i)}{p\cdot k_i\cdot(r+s)\cdot\gamma_i}\quad\text{for } i\in\{a,b\}. \tag{A2}$$

The negative sign of this derivative implies that the share of rents accruing to workers is lower than in the scenario presented in subsection 2.3. because unions take into account the negative effect on employment creation of a higher wage. Substituting equation $(A2)$ into equation $(A1)$ and proceeding as in subsection 2.3., we can easily get the equivalent of the F.O.C. for k_i (16) in this scenario:

$$(1-\beta\cdot\Omega)\,p_{Y_i}\cdot\alpha k_i^{\alpha-1}-p\frac{(r\;+\;s)\gamma_i+\;q(\theta_i)(1-\beta\cdot\Omega)}{q(\theta_i)}=0 \tag{A3}$$

where $\Omega \equiv \frac{\eta(r+s)}{\eta(r+s)+1-\eta} \in (0,1)$. Similarly, the equivalent of the zero profit condition (20) is:

$$\frac{(1-\beta\cdot\Omega)\,p_{Y_i}k_i^{\alpha}}{[\,(r\,+\,s)\gamma_i\,+\,q(\theta_i)(1-\beta\cdot\Omega+\beta\cdot\Omega\gamma_i\theta_i)\,]} = \frac{p\cdot k_i}{q(\theta_i)} \tag{A4}$$

It can be easily shown that the no arbitrage condition (17) takes the same form even in this scenario. Using (17), ($A3$) and (20) we can follow the same steps that we illustrate in Appendices A2 and A3 in order to prove the existence of a steady state equilibrium and get the same comparative statics results. The only difference is that the necessary and sufficient condition in Proposition 1, namely $\beta > \eta$, in this scenario becomes $\beta\cdot\Omega > \eta$.

A2. Existence of Equilibrium

We look for the conditions that ensure the existence and uniqueness of a steady-state equilibrium. It is straightforward to see that if there exist steady-state equilibrium values for k_i, λ and θ_i, for $i \in \{a,b\}$, then all the other remaining variables of the model (e_i, u, $w(k_i)$, and the expected discounted utilities of the agents) are also uniquely determined. We proceed by dividing equation (16) by equation (20) evaluated at the steady-state. We get:

$$\mathbb{W}(\theta_i) \;\equiv\; \frac{1}{\alpha} - 1 - \frac{\beta\cdot\gamma_i\theta_i q(\theta_i)}{(r+s)\gamma_i\,+\,q(\theta_i)(1-\beta)} \;=\; 0 \tag{A5}$$

for $i \in \{a,b\}$. The equations $\mathbb{G}_i(\theta_i,\theta_j,\lambda,k_i,k_j) = 0$, $\mathbb{W}(\theta_i) = 0$ for $i \in \{a,\,b\}$, and (18) compose a system in five unknowns: θ_a, θ_b, k_a, k_b, and λ. It is easy to check that there exists a unique θ_i that solves the equation $\mathbb{W}(\theta_i) = 0$ for $i \in \{a,\,b\}$. This is because $\frac{d\,\mathbb{W}(\theta_i)}{d\,\theta_i} < 0$ and the last term in the LHS of such equation goes to 0 (resp. $-\infty$), as θ_i goes to 0 (resp. $+\infty$) for the Inada conditions for the job filling rate.

From the no arbitrage condition (18), we have $k_a = k_b\cdot\frac{\gamma_b\theta_b}{\gamma_a\theta_a}$. Using the RHS of equation and $\mathbb{W}(\theta_i) = 0$, the implicit functions $\mathbb{G}_a(\theta_a,\theta_b,\lambda,k_a,k_b) = 0$ and $\mathbb{G}_b(\theta_b,\theta_a,\lambda,k_b,k_a) = 0$ respectively become:

$$\begin{aligned} p_{Ya}\cdot k_b^{\alpha-1} &= \frac{p\,\beta\,\gamma_a\,\theta_a}{(1-\alpha)(1-\beta)}\cdot\left(\frac{\theta_a\gamma_a}{\theta_b\gamma_b}\right)^{\alpha-1} \\ p_{Yb}\cdot k_b^{\alpha-1} &= \frac{p\,\beta\,\gamma_b\,\theta_b}{(1-\alpha)(1-\beta)} \end{aligned} \tag{A6}$$

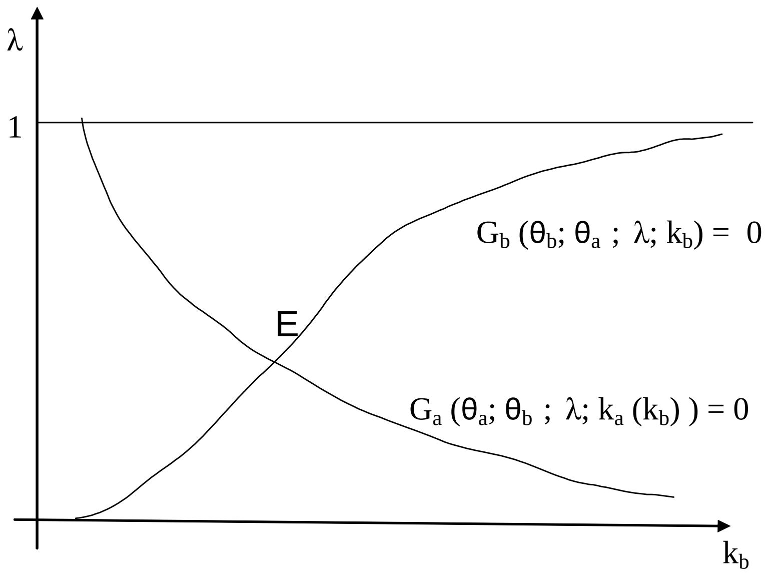

Figure A1: Equilibrium

in which

$$
\begin{aligned}
p_{Ya} &= \left\{1 + \left[\frac{1-\lambda}{\lambda}\left(\frac{\theta_a\gamma_a}{\theta_b\gamma_b}\right)^{\alpha} \cdot \frac{\theta_b q(\theta_b)}{\theta_a q(\theta_a)}\right]^{\frac{\sigma-1}{\sigma}}\right\}^{\frac{1}{\sigma-1}} \\
p_{Yb} &= \left\{1 + \left[\frac{\lambda}{1-\lambda}\left(\frac{\theta_b\gamma_b}{\theta_a\gamma_a}\right)^{\alpha} \cdot \frac{\theta_a q(\theta_a)}{\theta_b q(\theta_b)}\right]^{\frac{\sigma-1}{\sigma}}\right\}^{\frac{1}{\sigma-1}}
\end{aligned}
\tag{A7}
$$

Note that $\frac{d\mathbb{G}_a}{d\lambda} < 0$ and $\frac{d\mathbb{G}_a}{dk_b} < 0$. So $\mathbb{G}_a = 0$ describes a decreasing relationship in the (k_b, λ) space. In addition, the Inada conditions for the job filling rate and the concavity of the production function imply that $k_b \to +\infty$ as $\lambda \to 0$ and k_b tends to a positive finite number when $\lambda \to 1$.

As far as it concerns $\mathbb{G}_b = 0$, $\frac{d\mathbb{G}_b}{d\lambda} > 0$ and $\frac{d\mathbb{G}_b}{dk_b} < 0$. So $\mathbb{G}_b = 0$ describes an increasing relationship in the (k_b, λ) space. In addition as $\lambda \to 1$, $k_b \to +\infty$ and as $\lambda \to 0$, k_b tends to a positive finite number. Figure $A1$ intuitively shows that an equilibrium in λ and k_b exists and is unique. Once k_b is determined, we get the steady-state value of k_a via the no arbitrage condition (18). All the remaining variables of the model (e_i, u_i, and the expected discounted values for workers and firms) are obtained by using the steady-state values of θ_a, θ_b, k_a, k_b, and λ.

A3. Comparative Statics

Proof of Proposition 1. We need to prove the inequalities in equation (21). Rearranging eqs. (2), (3), (4) and (18) we have

$$\frac{p_{Ya}}{p_{Yb}} = \left(\frac{Y_a}{Y_b}\right)^{-\frac{1}{\sigma}} = \left[\frac{\lambda\theta_a q(\theta_a)}{(1-\lambda)\theta_b q(\theta_b)} \cdot \left(\frac{\theta_a\gamma_a}{\theta_b\gamma_b}\right)^{-\alpha}\right]^{-\frac{1}{\sigma}}$$

Using the above expression, and dividing the first equation in $(A6)$ by the second one, we can get an explicit solution for $(1-\lambda)/\lambda$ (conditional on θ_i that is determined by $\mathbb{W}(\theta_i) = 0$, for $i \in \{a, b\}$):

$$\frac{1-\lambda}{\lambda} = \left(\frac{\gamma_a}{\gamma_b}\right)^{\alpha\cdot\sigma-\alpha} \cdot \left(\frac{\theta_a}{\theta_b}\right)^{1-\eta+\alpha\cdot\sigma-\alpha} \tag{A8}$$

Plugging the RHS of $(A8)$ into the second equation in $(A6)$ allows us to have an equation in which k_b depends on θ_a and θ_b only:

$$k_b^{\alpha-1} \cdot \left[1 + \left(\frac{\theta_a\gamma_a}{\theta_b\gamma_b}\right)^{-\alpha(\sigma-1)}\right]^{\frac{1}{\sigma-1}} - \frac{p\,\theta_b\gamma_b}{(1-\alpha)}\frac{\beta}{1-\beta} = 0 \tag{A9}$$

From equation (18), we also get:

$$k_a^{\alpha-1} \cdot \left[1 + \left(\frac{\theta_a\gamma_a}{\theta_b\gamma_b}\right)^{\alpha(\sigma-1)}\right]^{\frac{1}{\sigma-1}} - \frac{p\,\theta_a\gamma_a}{(1-\alpha)}\frac{\beta}{1-\beta} = 0 \tag{A10}$$

We first show that $\frac{dk_b}{d\beta} < 0$. For the concavity of the production function, it is sufficient to prove that the LHS of $(A9)$ is decreasing in β. Differentiating equation $(A9)$ we have:

$$\frac{dk_b}{d\beta} = k_b\frac{1}{\alpha-1}\frac{1}{1-\beta}\frac{1}{\beta} + \frac{1}{\alpha-1}\frac{1}{\theta_b}k_b\left(1-\alpha\tau_b\right)\frac{d\theta_b}{d\beta} + \frac{1}{\alpha-1}\frac{1}{\theta_a}k_b\alpha\tau_b\frac{d\theta_a}{d\beta}$$

in which:

$$\tau_i \equiv \frac{\left(\frac{\theta_i\gamma_i}{\theta_j\gamma_j}\right)^{\alpha(\sigma-1)}}{1+\left(\frac{\theta_i\gamma_i}{\theta_j\gamma_j}\right)^{\alpha(\sigma-1)}} \text{with } i, j \in \{a, b\}, i \neq j \tag{A11}$$

and the derivatives

$$\frac{d\theta_i}{d\beta} = -\frac{\theta_i}{\beta}\frac{\gamma_i(r+s)+q(\theta_i)}{(1-\eta)\gamma_i(r+s)+(1-\beta)q(\theta_i)} \qquad \text{for } i \in \{a, b\} \tag{A12}$$

are obtained differentiating $\mathbb{W}(\theta_i) = 0$ for $i \in \{a,\, b\}$. After some computations, we get:

$$\begin{aligned}\frac{dk_b}{d\beta} &= -(1-\beta)\,\alpha\tau_b(\beta-\eta)(r+s)[\gamma_a q(\theta_b - \gamma_b q(\theta_a)] - (\beta-\eta)\gamma_b(r+s)\cdot \\ &\quad \cdot[(1-\eta)\gamma_a(r+s) + (1-\beta)q(\theta_a)]\end{aligned}$$

It is easy to show that $\gamma_a q(\theta_b) - \gamma_b q(\theta_a) > 0$ (details are available upon request). Then the inequality $\beta > \eta$ is a necessary and sufficient condition for $\frac{dk_b}{d\beta} < 0$.

Now, instead of computing $\frac{dk_a}{d\beta}$, note that

$$\frac{d\frac{k_b}{k_a}}{d\beta} = \frac{k_b}{k_a}.\left(\frac{dk_b}{d\beta}\frac{1}{k_b} - \frac{dk_a}{d\beta}\frac{1}{k_a}\right). \tag{A13}$$

So $\frac{d\frac{k_b}{k_a}}{d\beta} > 0$ is a necessary and sufficient condition to prove that both inequalities in (21) are verified. Using the non arbitrage condition in (18), we get:

$$\frac{d\frac{k_b}{k_a}}{d\beta} = \frac{\gamma_a\gamma_b\left(\frac{d\theta_a}{d\beta}\theta_b - \frac{d\theta_b}{d\beta}\theta_a\right)}{(\theta_b.\gamma_b)^2}. \tag{A14}$$

Substituting $(A12)$ into $(A14)$ we get:

$$\frac{d\frac{k_b}{k_a}}{d\beta} = \frac{\theta_a\theta_b\beta^{-1}\left[\gamma_a q(\theta_b) - \gamma_b q(\theta_a)\right](r+s)(\beta-\eta)}{\left[(1-\eta)\gamma_a(r+s) + (1-\beta)q(\theta_a)\right]\left[(1-\eta)\gamma_b(r+s) + (1-\beta)q(\theta_b)\right]}.$$

Using $\mathbb{W}_a(\theta_a) = 0$ and $\mathbb{W}_b(\theta_b) = 0$, it is easy to show that $\gamma_a q(\theta_b) > \gamma_b q(\theta_a)$.[39] We conclude that $\frac{d\frac{k_b}{k_a}}{d\beta} > 0 \Leftrightarrow \beta > \eta$. Therefore the condition in equation (21) is verified.

The average productivity of labour is equal to k_i^α for $i \in \{a, b\}$.[40] Therefore we have:

$$\frac{dk_i^\alpha}{d\beta}\frac{1}{k_i^\alpha} = \alpha\frac{dk_i}{d\beta}\frac{1}{k_i},$$

For the condition (21), the change in average labour productivity is bigger in absolute value in the sector with a higher fraction of sunk capital if and only if $\beta > \eta$.

[39] Details are available upon request from the authors.
[40] Recall that in each intermediate sector $Y_i = k_i^\alpha \cdot e_i$

Appendix B: Data

B1. Conversion of Sectors and Weights

Although detailed information and appropriate routines are available upon request, in this Appendix we provide a sketch of the procedures for aggregation of data and conversion of sectors using different classification systems. Our measure of sunk capital from Balasubramanian and Sivadasan (2009) is available at the SIC1987 – 4 digits level (459 industries) for the years 1987 and 1992, while data for investment per worker are available at the ISIC Rev2 – 3 digits level (28 industries). Hence, we first aggregate the sunk capital index at the 3 digits level of the SIC87 classification by using 1987 and 1992 yearly shares of value added obtained from the 2005 release of the NBER-CES Manufacturing Industry Database by Bartelsman and Gray (1996). Then, following Balasubramanian and Sivadasan (2009), for each sector we calculate an average between the index in 1987 and 1992. To convert the sunkness measure to the ISIC Rev2 – 3 digits level (28 industries) we aggregate SIC87 at 3 digit level (143 industries) and use routines provided by J. Haveman and available at his homepage. Finally, depending on different classification systems, we use similar procedures for the other industry level variables from US sources mentioned in the Data section and reported in Table 1, i.e., physical capital intensity, external financial dependence, human capital intensity and R&D intensity.

B2. Other Country-Industry Variables

In columns 5 to 8 of Table 3, we report regression results that contain additional controls that vary both at the country and sector level. The first (Skill Intensity), taken from the EUKLEMS database and originally derived from the Labour Force Surveys (LFS), is the share of hours of high skilled workers over total hours. The level of aggregation is somewhat higher with 13 manufacturing sectors: hence we assign the high skill intensity of each aggregated EUKLEMS sector to the corresponding UNIDO (sub)sectors. Then, we consider the average high skill intensity for each country-sector combination over the 1980-2000 period. The second (Job-to-Job Transition Rate) is calculated as the number of job-to-job transitions divided by average employment as reported in LFS data, and it is made available by Bassanini and Garnero (2013). The third (Share of Temporary Workers) represents the share of workers on temporary contracts over total employment in LFS data, and it is also taken from Bassanini and Garnero (2013). Note that the latter source of data is available at a slightly higher level of aggregation and for a smaller number of countries, hence we have to use the sectoral averages to impute missing values. The fourth (Subsidies Intensity) is taken from the OECD STAN Database (ISIC Rev3 version). The variable measures, for each country, sectoral subsidies net of taxes: it is positive in the case of industries where subsidies are larger than taxes, and viceversa. We take the ratio of "subsidies less taxes" on value added to derive a proxy for country-by-sector differences in "subsidies intensity". Then, we consider the average ratio for each country-sector combination over the sample period.

B3. Other Country Level Variables

Other labour market variables that are directly correlated with union presence are also included in our analysis. We first consider an index of coordination of wage bargaining taken from Visser (2011) that "ranges from economy-wide bargaining, based on enforceable agreements between the central organizations of unions and employers affecting the entire economy or entire private sector, or on government imposition of a wage schedule, freeze, or ceiling (level 5), to industry bargaining with no or irregular pattern setting, limited involvement of central organizations, and limited freedoms for company bargaining (level 3) to fragmented bargaining, mostly at company level (measure 1)." We recode the above categories in three main groups corresponding to high, medium and low level of coordination of wage bargaining.

Other labour market institutions that are strictly correlated with union presence are the generosity of unemployment benefits and employment protection legislation. We derive a measure of generosity of unemployment benefits from the FRDB database on labour market institutions (see Aleksynska and Schindler, 2011): the latter is the gross replacement rate of unemployment benefits over wage, taken as an average over the first two years of unemployment. We use, as a measure of EPL, the recent OECD indicator EP_v1, which is an unweighted average of employment protection for regular and temporary contracts, and we construct an average measure for the period 1985-2005. As there is a strong link between labour and product market regulation, we also include a measure of barriers to foreign direct investments (FDI) taken from the OECD. A measure for the rule of law has been proxied with the structure and security of property rights index reported in the Economic Freedom of the World database.

As mentioned in the paper, in our study we also include a set of variables that should capture some relevant aspects of the industrial relations system. The first is taken from Visser (2011) and it is a summary measure of concentration/fragmentation of unions. In particular, it is the effective number of confederations, defined as the inverse of the Herfindahl index appropriately discounted to take into account the weight of smaller confederations: the index gives an idea of the (inverse) degree of concentration at the central or peak level in a given country. The second is taken from the 1999 Global Competitiveness Report and recently used by Mueller and Philippon (2011): this variable is derived from a series of cross-country surveys based on interviews with about 4000 executives in 59 countries, who were asked how much they agreed (on a scale from 1, no agreement, to 6, full agreement) with the statement "The collective bargaining power of workers is high". The main attraction of using this variable is that it is an attempt to measure union bargaining power directly, at least as perceived by top managers. By way of contrast, the variable is measured at the end of our sample period and there can be differences across countries that, to a certain extent, might not reflect "true" dissimilarities in union strength, but just country idiosyncrasies in how managers judge unions power. The third, obtained from the same source as the previous one, is a measure of the quality of labour relations that ranges from hostile to productive ones, as reported by direct interviews with managers of firms in different countries.

We also use a set of indicators that reflect some aspects of labour legislation and are directly related to collective disputes, union behaviour and involvement of unions and employers in government decisions on social and economic policy. Four of them are from Botero et al (2004). The first is a dummy variable that equals one if a strike is not illegal even if there is a collective agreement in force, and zero otherwise; the second equals one if there is no mandatory waiting period or notification requirement before strikes can occur, and zero otherwise; the third equals one if labour laws do not make conciliation procedures or other alternative-dispute-resolution mechanisms (other than binding arbitration) mandatory before a strike, and zero otherwise; the fourth equals one for countries where parties to a labour dispute are not required by law to seek third party arbitration or the government is not always entitled to impose compulsory arbitration on them, and equals zero otherwise. The fifth (see Visser, 2011) equals one if there is a social pact, defined as "publicly announced formal policy contracts between the government and social partners over income, labour market or welfare policies that identify explicitly policy issues and targets, means to achieve them, and tasks and responsibilities of the signatories."

Finally, we also include in our set of controls standard macroeconomic variables that should influence investment and are obtained from conventional sources. The level of financial development is measured as the ratio between domestic credit to private sector and GDP in 1980 and is taken from the World Bank Global Development Finance database. From the Barro and Lee (2001) dataset we extract the country level years of schooling in the population with more than 25 years in 1980, while we compute the capital-output ratio by applying a standard perpetual inventory method to derive the capital stock (and therefore the capital-output ratio) for 1980 using data from the most recent release of the Penn World Tables.

Appendix C: Additional Robustness

C1. Panel Data Evidence for Levels of Investment

In this Appendix, we report additional evidence on the effect of union power on levels of investment per worker. In particular, we estimate the following panel data version of our baseline equation (22):

$$\ln k_{s,c,t} = \alpha(Sunk_s \times Union_{c,t}) + \delta \ln k_{s,c,t-1} + \omega_{s,c} + v_{s,t} + u_{c,t} + \varepsilon_{s,c,t} \tag{A15}$$

where $\ln k_{s,c,t}$ is the level of investment per worker in sector s of country c in year t; $Union_{c,t}$ is union coverage in country c at date t; $Sunk_s$ is the average level of sunkness in sector s; $\ln k_{s,c,t-1}$ is the log of investment per worker at $t-1$. Moreover, $\omega_{s,c}$ represents country-by-sector fixed effects, while $v_{s,t}$ and $u_{c,t}$ are sector-by-year and country-by-year fixed effects, respectively. Finally, $\varepsilon_{s,c,t}$ is an error term. In particular, we estimate a 5-year panel as we consider an observation every five years from 1980 to 2000. We do not consider a more conventional annual panel for two reasons. First, we believe that changes in union power affect investment decisions after some years; second, we prefer to avoid that our estimates are too affected by the strong volatility of investment. Moreover, we do not take an average over the five year period because, in a panel contest, this would create complex serial correlation patterns.

In equation (A15), the inclusion of $\omega_{s,c}$ captures unobserved heterogeneity at the sector-country level, such as country differences in industry propensity to invest. Moreover, sector-by-year fixed effects control for the possibility that different industries are in different stages of their life cycles and for industry specific technical change. The country-by-year fixed effects capture all unobserved country level variables that are unlikely to have a differential effect on investment particularly in sunk capital intensive industries.

The equation above is estimated with both the within-group and the GMM/SYS estimator, in order to take into account possible endogeneity concerns associated with the presence of the lagged dependent variable. Empirical estimates, displayed in Table A1, confirm the results of the cross sectional analysis reported in the first column of Table 3, although the size of the estimated interaction term between sunk intensity and union coverage is reduced. If we consider the long run effect associated to the interaction term in the case of the GMM estimates reported in column 3, this is about half the average impact found in the cross sectional case.

C2. Results for Labour Productivity

In this Appendix, we provide evidence on the effect of union power in sunk capital intensive industries on the average level of hourly labour productivity. The source of data is the public release of the EUKLEMS database which contains detailed information on various industry-level variables for a set of OECD countries over the period 1980-2005. We extract information on hourly labour productivity for 23 manufacturing sectors according to the ISIC Rev3.1 classification for 17 countries: Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Portugal, South Korea, Spain, Sweden, and the United Kingdom. Then, we use value added deflators available in the EUKLEMS database.

As previously discussed for the UNIDO database in Appendix B1 above, also in the case of EUKLEMS database, we follow procedures for aggregation of data and conversion of sectors using different classification systems. In particular, to obtain our sunkness measure at the ISIC Rev3.1 – 2 digits level we use the SIC87 at 2 digit level (20 industries) that gives almost a perfect match between the two sources of data. However, as the latter has a lower number of sectors, we use the 3 digit classification when necessary. Using this procedure, we are not able to match only one sector (Recycling). Descriptive statistics for main sectoral and country variables are available in Tables E1 and E2 in the online Appendix E. We estimate various specifications of equation (22), with the logarithm of average hourly labour productivity over the period 1980-2005 as dependent variable. Regression results are generally consistent with those found in the case of investment per worker. A selection of these results is reported in Table A2.

Table A1: Panel Data Models for Levels of Investment per Worker

Dependent Variable Ln of Levels of Investment per Worker	(1) Within Group	(2) Within Group	(3) GMM
Sunk Capital Intensity × Union Coverage	-0.0183***	-0.0254***	-0.0355***
	(0.00643)	(0.00831)	(0.0164)
Lagged Investment per Worker		-0.234***	0.0142*
		(0.0358)	(0.0850)
Long Run Effect of Sunk × Union Coverage		-0.0206***	-0.0414**
M2 (p value)			0.73
Hansen (p value)			0.15
Diff-Hansen (p value)			0.28
Country by sector fixed effects	Yes	Yes	Yes
Country by year fixed effects	Yes	Yes	Yes
Sector by year fixed effects	Yes	Yes	Yes
Observations	1622	1183	1231
R^2	0.006	0.083	–
Number of country by sector clusters	396	363	411

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Time interval is 5 years: 1980, 1985, 1990, 1995 and 2000. Sunk capital intensity is one minus the share of used capital investment in total capital investment outlays in US, average 1987-92. Union coverage is the share of covered workers over total employment. All regressions employ standard errors clustered at the country-industry level. In all regressions we allow for a full set of country-by-industry fixed effects, country-by-year fixed effects and industry-by-year fixed effects. In column 3 the estimation method is Arellano - Bover GMM-SYS: the instrument set includes the dependent variable lagged twice and more for the first difference equation and the first lag of the dependent variable lagged once and more in the level equation. M2 is the Arellano Bond test for second order serial correlation (p value); Hansen is the Hansen test for over identifying restrictions (p value); Diff-Hansen is the Hansen test for the validity of the restrictions in the level equation (p value). We use the two-step estimator with robust standard errors with the Windmeijer correction. Long run is the long run effect of Sunk Capital Intensity × Union coverage, computed as $\alpha/(1-\delta)$ as in equation above.

Table A2: Models for Levels of Labour Productivity: Main Sectoral and Country Level Controls

Dependent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Ln of Labour Productivity										
Sunk Capital Intensity ×	-0.114**	-0.129**	-0.114**	-0.109**	-0.105**	-0.113**	-0.119**	-0.133**	-0.115**	
Union Coverage	(0.0461)	(0.0590)	(0.0503)	(0.0459)	(0.0431)	(0.0477)	(0.0519)	(0.0519)	(0.0457)	
R&D Intensity ×			-0.0130**							
Union Coverage			(0.00511)							
Physical Capital Intensity ×				-0.000951						
Union Coverage				(0.00234)						
Skill Intensity ×					-0.000209					
Union Coverage					(0.000251)					
Subsidies Intensity ×						-0.0157				
Union Coverage						(0.0128)				
Sunk Capital Intensity ×							0.0148			
Union Density							(0.0468)			
Sunk Capital Intensity ×								4.376		
High Wage Coordination								(3.218)		
Sunk Capital Intensity ×								2.080		
Med. Wage Coordination								(2.862)		
Sunk Capital Intensity ×									1.064	
Rule of Law									(1.406)	
Sunk Capital Intensity ×										-0.0856*
Change Union Coverage										(0.0505)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country and Sector Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	370	370	353	370	370	292	370	370	370	348
R-squared	0.626	0.626	0.626	0.627	0.640	0.640	0.626	0.629	0.627	0.556

Notes: Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Dependent variable is the average level of hourly labour productivity over the period 1980-2005. Controls, Sunk Capital and Union Coverage are described in Table 3. Other sector, country-sector and country control variables are described in Tables 1, 2, 3 and 4. In columns 5 and 6 level effects for skill and subsidies intensity are included but not reported. See section 3 and Appendix B for further sources and more details.