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

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Abstract

In this paper we test for the hold-up problem by considering the effect of unions' bargaining power on the rate of growth of investment per worker and labour productivity across sectors characterised by different levels of sunk capital investments. 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 1980-2005. We find that union power slows down investment and labour productivity particularly in high sunk capital 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 less fragmentation of unions and the presence of social pacts sustain cooperative equilibria and alleviate such a 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 institutions for investment and productivity growth? Which are the channels through which such institutions influence these outcomes? Does the size of these effects depend on the degree of sunkness and/or the timing of investments by firms? In this paper we try to answer the above questions by focusing on the relation between sunk investments, unions' bargaining power and the underlying hold-up problem. In particular, we construct a search and matching model with sunk capital investments and ex-post collective wage negotiations to look at the effects of unions' bargaining power on the rate of growth of investment and labour productivity. We then put the model to data by evaluating the quantitative effect of coverage of union bargaining agreements on growth of investment per worker and hourly labour productivity across manufacturing sectors in a set of OECD countries during the period 1980-2005.

We show that higher union power has a relatively stronger negative effect on investment and productivity 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 unions' bargaining power increases the quasi-rents workers receive (via higher wages) without paying any capital cost; anticipating this, firms decide to invest less. In this paper, 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 relet in case there is no production. Higher union's bargaining power lowers the rate of investment per worker and labour productivity relatively more in high sunk capital sectors. The intuition goes as follows: stronger union's bargaining power pushes unemployed workers to search for jobs in the sectors where the hold-up problem is more serious and wages are expected to be higher. Moreover, higher union power dampens vacancy creation in both sectors (as expected profits are lower), but less so in the one 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. In order to avoid that all unemployed workers stop applying for their jobs, firms in the low sunk capital sector react by reducing capital investment less than these operating in high sunk capital sectors.

We test the theoretical predictions of the model using different sources of data for growth of investment per worker and labour productivity in manufacturing sectors using a difference-in-difference approach as proposed by Rajan and Zingales (1998). In particular, we interact an indicator of union power at the country level (the coverage of union bargaining agreements) with a sectorial measure of sunk capital intensity (one minus the share of used capital investment in total capital investment outlays at the industry level) recently proposed by Balasubramanian and Sivadasan (2009) which is invariant across countries and derived from US industry data.

The paper 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 extent of sunk capital across sectors of the economy. In such a framework, we show that mobility of workers, by influencing vacancy creation and capital investment, is key to analyse the relative importance of the hold-up problem across different sectors. In second place, by using a difference-in-difference approach, we 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. Thirdly, ours is the first paper, to our knowledge, that investigates the effects of unions on productivity and investment using a cross country-cross industry consistent source of data. Finally, we further explore the possibility that the relevance of the hold-up problem is influenced by features of the system of industrial relations and labour regulations that have somewhat been neglected in the previous literature, such as the concentration of unions, the role of strikes after a contract has been signed, and the quality of labour relations.

Our empirical results imply a yearly investment growth differential over the period 1980-2000 of about 1.1% between a sector at the 75^{th} percentile (*Transport equipment*) and 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, with an average of 53.7%) compared to a country at the 75^{th} percentile of union coverage (such as Spain, with an average of 83.6%). In the case of the growth rate of productivity, we find a growth differential of about 0.8%. We also find that an increase in union coverage during the period had a strong and negative effect on investment per worker. Moreover, our empirical results suggest that the negative effect of union coverage in sunk capital intensive sectors is stronger in countries in which regulation of strikes and arbitration are not legally binding, and in countries in which there is more fragmentation across unions. Finally, we show that, in countries in which there is a Social Pact between the government and the confederations of unions and employers (see Visser, 2011), the negative effect of unions on investment and productivity turns out to be not statistically significant.

We check the robustness of these results considering various different specifications. First, our results are robust to alternative measures of union power, such as union density and a more qualitative measure of union bargaining power, and to using R&D intensity as an alternative proxy for the industry degree of sunk capital. Second, we analyse the role of alternative determinants of industry growth by including the relevant interactions between industry and country characteristics, such as the average years of schooling at the country level and the sectorial human capital intensity, the country capital output ratio and the industry physical capital intensity, the sectorial measure of financial dependence and the country level of financial development. Third, we include interactions between sunk capital intensity and country level variables potentially correlated with union coverage such as union density, the coordination of wage bargaining, the coverage of unemployment benefits, the extent of employment protection legislation, the presence of barriers to foreign direct investments and the rule of law. Fourth, we examine whether the interaction between union coverage and sunk capital intensity partly captures other interactions of unions with industry features that might be correlated with sunk capital intensity, such as R&D intensity and physical capital intensity. Finally, we control for possible endogeneity of union power by instrumenting it with political economy variables. We conclude that our robustness checks confirm the baseline results.

Our paper is associated to different strands of literature. It is related to 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, 1990).[1] In this context, Grout (1984) shows that, when there is rent sharing, irreversibility of capital investments and the structure of wage bargaining reduce investments. In fact, when long term contracts are not binding and capital investment is sunk, unions have the ex-post incentive to appropriate quasi-rents determining lower levels of

[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, and that the impact of contractual incompleteness tends to be stronger when there are important complementarities among the intermediate inputs, thus shaping the pattern of endogenous comparative advantage. Such intuition is empirically confirmed by Nunn (2007).

investment. 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 thus generating losses for the firms.[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 unions 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 do not allow them to exclude modest degrees of hold-up.[3]

Our paper is also referred to the studies on the cross-country effects of labour market regulations and institutions. In this setting, Fiori et al (2012) look at the effect of the interaction of labour and product regulations on employment in OECD countries, and find that product market liberalisation is more beneficial when firing restrictions are higher, and that bargaining power of unions has negative employment effects. Using a sample of firms for a group of EU countries, Cingano et al (2010) show that employment protection legislation reduces investment per worker and value added per worker especially in high reallocation sectors.[4], [5] Finally, our study is also related to the literature on the relationship between unions' power, the structure of wage bargaining and macroeconomic outcomes (Cuckierman and Lippi, 1999).

[2] A large body of research has studied how agents may prevent the occurrence of hold-up even in presence of incomplete contracts. Specific option contracts, breach remedies, or long-term relations can do a good job of protecting investments and ensuring efficiency (see Williamson, 1975; Grossman and Hart, 1986; Hart and Moore, 1988; Malcomson, 1997 and Mutoo, 1998). On the other hand, 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 (see Hart and Moore, 1999 and 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 to eliminate 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] Manning (1987) and Cavanaugh (1998) are early attempts to empirically evaluate the Grout effect. For papers that study the effects of unions on investment and productivity see Hirsch (1991) for the US, Morikawa (2010) for Japan, Addison et al (2007) for Germany, and Machin and Wadhwani (1991) for the UK among the others. Menezes-Filho and Van Reenen (2003) provide a review of the literature and some considerations on unions, sunk R&D investments and the hold-up problem. Metcalf (2003) proposes a cross country analysis of the effects of unions, while the papers by Doucouliagos and Laroche (2003a, 2003b) present meta-analyses on the relationship between unions and productivity and unions and investments, respectively. See Boeri et al (2001) for a discussion of recent stylised facts and interpretations concerning the role of unions.

[4] Cuñat and Melitz (2012) theoretically show that industry differences and labour institutions can determine the pattern of comparative advantage: as a result, countries with more flexible labour markets tend to specialise in more dynamic industries. Conti and Sulis (2010) find that the negative effect of labour institutions as employment protection legislation on value added growth is stronger in more human capital intensive sectors.

[5] Using firm-level data on multinationals located in France, Bas and Carluccio (2010) show that multinational firms are more likely to import intermediate inputs from external independent suppliers instead from their own subsidiaries when importing from countries with empowered unions. Moreover, this effect is stronger for firms operating in capital-intensive industries.

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 common discount rate r. The economy is composed by one final consumption good Y, whose price is normalised to 1, and two intermediate goods.[6] 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. Perfect competition is assumed in both intermediate and final good markets, therefore cost minimisation in the final good sector leads to the following inverse demand function for 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. Firms in sector i have to choose an amount of equipment k_i before meeting the workers. Notice that, as in Acemoglu and Shimer (1999), k_i is the level of investment per worker that any firm chooses at each point in time. In fact, it is a control variable, not a predetermined one as the capital stock in standard growth models.[7] The unit price of capital is assumed fixed and equal to

[6] 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 unions' bargaining power and the associated impact on the allocation of workers across sectors. Moreover, our two sector model allows us to derive precise empirical implications that we explicitly test in the rest of the paper, where we consider the effect of union power across sectors characterised by different degree of sunk capital investments.

[7] This formulation is coherent with the regression analysis in the empirical part, where the dependent variable is the growth rate of investment per worker.

p: the latter has to be paid at any instant in time by a firm, either with a vacancy open or with a filled job. Our assumption of a rental price of capital is different from the one made by Acemoglu and Shimer (1999) who assume that the firm buys up-front the total amount of capital; by way of contrast, in our case, the firm is allowed to relet at least a share $1-\gamma_i$, with $0<\gamma_i<1$, for $i \in \{a,b\}$ of it. A hold-up problem arises because firms must choose and pay the amount of capital k_i before the wage negotiation takes place.

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 it 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.[8] Following most of the literature, we consider a Cobb-Douglas technology for the matching function: $m_i = u_i^{\eta}\, v_i^{1-\eta}$; however, our results still apply to more general functional forms. At a certain exogenous rate s, the capital investment k_i attached to either a vacancy or a filled job breaks down: in that case, the worker becomes unemployed. We also assume that unemployed workers are able to direct their search towards either sector and a non-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 have the following laws of motion of unemployment in the two sectors:

$$\dot{u}_a = s\cdot e_a - \theta_a q(\theta_a)\cdot \lambda u \tag{3}$$

$$\dot{u}_b = s\cdot e_b - \theta_b q(\theta_b)\cdot (1-\lambda) u \tag{4}$$

in which e_a, e_b and u denote the level of employment in sector a, in sector b and the total number of unemployed people in the economy, respectively. Using $1 = e_a + e_b + u$, we can derive the level of employment in both sectors at the steady state:

$$e_a = \frac{\lambda\theta_a q(\theta_a)}{s+\lambda\theta_a q(\theta_a)+(1-\lambda)\theta_b q(\theta_b)} \tag{5}$$

[8] 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 $\lim_{\theta_i\to +\infty}\theta_i q(\theta_i) = +\infty$.

$$e_b = \frac{(1-\lambda)\theta_b q(\theta_b)}{s + \lambda\theta_a q(\theta_a) + (1-\lambda)\theta_b q(\theta_b)} \tag{6}$$

In sector $i = \{a, b\}$, each worker produces y_i units of the intermediate good via a technology $y_i = f(k_i) = k_i^{\alpha}$.

2.2 Investment Decision and Free-Entry Condition

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

$$r\Pi_i^E = p_{Y_i} \cdot k_i^{\alpha} - w(k_i) - p \cdot k_i - s\Pi_i^E + \dot{\Pi}_i^E \tag{7}$$

for $i = \{a, b\}$, where the last term on the RHS measures the appreciation of $\Pi_i^E(k)$. 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 equipment that the firm must pay as long as the capital is not destroyed, $p \cdot k_i$; in the latter case, the firm exits the market. The expected discounted value of a firm with a job vacancy reads as:

$$r\Pi_i^V = \max_{k_i} -\gamma_i\, p \cdot k_i + q(\theta_i)\left[\Pi_i^E - \Pi_i^V\right] - s\Pi_i^V + \dot{\Pi}_i^V \tag{8}$$

for $i = \{a, b\}$. The firm's problem is to choose the optimal level of capital investment that maximises $r\Pi_i^V$. It is important to note that when the vacancy is idle the capital equipment is not used in the production process; however, we assume that there is a fraction $1 - \gamma_i$ of the equipment that firms are able to relet or dispose in other ways in order to cover its cost. As a result, $\gamma_i p \cdot k_i$ is the flow cost of capital paid by firms that are searching for a worker: in this sense, the parameter γ_i measures the extent of sunkness of capital. 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. As Acemoglu and Shimer (1999), we restrict the firms to choose the same level of capital investment for any job in each sector.

Inserting the expression for $r\Pi_i^E$ in equation (7) into equation (8) and computing the first order condition yields:

$$\frac{q(\theta_i)}{r + s + q(\theta_i)}\left[\, p_{Y_i}\alpha \cdot k_i^{\alpha-1} - w'(k_i) - (1-\gamma_i)p\,\right] = \gamma_i p \tag{9}$$

for $i \in \{a, b\}$. At the equilibrium, the marginal cost of capital - the RHS of (9) - must be equal to its marginal revenue - the LHS of (9).

There is free-entry of vacancies: in particular, firms enter the labour market as long as expected profits are nonnegative: $\Pi_i^V = 0$. Following Pissarides (1985), we also impose that the level of vacancies instantaneously changes in order to ensure that the condition $\Pi_i^V = 0$ always holds, both in and out of the steady-state equilibrium. In this case, $\dot{\Pi}_i^V = 0$ and equation (8) becomes:

$$\Pi_i^E = \frac{\gamma_i\, p \cdot k_i}{q(\theta_i)} \qquad \text{for } i \in \{a, b\}. \tag{10}$$

Then, rearranging equations (7) and (8) in order to get rid of Π_i^E and Π_i^V yields:

$$\frac{p_{Y_i} k_i^{\alpha} - w(k_i) - (1-\gamma_i) p\, k_i + \dot{\Pi}_i^E}{r + s + q(\theta_i)} = \frac{\gamma_i p \cdot k_i}{q(\theta_i)} \quad \text{for } i \in \{a, b\}. \tag{11}$$

Equation (11) says that the expected cost of filling a vacancy is equal to the expected revenues obtained from a job. Notice that the parameter γ_i has a twofold effect on the zero profit condition. On the one hand, it raises the expected cost of a vacancy, as the latter is increasing in the rental cost of capital in case of no production, i.e. $\gamma_i p$. On the other hand, it also raises the expected revenues for a vacancy, because the capital gain for filling a vacancy is greater the larger the fraction of sunk capital.

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:

$$\begin{aligned} rJ_i^E &= w(k_i) + s\left[J_i^U - J_i^E\right] + \dot{J}_i^E, & (12)\\ rJ_i^U &= \theta_i q(\theta_i)\left[J_i^E - J_i^U\right] + \dot{J}_i^U. & (13) \end{aligned}$$

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 $w(k_i)$ (respectively zero, as we assume for simplicity that there are neither unemployment benefits nor home production in this economy) and the capital gain in case the worker becomes unemployed (respectively gets a job) multiplied by the corresponding entry rate. Finally, $\dot{J}_i^E$ and $\dot{J}_i^U$ are the appreciation terms.

Since unemployed workers are free to search for either a job in sector a or a job in sector

b, a non-arbitrage condition must ensure that the expected utility of being unemployed is the same across sectors:[9]

$$r J_a^U - \dot{J}_a^U = r J_b^U - \dot{J}_b^U. \tag{14}$$

In order to solve the model, we need to impose a wage rule: as our main interest is the effect of union power on investment and productivity, we do not consider the individual bargaining process that is common in standard search and matching models (see Pissarides, 2000); we instead consider a collective bargaining process where, in each sector, unions and firms' representatives negotiate over the wage.

To model unions' preferences, we consider a utilitarian case. In particular, firms in sector i have a utility equal to $e_i \cdot \Pi_i^E$, i.e. the expected revenues of each single firm multiplied by the number of firms with a filled job in the market. Moreover, there is a union which cares about the sum of the utilities of its members. For simplicity, we also assume that the workers' union represents all the 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:

$$w(k_i) = \operatorname{argmax} \left[e_i \cdot J_i^E + u_i \cdot J^U - (e_i + u_i) \cdot J^U \right]^\beta \cdot \left[e_i \cdot (\Pi_i^E - \Pi_i^V) \right]^{1-\beta} \tag{15}$$

for $i \in \{a, b\}$. Here we can envisage two different cases. In the simpler one, unions of workers and firms choose the wage level by taking the level of employment as given; alternatively, one can imagine that unions consider the negative effects of the wage on the level of employment, e_i. In Appendix A, we show that both cases deliver the same results in terms of dynamics and comparative statics. In particular, in both scenarios the negative effects on investment of workers' unions bargaining power increase with the share of sunk capital. Therefore, in the following pages we proceed with the simpler model and refer to Appendix A for further details.

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

$$\beta \cdot \left(\Pi_i^E - \Pi_i^V \right) = (1 - \beta) \cdot \left(J_i^E - J^U \right) \quad \text{for } i \in \{a, b\}. \tag{16}$$

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

Using the Bellman equations for workers and firms (7), (8), (12) and (13), the F.O.C. of the bargaining problem yields:

$$\beta \left[\, p_{Y_i} k_i^{\alpha} \;-\; w(k_i) \;-\; p\, k_i \,\right] \;=\; (1-\beta) \left[w(k_i) \;-\; rJ^U \;+\; \dot{J}^U \right] \tag{17}$$

for $i \in \{a, b\}$.[10] Rearranging, we get:

$$p_{Y_i} k_i^{\alpha} \;-\; w(k_i) \;=\; (1-\beta) \,\left[\, p_{Y_i} k_i^{\alpha} \;-\; rJ^U \;+\; \dot{J}^U \right] + \beta \cdot p \cdot k_i \tag{18}$$

for $i \in \{a, b\}$. Differentiating this equation with respect to k_i and plugging it into (9) yields:

$$\mathbb{G}_i(\theta_i, \theta_j, \lambda, k_i, k_j) \equiv (1-\beta)\, p_{Y_i} \cdot \alpha k_i^{\alpha-1} - p \frac{(r\,+\,s)\gamma_i + q(\theta_i)(1-\beta)}{q(\theta_i)} = 0 \tag{19}$$

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 capital investment in sector i when the wage is determined by bilateral bargaining. Notice that the endogenous variables θ_j, λ, and k_j appear in equation (19) because the price of the intermediate good p_{Y_i} depends on them (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, which in turn implies more time with an idle 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. Notice also that the higher the fraction of sunk capital γ_i, the higher the marginal cost of investment.

Using the free entry condition (10), the Bellman equations for unemployed workers (13), and the Nash sharing rule (16), the non-arbitrage condition (14) takes the following form:

$$rJ^U - \dot{J}^U \;=\; \beta \cdot p \cdot \theta_a \cdot \gamma_a \cdot k_a = \beta \cdot p \cdot \theta_b \cdot \gamma_b \cdot k_b. \tag{20}$$

Rearranging we get:

$$\frac{k_b}{k_a} = \frac{\theta_a \cdot \gamma_a}{\theta_b \cdot \gamma_b}. \tag{21}$$

[10] Note that $\beta \cdot \left[\, \dot{\Pi}_i^E \;-\; \dot{\Pi}_i^V \right] \;=\; (1-\beta) \cdot \left[\, \dot{J}_i^E \;-\; \dot{J}^U \right]$.

Equation (20) allows us to express the wage equation below without the terms J^U and $\dot{J}^U$:

$$w(k_i) = \beta \cdot [p_{Y_i} \cdot k_i^{\alpha} + p \cdot k_i (\gamma_i \cdot \theta_i - 1)] \quad \text{for } i \in \{a, b\} \tag{22}$$

The expression in (22) is similar to the wage equation obtained in search and matching models with individual bargaining and no sunk capital. Workers receive a fraction β of the revenues earned by the intermediate firms plus an amount that positively depends on labour market tightness. Notice also that the wage equation is increasing in γ_i: the larger the extent of sunk capital in the production function (i.e. the closer is γ_i to 1), the bigger the hold-up problem faced by firms, as they have a greater fraction of capital that cannot be employed for alternative uses when production does not occur (i.e., before the matching with the worker and in case of wage disagreement). In other words, a higher share of sunk capital weakens the firms' bargaining position and, as a result, the bargained wage tends to be higher.

Thanks to equation (22) the non-arbitrage condition (21) can also be easily interpreted. In fact, it simply states that one sector cannot jointly combine a bigger share of sunk capital γ_i, a higher level of equipment 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 22) and a lower expected duration in unemployment, which in turn would entail that 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 can substitute the RHS of (22) into (11) and rewrite the free entry zero profit condition as:

$$\frac{(1-\beta)\, p_{Y_i} k_i^{\alpha} + \dot{\Pi}_i^E}{[\,(r+s)\gamma_i + q(\theta_i)(1-\beta+\beta\gamma_i\theta_i)\,]} = \frac{p \cdot k_i}{q(\theta_i)} \tag{23}$$

for $i \in \{a, b\}$. Notice that, after taking the wage equation into account, the effect of γ_i on the expected profits is negative. Therefore a higher share of sunk capital entails a lower rate of vacancy creation. The increase in the wage bill and in the expected costs of a vacancy, that a higher share of sunk capital entails, outweighs the positive "capital gain" effect on revenue present in equation (11).

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 laws of motion of employment evaluated at the steady state* (5) *and* (6)*; (iii) the implicit functions* $\mathbb{G}_i(\theta_i, \theta_j, \, \lambda, k_i, k_j) = 0$*; (iv) the non arbitrage condition* (21)*; (v) the free entry zero profit condition* (23)*; (vi) the consumption good product function* (1)*.*

In Appendix B we show that a steady state equilibrium exists and is unique. The purpose of our paper is to determine the impact of unions' bargaining power on sectors that, for some technological reason, differ in terms of the amount of sunk capital used in their production function. In terms of our model, this amounts to study the dynamics of the growth rate of investment per worker and the average productivity of labour in both sectors following an increase in β, the parameter that represents the bargaining power of unions. In fact, when β increases, both labour market tightness θ_i and capital investment k_i adjust immediately to their new steady state values. Hence, to study the growth rate of investment (labour productivity), we just need to compare the "new" steady state value with the "old" one. In Appendix C1 we show that the unique equilibrium is an unstable node, while the Proposition below illustrates the main results of the model that we explicitly test in the empirical part of the paper:

Proposition 2 *If and only if* $\beta > \eta$*, an increase in the bargaining power of unions* β *lowers both the growth rate of investment and the growth rate of average labour productivity. The decrease is more pronounced in sector* a*, that has a higher fraction of sunk capital,* γ_a*.*

In formal terms, the Proposition means that:

$$0 > \frac{dk_b}{d\beta}\frac{1}{k_b} > \frac{dk_a}{d\beta}\frac{1}{k_a} \Longleftrightarrow \beta > \eta. \tag{24}$$

The proof is in Appendix C2, while here we simply provide an intuition. Proposition above tells that (i) capital 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 $\beta > \eta$.[11] Let us

[11] In the empirical literature the range of estimates for both η and β is quite large and a consensus is yet to

focus on the first point. For the zero-profit condition (11) an increase in workers' bargaining power lowers the fraction of rents going to firms, dampening vacancy creation and labour market tightness θ_i. In order to understand the effect of β on capital investment k_i, consider equation $G_i(\theta_i, \theta_j, \lambda, k_i, k_j) = 0$. A higher β has a direct negative effect on investment, as firms realise that they will get lower marginal revenues.[12] But there is a second, indirect, effect that goes in the opposite direction. The decrease in labour market tightness tends to reduce the marginal cost of capital, because the expected duration of a vacancy is shorter and the investment remains unproductive for less time.[13] The magnitude of this 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 capital investment k_i when workers' bargaining power goes up.[14] 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.

As far as it concerns point (ii), the inequality $0 > \frac{d\theta_a}{d\beta}\frac{1}{\theta_a} > \frac{d\theta_b}{d\beta}\frac{1}{\theta_b}$ means that an increase in union's bargaining power reduces labour market tightness relatively more in the sector with a lower share of sunk capital. This is because a higher β pushes unemployed workers to search for a job in the sector with more sunk capital, as the wage gains stemming from the hold-up problem are increasing with union's bargaining power.[15] This shift of the unemployed workers mitigates the negative effect of higher β in the sector with a larger share of sunk capital because it reduces the expected costs of filling a vacancy in that sector. Therefore vacancy creation, and in turn labour market tightness, decreases less in sector a than in the sector b. Finally, for the non arbitrage condition (21), one sector cannot experience a larger reduction in both capital investment and tightness compared to the other. This would imply lower wages and a smaller probability of finding a job and all unemployed workers would stop searching for a job in that sector. Therefore the sector with a higher share of sunk capital, which is characterised

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 may hold through.

[12] 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.

[13] 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.

[14] Note that the negative effect on firms' marginal revenues of β is more acute when workers' bargaining power is already strong.

[15] In the limit case in which $\beta = 0$ the wage is the same across sectors.

by a smaller decrease in tightness, must display a larger reduction in the rate of investment per worker.

3 Data

3.1 Country-Industry Level

We use two different sources of data for our two dependent variables, the growth rate of investment per worker and the growth rate of hourly labour productivity. The first source is the "Trade, Production and Protection, 1976-2004" database by Nicita and Olarreaga (2007) originally based on the UNIDO database (UNIDO henceforth). From this data, we extract investment (gross fixed capital formation) per worker as our main dependent variable for a set of 11 OECD countries: Australia, Austria, Belgium, Finland, Greece, Italy, Japan, South Korea, Portugal, Spain and the United Kingdom. In the UNIDO database, the sectorial 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.[16]

As in the UNIDO dataset monetary variables are in current prices, we had to use EUKLEMS country-sector deflators to obtain such variables at constant prices. In the case of gross fixed capital formation, for most countries we recover such information at a level of sectorial aggregation of 13 manufacturing sectors.[17] If not available, we obtain data on gross investment deflators from the OECD's STAN database (Austria and Belgium) or national sources (Greece, Portugal and South Korea). Finally, when information was not available at all, we use averages for other countries. Finally, we also face a problem linked to currency conversions. As original data are expressed in US dollars, we also decided to take into account purchasing power parities: we convert back the currency units into national currencies and then apply PPPs for GDP conversion factors to eliminate price variations, taken from the Penn World Table version 7.1.

The second source of data is the public release of the EUKLEMS database which contains detailed information on various industry-level variables for a larger set of OECD countries

[16] 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.

[17] In principle, if one works with first differences (e.g. growth of investment), this should not matter because in our empirical specification we have country and sector fixed effects. Still, we decided to deflate the data to allow for more precision in our estimates.

for the period 1980-2005 (see Inklaar et al., 2008). We extract information on hourly labour productivity (which is not available in the UNIDO database) 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.[18] We drop other EU and non-EU countries as data were not available for the complete covered period and the US, as the latter is used as the benchmark in our differences-in-differences approach.[19]

For some countries we do not have information on investment and productivity for all sectors, but in no case the number of sectors falls below 20 (out of 28) and 17 (out of 23) in the UNIDO and EUKLEMS dataset respectively. Our regressions are based on 266 and 347 observations which correspond to more than 85% of potential observations in both datasets. We report descriptive statistics for sectorial growth of investment per worker and hourly labour productivity in the first columns of Tables 1 and 2.

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 Tables 1 and 2, we report for the UNIDO and EUKLEMS datasets respectively, 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

[18] We also extracted information for labour productivity, calculated as value added divided by the number of employees in the UNIDO database. We have only used the latter to verify the robustness of our estimates: results are available upon request.

[19] As the data for value added are in current prices, we use price deflators available in the EUKLEMS dataset. When not directly available, we use averages for the other countries over the same years.

sectors using different classification systems (see the Appendix D1 for details).[20]

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/skill intensity we use the measure proposed by Ciccone and Papaioannou (2009) and subsequently used in Conti and Sulis (2010).[21] 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 R&D expenditure to value added ratio in the US in 1990 using data taken from the OECD ANBERD database. Finally, our measure of external financial dependence for 1980 is directly derived from Rajan and Zingales (1998).

3.3 Country Level

The main country level variables are reported in Table 3 as averages for the period 1980-2005.[22] Our measure of union power is 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. Such 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 inspection of Table 3 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 both very high

[20] 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.

[21] 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.

[22] Note that the UNIDO and EUKLEMS datasets cover a slightly different period of time (1980-2000 and 1980-2005, respectively); hence average measures of such variables can slightly differ across datasets. In both cases we use appropriate country level measures, but for space reason we just report relevant information for the period 1980-2005. If information for 1980 or 2005 was absent, we use data for the most recent available year.

union density and coverage (higher than 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.[23] We refer to Appendix D2 for other country variables used in the empirical analysis.

4 Estimation Method

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 unions' power tends to reduce the growth of investment per worker and labour productivity particularly in sunk capital intensive industries, we estimate different versions of the following baseline equation:

$$\Delta \ln y_{s,c} = \alpha(Sunk_s * Union_c) + \phi W_s^{'} Z_c + \delta \ln y_{s,c,1980} + v_s + u_c + \varepsilon_{s,c} \tag{25}$$

where the dependent variable $\Delta \ln y_{s,c}$ is the yearly average growth rate of investment per worker (labour productivity) in country c and sector s over the period 1980-2000 (1980-2005). Notice that investment per worker y_i is equivalent to the variable k_i in the theoretical framework. In fact, as in Acemoglu and Shimer (1999), k_i is the level of investment per worker that any firm chooses at each point in time. $Sunk_s$ is the sunkness intensity of each industry derived from US data; $Union_c$ defines different indicators of average union power at the country level over the period; $\ln y_{s,c,1980}$ is the log of the dependent variable at the beginning of the period; while v_s, u_c and $\varepsilon_{s,c}$ are sector and country specific fixed effects and a conventional error term, respectively.[24]

A negative sign for the coefficient α of the interaction term $Sunk_s * Union_c$ would indicate that countries in which unions are stronger tend to have slower growth of investment per worker and labour productivity, especially in industries with higher sunk costs. The identifying assumption behind equation (25) is that union power is likely to be more binding in more sunk capital intensive sectors. As correctly noted by Bassanini and Garnero (2013), this approach

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

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

"allows us identifying only differential effects between binding and other 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, which directly stems from our theoretical model, that the effect of unions in non-binding industries is of the same sign and smaller than in union-binding industries or, alternatively, zero. In other words, union power tends to slow down the growth of labour productivity and 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 that unions tend to concentrate in sectors in which the degree of sunk capital investment is larger. As information on unionisation rates at the sectorial level for the countries in our sample is not readily available, to test this hypothesis we use US data and correlate the original measure of sunkness with sectorial data on union coverage and union density.[25] Reassuringly, results indicate a very small correlation between sunkness and union power (0.0797 for union coverage and 0.0827 for union density). Moreover, we have computed 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 have found 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 sectors, which in turn suggests that our measure of sunkness captures a technological characteristic of sectors and may not be related to union behaviour.

In equation (25) we take into account possible convergence effects by including in all regression specifications the log of the dependent variable at the beginning of the period. Moreover, country fixed effects should control for any omitted variable at the country level that has the same effect on investment and productivity growth 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 growth. Furthermore, our regression specification takes into account other possible determinants of industry

[25] 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 that 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, available at http://www.macalester.edu/research/economics/page/haveman/
Trade.Resources/Concordances/FromusSIC/87sic.to83cic.manuf.txt.

productivity and investment growth by including the relevant country and sector interactions $W_s' Z_c$, such as the country years of schooling and the sector human capital intensity in 1980; the country capital-output ratio and the sectorial physical capital intensity in 1980 and the industry dependence on external finance and the country level of financial development. The inclusion of $W_s' Z_c$ 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, level of financial development, etc.) and $Union_c$ are correlated: in this case, the omission of the relevant country-industry interactions would tend to bias the OLS estimates of α. In addition to this, there might be other country-level variables, potentially correlated with $Union_c$, that might interact with industry sunk capital intensity: hence, as a robustness check, in some regression specifications we also include additional interactions between $Sunk_s$ and country level variables such as financial development, human capital, employment protection legislation, other labour market institutions, rule of law, etc.

Finally, 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, human and physical capital intensity as well as industry dependence on external finance. Furthermore, given that there might be reasons to believe that causality might go in the other direction, namely from growth to union power (see below), we also estimate a version of equation (25) in which we instrument $Union_c$ with variables related to the political history of each country.

5 Results

5.1 Main Results

In Tables 4 and 6 we start testing the main implication of our model, namely that the growth rates of investment per worker and labour productivity are reduced particularly in high sunk cost industries in countries where labour unions have strong bargaining power, the latter mainly proxied by the average percentage of employees covered by wage bargaining agreements over the sample period.

In column 1 of both Tables we start with a parsimonious specification of equation (25), as we only control for the initial level of investment per worker (labour productivity) in 1980 as well as for both country and industry fixed effects. As we can see, the coefficient of the interaction between the industry degree of sunkness and union coverage is negative and strongly statistically significant in both regressions. In particular, the coefficient of -0.00791 in Table 4 implies a yearly investment growth differential of about 1.1% between a sector at the 75^{th} percentile (*Transport equipment*) and 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, with an average of 53.7% over the period 1980-2000) compared to a country at the 75^{th} percentile of union coverage (such as Spain, with an average of 83.6%). In the case of the growth rate of labour productivity, the coefficient reported in column 1 of Table 6 suggests a yearly growth differential of about 0.8% between two sectors at the 75^{th} and 25^{th} percentile of the sunk capital intensity distribution in a country at the 25^{th} percentile of the union coverage distribution compared to a country at the 75^{th} percentile of union coverage.

In column 2 of Tables 4 and 6 we start assessing the robustness of this result by including the relevant country-industry interactions contained in the matrix $W_s^{\prime}Z_c$ discussed in the previous section and commonly employed in cross country-industry growth regressions: we can see that the interaction between sunk intensity and union coverage remains negative and statistically significant. In column 3 we start adding country level variables that might be plausibly thought to affect investment per worker or labour productivity growth particularly in high sunk cost industries. First, we consider the role played by union density given that it has often been treated as an alternative to union coverage as a proxy for the bargaining power of unions: as we can see, the interaction term is very small and largely insignificant in both Tables, while the sunk intensity-union coverage interaction is remarkably stable. However if we drop the sunk-union coverage interaction in our baseline specification, the interaction of sunk and union density is negative and statistically significant, suggesting that measuring union bargaining power either with coverage or density does not matter much.

In column 4 we consider the role played by wage bargaining levels: because previous literature has found that the effect of bargaining levels may be non-linear, we interact $Sunk$ with two dummies for different levels of wage coordination, i.e., nation-wide and sectorial, with firm level bargaining being the omitted category. While our coefficient is barely unaltered, such interactions turn out to be largely statistically insignificant. In column 5 we add the interactions of *Sunk* with an indicator of coverage of unemployment benefits and with an OECD index of employment protection legislation (henceforth 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). Empirical results suggest that these two interactions are positive in both regressions, but that only the one involving EPL is statistically significant in the labour productivity regression. There might be different explanations for the positive effect of EPL: perhaps a more rigid labour market might tend to incentivise firms to invest in on the job training particularly in high sunk cost industries, given the likely relatively more limited scope in these industries to substitute capital for labour.[26]

Finally, in columns 6 and 7 we add interactions of *Sunk* with an indicator of barriers to foreign direct investments in the manufacturing sector and an indicator of the rule of law.[27] While the interaction between *Sunk* and barriers to foreign direct investment (henceforth FDI) is not statistically significant in both regressions, there is some evidence that countries with a stronger rule of law tend to have a higher growth rate of investment per worker in high sunk cost industries, probably reflecting the fact that a stronger rule of law might be associated to higher government commitment power not to use taxation to expropriate investors of the quasi rents generated by sunk investments.[28]

In Tables 5 and 7 we consider different extensions as well as additional robustness checks to our baseline regression. In column 1 we address possible endogeneity concerns of union coverage: first, there can be some country level omitted variables for which we have not controlled for that might tend to affect the growth rates of labour productivity and investment per worker especially in high sunk costs industries; alternatively, it might be argued that growth and union coverage are jointly determined if countries that tend to specialise in industries characterised by both slow growth in 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

[26] Some mild favorable empirical evidence for this pattern of the capital labour elasticity of substitution can be found in Oberfield and Raval (2012). See also Belot et al (2004).

[27] Countries with strong unions might have stronger incentives to attract foreign direct investments, as recently argued by Haufler and Mittermaier (2011).

[28] We have also separately included interaction of *Sunk* 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 were virtually unaltered. Regression results have been omitted for reasons of space.

column 1 of both Tables we report the result of an IV regression otherwise identical to that reported as column 2 of Tables 4 and 6 where we have instrumented 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.[29] The rationale for these two instruments is that right-wing dictatorships might have fought the development of the labour unions movement while, in turn, a strong presence of left wing parties in the governments might have favoured the growth of labour unions (Fiori et al, 2012). The first stage regression, whose results are available from the authors upon request, confirms our expectations and suggests that our instruments are not weak and pass the Sargan test of instrument validity.[30] The second stage regression displayed in column 1 of Tables 5 and 7 confirm that higher union coverage rates slow down growth in investment per worker and labour productivity particularly in sunk intensive industries, although the magnitude of the effect is reduced with respect to OLS estimates.

In column 2 we add an interaction between a country's union coverage rate and the industry R&D intensity for two reasons. The first is that R&D expenditure is often sunk and, therefore, to a certain extent, the industry R&D intensity might be considered as an alternative proxy of an 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 $Sunk$ and union coverage is not simply capturing the negative effect of union coverage on investment rates and productivity growth in R&D intensive industries. Empirical results displayed in column 2 do not confirm that this is the case, as the sunk-union coverage interaction is always negative and statistically significant; in turn, the R&D-union coverage interaction is negative but statistically significant only in the investment regression.[31] It is interesting to note that, if we drop the interaction between union coverage and sunk, we find that the interaction of the industry R&D intensity with union coverage is significant at 10% in both regressions. If we interpret the degree of R&D

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

[30] The Kleibergen-Paap test statistics are 55.5 and 44.2 in the investment per worker and labour productivity regressions, respectively; in turn, the Sargan test statistics are 0.75 (p value 0.102) and 1.9 (p value 0.16), respectively.

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

intensity as a different proxy for the importance of sunk costs, this result provides additional empirical evidence that union bargaining power might have negative effects in industries where sunk costs and the associated hold-up problem may be more important.

In column 3 we include an interaction between the union coverage rate and the industry physical capital intensity: controlling for this interaction is very important not only because the latter is positively correlated with the industry degree of sunkness, but because our theoretical model predicts that it is the sunk nature of capital investments to generate the hold-up problem, and not physical capital intensity per se. As the empirical results show, the union coverage-physical capital intensity interaction is never significant and the magnitude of the sunk intensity-union coverage interaction is barely altered.[32]

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 proxied union's bargaining power with the value taken by union coverage as of 1980. Econometric results displayed in column 4 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.[33]

So far we have not exploited the panel dimension of our dataset because, by focusing on the long run effects of union power, we think it is less likely that the empirical results are driven by short term dynamics related to business cycles effects. However, using the panel nature of our data allows us to exploit the substantial time variation in union power that has occurred over the sample period in some countries. Therefore, as a robustness check, we have estimated the following panel data version of our baseline equation (25):

$$\Delta \ln y_{s,c,t} = \alpha(Sunk_s * Union_{ct-1}) + \delta \ln y_{sct-1} + v_{st} + u_{ct} + \varepsilon_{sct} \tag{26}$$

[32] It is possible to argue (Baldwin, 1983) that firms in high sunk cost industries might tend to increase debt as a sort of committment device to be tough against unions. If this results in structurally higher dependence towards external finance in high sunk cost industries, then it might be important to control for an interaction betweenn 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. Finally, we have also run a regression where we have controlled for an interaction between union coverage with an industry's human capital intensity without affecting our main results. Results are available from the authors upon request.

[33] It is important to note that proxying union bargaining power with the beginning of the period union coverage does not alter none of our main results.

where $\Delta \ln y_{s,c,t}$ is the growth rate of investment per worker (labour productivity) between $t-1$ and t in sector s of country c; $\ln y_{sct-1}$ is the log of investment per worker (labour productivity) at $t-1$; $Union_{ct-1}$ is union coverage in country c at date $t-1$; v_{st} and u_{ct} are sector-by-year and country-by-year fixed effects, respectively; ε_{sct} is an error term and we consider the time interval to be five years.[34] Empirical results, available from the authors upon request, confirm the results of the cross sectional regressions, with $\alpha = -0.021$ (t stat -4.9) in the investment growth regression and $\alpha = -0.009$ (t stat -4.2) in the labour productivity growth regression.

In column 5 we have considered the possibility that it is not the level of union coverage per se to be important, but its change over the period: empirical results suggest that countries that experienced a larger increase in union coverage over the sample period had both a lower growth of investment per worker and labour productivity in high sunk cost industries, although the effect is estimated with noise in Table 7.[35] In column 6 instead we measure union's strength with the variable "bargaining power" recently used by Mueller and Philippon (2011). As we discussed in previous sections, 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. As we can see in both Table 5 and 7, the interaction between sunk and union bargaining power is negative, but statistically significant at conventional confidence levels in the investment regression only.

In column 7 we have added an interaction between *Sunk* and the degree of fragmentation of confederations of unions (see see the Appendix D2 below): 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. We find confirmation for this prediction in the data: in fact, empirical results suggest that countries where union membership is very fragmented tend to

[34] We consider t=1980, 1985, 1990, 1995, 2000. The inclusion of sector-by-year fixed effects controls 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 control for all unobserved country level variables that are unlikely to have a greater effect on investment and productivity growth particularly in high sunk capital industries.

[35] We have repeated the same exercise with the change in union density (but omitting union coverage), given the large changes that occurred during our sample period in the latter variable in many countries: results again suggest that countries where union density increased more over the period might have experienced a reduction in both labour productivity and investment per worker growth rates, although only in the latter case the effect is estimated with precision.

have a significantly lower investment growth in sectors characterised by a relatively higher share of sunk capital, while in the case of the productivity regression the coefficient of the interaction is highly insignificant.[36]

Finally, in column 8 we have interacted *Sunk* with a variable measuring the quality of the labour relations (Mueller and Philippon, 2011): 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 and labour productivity. However, when we control for the quality of labour relations (see the Appendix D2) we do not find confirmation of this effect, as the interaction between labour relations and *Sunk* is positive as expected (which means that countries with "bad" labour relations tend to display lower investment and productivity growth 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.[37]

5.2 Refinements

So far we have presented empirical evidence showing that union bargaining power tends to reduce the growth rates of investment per worker and labour productivity particularly in industries characterised by a relatively large fraction of sunk capital stock, 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 D2 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 there exist mandatory conciliation procedures before a strike can occur; in turn, in some countries it is forbidden for unions to strike if there is a collective agreement in

[36] We also run our baseline regressions splitting the sample into different groups of countries, depending on weather the fragmentation index was above or below the median. Both for investment and labour productivity growth regressions, we find that the negative effect of union coverage in sunk industries is much stronger in the case of countries with more fragmented union confederations. Results are available upon request.

[37] 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 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 have therefore augmented 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 was barely altered.

place, or there is a waiting or notification period before a strike can take place. For this reason, using information contained in Botero et al. (2004), we have run a series of baseline regressions (corresponding to column 2 of Tables 4 and 6) splitting the sample across some of the country-level dimensions of labour relations we have just mentioned. Before turning to the discussion of empirical results for the growth rate of investment per worker, 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 Table 8 we have split the sample according to the existence (column 2) or not (column 1) of a law that allows strikes when a collective agreement has been already signed.[39] The existence of such a regulation is important because one could expect that, if the law is in place, the hold-up problem should be significantly alleviated, 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.[40] Then we have split the sample according to whether there is (column 4) or not (column 3) in the country a mandatory waiting period before a strike can take place.[41] Econometric results show that higher union coverage tends to significantly slow down the growth of investment per worker particularly in high sunk capital industries for both country groups, but the magnitude of the effect seems to be notably smaller in countries where a notification or waiting period before a strike can occur is compulsory. In subsequent columns countries have instead been split according to whether there is (column 6) or not (column 5) a mandatory conciliation procedure: empirical results suggest that, in both country groups, union coverage negatively affect the growth of investment per worker, but that the magnitude is three times larger in countries where there is not a mandatory conciliation procedure.[42] In columns 7 and 8 the sample has been instead split according to whether in the country there is (column 8) or not (column 7) a

[38] Moreover, we do not explore the issue of why some regulations are in place in some countries but not in others. Qualitatively the results for labour productivity growth are very similar with one exception that we will discuss later. Results are available from the authors upon request.

[39] The countries in our sample where such regulation is not in place are the UK, France, Italy and the Netherlands.

[40] In the case of the labour productivity growth regression we do not see any notable difference in the magnitude of the effect between the two groups of countries.

[41] The countries where there was a mandatory waiting period were Canada, Denmark, Spain, Finland, Greece, Korea, Netherlands, Portugal and Sweden.

[42] Countries with mandatory concliation procedures were Australia, Denmark, Spain, Finland, Korea, Netherlands

mandatory arbitration procedure and we find that the negative impact of union coverage is higher in countries where there is no mandatory arbitration, while for countries where there is a compulsory and binding arbitration, the negative impact of union coverage is marginally statistically insignificant.[43]

Finally, we have considered, for each country, whether, for the majority of years included in our sample period, both unions and employers had been routinely involved in government decisions concerning social or economic policy issues (i.e., Social Pacts; see Visser, 2011).[44] In this case, our idea is that the government, by involving (always, or at least irregularly) unions and employers in economic policy decisions, creates a more cooperative framework between the parts and favors 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 we see that only in countries characterised by the absence of concertation higher coverage ratios are associated to slower growth in investment per worker in sunk capital intensive industries.

6 Concluding Remarks

In this paper, we test for the hold-up problem by considering the effect of union power on investment and productivity across sectors with different levels of sunk capital investments. We develop a search and matching model with sunk capital investments and ex-post collective wage bargaining and test the predictions of the model by considering the effects of unions' bargaining power on the rate of growth of investment per worker and hourly labour productivity. We use different sources of data on manufacturing sectors in two sets of partially overlapping OECD countries during the period 1980-2005.

Using a difference-in-difference approach, we verify that union power reduces the growth of investment per worker and labour productivity in industries with higher proportions of sunk physical capital. This result is robust to a series of sensitivity checks. First, we have controlled for other determinants of industry growth by means of interactions between a country factor abundance and an industry factor intensity. Second, we include interactions between sunk capital intensity and country level variables potentially correlated with union coverage such

[43] Countries with mandatory arbitration procedures were Australia, Spain and Korea.

[44] The countries where firms and unions were involved in economic policy decisions were Austria, Belgium, Canada, Germany, Denmark, Finland, Netherland, Portugal and Sweden.

as the change in union coverage over time, union density and its change over time, the coordination of wage bargaining, the coverage of unemployment benefits, the extent of employment protection legislation, the presence of barriers to foreign direct investments and the rule of law. Third, we examine whether our interaction between union coverage and sunk capital intensity partly captures other interactions of unions with industry features that might be correlated with sunk capital intensity, such as R&D and physical capital intensity. Finally, we have taken into account possible endogeneity concerns of union behaviour.

We refine our analysis using a set of indicators that reflect some aspects of industrial relations and that are directly related to collective disputes, union behaviour and involvement of unions and employers in government decisions on social and economic policy. In particular, we find that the effects of union power on investment and productivity is stronger when in a country there is the possibility of strikes even if there is a collective agreement in force, when there is no mandatory waiting period, there are no other alternative conciliation procedures or possibility of seeking third party arbitration. On the other hand, the effect of unions is less relevant when cooperative equilibria are sustainable: this happens when there is less fragmentation of union representation and when social pacts, by involving unions and employers in economic policy decisions, are in force.

Depending on model specification, our regression coefficients imply, in the case of investment per worker, an yearly growth differential of about 0.7-1.1 percentage points between a sector at the 75^{th} percentile and at the 25^{th}percentile of the sunk capital intensity distribution in a country at the 25^{th} percentile compared to a country at the 75^{th} percentile of union coverage distribution. The size of this effect is not negligible because, depending on model specification, it amounts to between one third to one half of the sample average differential in the rate of growth of investment per worker in the two sectors at the 25^{th} and 75^{th} percentile of the sunk intensity distribution, which is equal to 2.2 percentage points.

This result might be compared with that 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 the contractual incompleteness in labour relations and the resulting hold-up problem are a relevant phenomenon that might have sizeable effects on the growth of investment and labour productivity. On the other hand, there is some evidence that the system of industrial relations, by influencing the degree of contractual incompleteness, might 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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Appendices

A. Alternative Wage Bargaining

In this Appendix we sketch a different wage 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 (15) becomes:

$$(1-\beta)\cdot\frac{e_i-\frac{de_i}{dw(k_i)}\Pi_i^E}{e_i\left(\Pi_i^E-\Pi_i^V\right)}=\beta\cdot\frac{e_i+\frac{de_i}{dw(k_i)}\left(J_i^E-J^U\right)}{e_i\left(J_i^E-J^U\right)}\quad\text{for } i\in\{a,b\}. \tag{27}$$

It is easy to see that equation (27) coincides with (16) if $\frac{de_i}{dw(k_i)} = 0$. Such a derivative can be computed using equations (5), (6) and (11):

$$\frac{de_i}{dw(k_i)} = -\frac{1-\eta}{\eta} \frac{e_i \cdot q(\theta_i)}{p \cdot k_i \cdot (r+s) \cdot \gamma_i} \quad \text{for } i \in \{a, b\}. \tag{28}$$

The negative sign of this derivative implies that the share of rents accruing to workers is lower than in the scenario presented in Section 2.3. because unions take into account the negative effect on employment creation of a higher wage. Substituting equation (28) into equation (27) and proceeding as in Section 2.3., we can easily get the equivalent of the F.O.C. for k_i (19) in this scenario:

$$(1 - \beta \cdot \Omega)\, p_{Y_i} \cdot \alpha k_i^{\alpha-1} - p \frac{(r\, +\, s)\gamma_i + q(\theta_i)(1 - \beta \cdot \Omega)}{q(\theta_i)} = 0 \tag{29}$$

where $\Omega \equiv \frac{\eta(r+s)}{\eta(r+s)+1-\eta} \in (0, 1)$. Similarly, the equivalent of the zero profit condition (23) is:

$$\frac{(1 - \beta \cdot \Omega)\, p_{Y_i} k_i^{\alpha} \,+\, \dot{\Pi}_i^E}{[\,(r\, +\, s)\gamma_i \,+\, q(\theta_i)(1 - \beta \cdot \Omega + \beta \cdot \Omega \gamma_i \theta_i)\,]} = \frac{p \cdot k_i}{q(\theta_i)} \tag{30}$$

It can be easily shown that the non-arbitrage condition (20) takes the same form even in this scenario. Using (20), (29) and (23) we can follow the same steps of Appendix B in order to prove the existence of a steady state equilibrium and get the same dynamics and comparative statics results. The only difference is that the necessary and sufficient condition in Proposition 2, namely $\beta > \eta$, in this scenario become $\beta \cdot \Omega > \eta$.

B. Existence of Equilibrium

We look for the conditions that ensure the existence and uniqueness of a steady-state equilibrium. It is straightforward to notice 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 (19) by equation (23) evaluated at the steady-state (i.e. with $\dot{\Pi}_i^E = 0$). We get:

$$\mathbb{W}(\theta_i) \;\equiv\; \frac{1}{\alpha} \;-\; 1 \;-\; \frac{\beta \cdot \gamma_i \theta_i q(\theta_i)}{(r+s)\gamma_i \;+\; q(\theta_i)(1-\beta)} \;=\; 0 \tag{31}$$

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 (21) 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 non-arbitrage condition (21), 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:

$$\begin{aligned} p_{Ya} \cdot k_b^{\alpha-1} &= \frac{p\,\beta\,\gamma_a\,\theta_a}{(1-\alpha)(1-\beta)} \cdot \left(\frac{\theta_a\gamma_a}{\theta_b\gamma_b}\right)^{\alpha-1} \\ p_{Yb} \cdot k_b^{\alpha-1} &= \frac{p\,\beta\,\gamma_b\,\theta_b}{(1-\alpha)(1-\beta)} \end{aligned} \tag{32}$$

in which

$$\begin{aligned} p_{Ya} &= \left\{1 + \left[\frac{1-\lambda}{\lambda}\left(\frac{\theta_a\gamma_a}{\theta_b\gamma_b}\right)^{\alpha} \cdot \frac{\theta_b q(\theta_b)}{\theta_a q(\theta_a)}\right]^{\frac{\sigma-1}{\sigma}}\right\}^{\frac{1}{\sigma-1}} \\ p_{Yb} &= \left\{1 + \left[\frac{\lambda}{1-\lambda}\left(\frac{\theta_b\gamma_b}{\theta_a\gamma_a}\right)^{\alpha} \cdot \frac{\theta_a q(\theta_a)}{\theta_b q(\theta_b)}\right]^{\frac{\sigma-1}{\sigma}}\right\}^{\frac{1}{\sigma-1}} \end{aligned} \tag{33}$$

Notice that $\frac{d\,\mathbb{G}_a}{d\,\lambda} < 0$ and $\frac{d\,\mathbb{G}_a}{d\,k_b} < 0$. 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 fa as it concerns $\mathbb{G}_b = 0$, $\frac{d\,\mathbb{G}_b}{d\,\lambda} > 0$ and $\frac{d\,\mathbb{G}_b}{d\,k_b} < 0$. 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 1 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 non-arbitrage condition (21). 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.

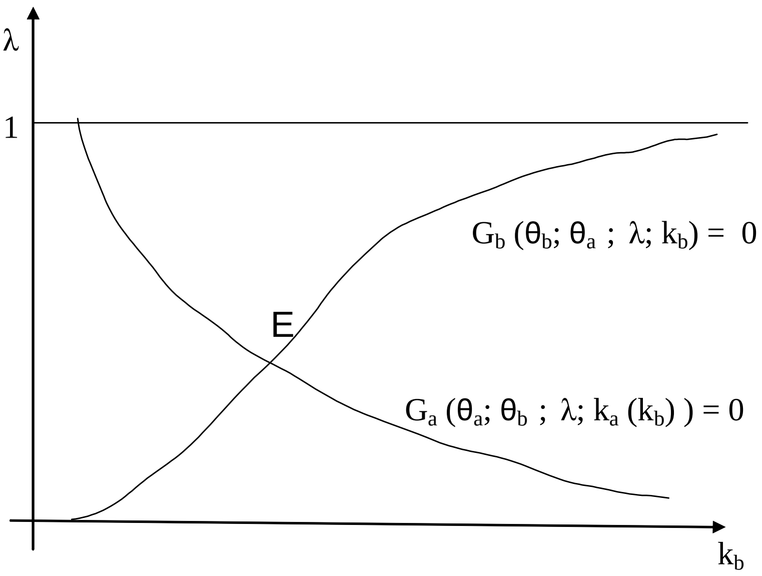

Figure 1: Equilibrium

C. Dynamics of the System and Comparative Statics

C1. Dynamics of the System

We first express (23) as a first-order non linear differential equation in θ_i. To do so, rearranging eqs. (2), (5), (21) and (6) we have

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

If we divide the first equation in (32) 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 $i \in \{a, b\}$):

$$\frac{1-\lambda}{\lambda} = \left(\frac{\gamma_a}{\gamma_b}\right)^{\alpha\cdot\sigma-\alpha} \cdot \left(\frac{\theta_a}{\theta_b}\right)^{1-\eta+\alpha\cdot\sigma-\alpha} \tag{34}$$

Plugging the RHS of (34) into the second equation in (32) allows us to have an equation in which k_b depends on θ_a and θ_b only:

$$k_b^{\alpha-1} \cdot \left[1 + \left(\frac{\theta_a\gamma_a}{\theta_b\gamma_b}\right)^{-\alpha(\sigma-1)}\right]^{\frac{1}{\sigma-1}} - \frac{p\,\theta_b\gamma_b}{(1-\alpha)}\frac{\beta}{1-\beta} = 0 \tag{35}$$

From the (21), we also get:

$$k_a^{\alpha-1}\cdot\left[1+\left(\frac{\theta_a\gamma_a}{\theta_b\gamma_b}\right)^{\alpha(\sigma-1)}\right]^{\frac{1}{\sigma-1}} \;-\; \frac{p\,\theta_a\gamma_a}{(1-\alpha)}\frac{\beta}{1-\beta} \;=\; 0 \tag{36}$$

Differentiating (10), we also get:

$$\dot{\Pi}_i^E \;=\; \gamma_i\left[\frac{d\,k_i}{d\,\theta_i}\cdot\frac{1}{q(\theta_i)} \;-\; k_i\frac{q'(\theta_i)}{q^2(\theta_i)}\right]\dot{\theta}_i \quad \text{with } i\in\{a,\,b\} \tag{37}$$

Plugging (35), (36), and (37) into (23) and using $\mathbb{G}_i = 0$ with $i \in \{a, b\}$, we get:

$$\begin{aligned}
\dot{\theta}_a &= p\frac{(1-\beta)(1-\alpha)\theta_a((1-\beta)q(\theta_a)+(r+s)\gamma_a)+\beta\gamma_a(\theta_a)^2q(\theta_a)(-1+(1-\beta)(1-\alpha))}{(\gamma_a(1-\beta)\,(1-\alpha))\left(-\frac{1-\alpha\tau_a}{1-\alpha}+\eta\right)}\\
\dot{\theta}_b &= p\frac{(1-\beta)(1-\alpha)\theta_b((1-\beta)q(\theta_b)+(r+s)\gamma_b)+\beta\gamma_b(\theta_b)^2q(\theta_b)(-1+(1-\beta)(1-\alpha))}{(\gamma_b(1-\beta)\,(1-\alpha))\left(-\frac{1-\alpha\tau_b}{1-\alpha}+\eta\right)}
\end{aligned} \tag{38}$$

in which:

$$\tau_i \;=\; \frac{\left(\frac{\theta_i\gamma_i}{\theta_j\gamma_j}\right)^{\alpha(\sigma-1)}}{1+\left(\frac{\theta_i\gamma_i}{\theta_j\gamma_j}\right)^{\alpha(\sigma-1)}}\text{with } \; i,j\in\{a,\,b\}\,, i\neq j \tag{39}$$

Notice that the unique equilibrium of the system is hyperbolic. After linearising the system in (38) around the steady state, it is easy to see that both eigenvalues of the Jacobian matrix are positive, and therefore the steady state is an unstable node. Moreover, for the implicit function $\mathbb{G}_i(\theta_i, \theta_j,\, \lambda, k_i, k_j) = 0$, the capital investment per worker k_i also has the same behaviour for $i \in \{a, b\}$. So, when a positive shock to β hits the economy, k_i will adjust immediately to its new steady-state value.

C2. Comparative Statics

Proof of Proposition 2. We need to prove the inequalities in equation (24). 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 (35) is decreasing in β. Differentiating equation (35) we have:

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

where the derivatives

$$\frac{d\theta_i}{d\beta} = -\frac{\theta_i}{\beta}\frac{\gamma_i(r+s)+q(\theta_i)}{(1-\eta)\gamma_i(r+s)+(1-\beta)q(\theta_i)} \qquad \text{for } i \in \{a,b\} \tag{40}$$

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

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

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 $\frac{dk_a}{d\beta}$, notice that

$$\frac{d\frac{k_b}{k_a}}{d\beta} = \frac{k_b}{k_a}.\left(\frac{dk_b}{d\beta}\frac{1}{k_b} - \frac{dk_a}{d\beta}\frac{1}{k_a}\right). \tag{41}$$

So $\frac{d\frac{k_b}{k_a}}{d\beta} > 0$ is a necessary and sufficient condition to prove that both inequalities in (24) are verified. Using the non arbitrage condition in (21), we get:

$$\frac{d\frac{k_b}{k_a}}{d\beta} = \frac{\gamma_a\gamma_b\left(\frac{d\theta_a}{d\beta}\theta_b - \frac{d\theta_b}{d\beta}\theta_a\right)}{\left(\theta_b.\gamma_b\right)^2}. \tag{42}$$

Substituting (40) into (42) 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 $\gamma_a q(\theta_b) > \gamma_b q(\theta_a)$.[45] We conclude that $\frac{d\frac{k_b}{k_a}}{d\beta} > 0 \Leftrightarrow \beta > \eta$. Therefore the condition in equation (24) is verified.

[45] Details are available upon request from the authors.

The average productivity of labour is equal to k_i^α for $i \in \{a, b\}$.[46] 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 (24), 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 $\beta > \eta$.

D. Data Appendix

D1. Conversion of Sectors and Weights

Although detailed information and appropriate routines are available upon request, in this subsection 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 and labour productivity are available at the ISIC Rev2 – 3 digits level (28 industries) and ISIC Rev3.1 – 2 digits level (23 industries), respectively. Hence, we first aggregate the sunk capital index at the 2 and 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.[47] 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). Finally, depending on different classification systems, we use similar procedures for the other industry level variables mentioned above and reported in Tables 1 and 2, i.e., physical capital intensity, external financial dependence, human capital intensity

[46] Recall that in each intermediate sector $Y_i = k_i^\alpha \cdot e_i$

[47] See http://www.macalester.edu/research/economics/page/haveman/Trade.Resources/tradeconcordances.html#FromusSIC

and R&D intensity.

D2. 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 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 coverage of unemployment benefits and employment protection legislation. We derive a measure of coverage of unemployment benefits from the FRDB database on labour market institutions (see Aleksynska and Schindler, 2011), the latter is calculated as the number of individuals who, at a given point in time, receive UI benefits relative to the number of unemployed. 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 above, 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 to 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.[48] 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 growth of investment and labour productivity as the physical capital to output ratio, the schooling level of the population aged 15 or more and the level of financial development. These variables come from conventional sources: financial development is measured as the ratio between domestic credit to private sector and GDP in 1980 and is taken from the World

[48] As explained in Botero et al (2004), the term "compulsory arbitration" refers to a law that imposes arbitration of private disputes even against the will of the parties. It may influence workers bargaining power in two ways, namely by granting them an alternative to costly strikes in case of deadlocks in the negotiation process, but it may also limit their right to strike.

Bank Global Development Finance database; from the Barro and Lee (2001) dataset we extract different measures of schooling at the country level such as years of schooling in the population with more than 25 years in 1980, while we compute the capital to 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.

Table 1: Descriptive Statistics, Main Sector Level Variables. UNIDO dataset

Sector (ISIC Rev2 Classification)	Investment Worker Growth	Sunk Capital Intensity	Physical Capital Intensity	External Financial Intensity	Human Capital Intensity	R&D Intensity
Beverages	0.0163	0.9605	1.7444	0.0772	11.3830	0.0115
Fabricated metal products	0.0373	0.8867	1.2548	0.2371	11.8440	.
Food products	0.0176	0.9376	1.3656	0.1368	11.3830	0.0115
Footwear, except rubber or plastic	0.0204	0.8766	0.4433	-0.0779	10.5209	0.0060
Furniture, except metal	0.0147	0.9040	0.7892	0.2357	11.5205	0.0163
Glass and products	0.0255	0.9706	1.9543	0.5285	11.4111	0.0202
Industrial chemicals	0.0147	0.9607	2.4068	0.2000	12.9635	0.1463
Iron and steel	0.0219	0.8700	2.1253	0.0871	11.4270	0.0202
Leather products	0.0258	0.8935	0.6374	-0.1400	10.5209	0.0060
Machinery, electric	0.0513	0.9309	0.9354	0.7675	12.4389	0.0749
Machinery, except electrical	0.0450	0.8930	0.9685	0.4453	11.8739	0.0295
Miscellaneous petroleum and coal product	0.0382	0.8923	1.1991	0.3341	13.1708	0.1042
Non-ferrous metals	0.0115	0.9186	2.0132	0.0055	11.4270	0.0202
Other chemicals	0.0435	0.9493	0.8002	0.2187	12.9635	0.1463
Other manufactured products	0.0081	0.9009	0.8782	0.4702	11.5205	0.0163
Other non-metallic mineral products	0.0192	0.9171	2.9001	0.0620	11.4111	0.0202
Paper and products	0.0170	0.9251	2.2146	0.1756	11.7346	0.0080
Petroleum refineries	-0.0139	0.9744	2.5929	0.0420	13.1708	0.1042
Plastic products	0.0229	0.9353	1.8958	1.1401	11.7338	0.0267
Pottery, china, earthenware	0.0191	0.9436	0.9032	-0.1459	11.4111	0.0202
Printing and publishing	0.0277	0.9061	0.7850	0.2038	12.2466	0.0080
Professional and scientific equipment	0.0261	0.9169	0.6542	0.9610	12.6221	0.1233
Rubber products	0.0135	0.9255	1.7246	0.2265	11.7338	0.0267
Textiles	0.0070	0.9212	1.8065	0.4005	10.5165	0.0060
Tobacco	-0.0023	0.9473	0.7304	-0.4512	11.2078	0.0115
Transport equipment	0.0476	0.9414	1.3201	0.3069	12.8481	0.0010
Wearing apparel, except footwear	0.0147	0.8967	0.4818	0.0286	10.5816	0.0060
Wood products, except furniture	0.0145	0.8582	1.6321	0.2840	10.6958	0.0428
Total	0.0219	0.9198	1.3985	0.2414	11.7244	0.0383

Note: Investment per worker growth is 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, average 1987-1992. Physical capital intensity is the ratio between real gross capital stock and value added in the US in 1980. External financial dependence for 1980 is directly derived from Rajan and Zingales (1998). Human capital intensity is calculated as average years of schooling of workers at the sectoral level in the US (see Ciccone and Papaioannou, 2009). R&D intensity is R&D expenditure to value added in US in 1990.

Table 2: Descriptive Statistics, Main Sector Level Variables. EUKLEMS dataset

Sector (ISIC Rev3.1 Classification)	Labour Productivity Growth	Sunk Capital Intensity	Physical Capital Intensity	External Financial Intensity	Human Capital Intensity	R&D Intensity
Electrical machinery and apparatus, nec	0.0456	0.9309	0.9596	1.0388	12.4389	0.0749
Radio, television and communication equi	0.0959	0.9309	0.8286	0.7675	12.5150	0.2293
Textiles	0.0240	0.9212	1.8065	0.4005	10.5165	0.0060
Wearing Apparel, Dressing and Dying of F	0.0267	0.8968	0.4808	0.0286	10.5816	0.0060
Basic metals	0.0417	0.9273	2.7457	0.0286	11.4270	0.0202
Chemicals and chemical products	0.0514	0.9575	1.7785	0.2088	12.9635	0.1463
Coke, refined petroleum and nuclear fuel	0.0311	0.9569	2.4152	0.0793	13.1708	0.1042
Fabricated metal	0.0205	0.8784	1.1735	0.2371	11.8440	.
Food and beverages	0.0268	0.9419	1.4344	0.1260	11.3830	0.0115
Leather, leather and footwear	0.0202	0.8835	0.5296	-0.1035	10.5209	0.0060
Machinery, nec	0.0300	0.8994	1.0227	0.4453	11.8739	0.0295
Manufacturing nec	0.0256	0.9009	0.8357	0.3492	11.5205	0.0163
Medical, precision and optical instrumen	0.0429	0.9169	0.6542	0.9610	12.6221	0.1233
Motor vehicles, trailers and semi-traile	0.0369	0.9414	2.2475	0.3891	11.6078	0.2518
Office, accounting and computing machine	0.1014	0.8994	0.6910	1.0598	13.4828	0.5196
Other non-metallic mineral	0.0318	0.9121	1.9175	0.1228	11.4111	0.0202
Other transport equipment	0.0316	0.9414	0.7056	0.3069	12.8481	0.0010
Printing, publishing and reproduction	0.0242	0.9061	0.7850	0.2038	12.2466	0.0080
Pulp, paper and paper	0.0350	0.9251	2.2146	0.1756	11.7346	0.0080
Recycling	0.0652	.	1.3251	0.4702	10.5165	.
Rubber and plastics	0.0355	0.9118	1.5624	0.9231	11.7338	0.0267
Tobacco	0.0320	0.9473	0.7304	-0.4512	11.2078	0.0115
Wood and of wood and cork	0.0262	0.8582	1.6321	0.2651	10.6958	0.0428
Total	0.0388	0.9175	1.3251	0.3492	11.7766	0.0792

Note: Labour productivity growth is average value added per hour during the period 1980-2005. Sunk capital intensity is one minus the share of used capital investment in total capital investment outlays, average 1987-1992. Physical capital intensity is the ratio between real gross capital stock and value added in the US in 1980. External financial dependence for 1980 is directly derived from Rajan and Zingales (1998). Human capital intensity is calculated as average years of schooling of workers at the sectoral level in the US (see Ciccone and Papaioannou, 2009).
R&D intensity is proxied by the R&D expenditure to value added ratio in the US in 1990.

Table 3: Descriptive Statistics, Main Country Level Variables 1980-2005

Country	Average Union Coverage	Change Union Coverage	Union Density	Employment Protection	Rule Law	Bargaining Power	Fragmentation Index	Quality Index
Australia	67.1429	-0.4118	35.4462	1.0590	7.3000	4.9000	1.2000	5.8000
Austria	97.6250	0.0421	44.1462	2.1700	8.0000	5.5000	1.0000	7.6000
Belgium	96.1250	-0.0103	52.8885	2.7300	7.8000	5.2000	2.2988	5.2000
Germany	69.0538	-0.1859	29.9808	2.7600	7.7000	5.3000	1.5003	7.0000
Denmark	83.2222	0.0122	76.2308	1.9286	7.2000	5.0000	1.9925	7.7000
Spain	85.0875	0.1533	14.0231	3.3414	6.3000	4.6000	2.9700	5.7000
Finland	87.1692	0.1688	73.9385	2.1586	6.8000	6.0000	2.8037	7.1000
France	89.5714	0.0588	10.8115	2.9343	6.8000	4.4000	6.9877	4.4000
United Kingdom	43.0438	-0.5085	37.9692	0.6362	7.0000	3.5000	1.3072	6.9000
Greece	67.1429	-0.0714	32.7154	3.4043	5.6000	4.3000	1.8995	4.8000
Ireland	58.3143	-0.1402	52.0615	0.9557	7.1000	4.8000	1.1960	7.1000
Italy	82.4231	-0.0588	39.1731	3.0233	5.7000	4.6000	2.8237	5.0000
Japan	22.2538	-0.4071	25.0269	1.6719	7.9000	4.2000	3.4742	7.7000
South Korea	13.2269	.	13.2269	2.3850	6.5000	4.6000	.	3.6000
The Netherlands	85.0000	0.0000	25.6923	2.5267	7.5000	5.2000	4.1162	7.7000
Portugal	68.0500	-0.1429	31.9000	3.8329	8.0000	3.8000	1.5000	6.3000
Sweden	90.0000	0.1059	81.5538	2.7600	6.6000	5.8000	2.3300	7.4000
United States	18.0885	-0.4669	15.5346	0.2100	8.3000	4.1000	1.6803	6.2000
Total	67.9189	-0.1096	38.4622	2.2493	7.1167	4.7667	2.3883	6.2889

Note: Average union coverage is the number of employees covered by wage bargaining agreements as a proportion of all wage and salary earners in employment. Change in union coverage is the absolute difference of union coverage between 1980 and 2005. 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 a index obtained by direct interviews with managers of firms. See the text for more details and sources of data.

Table 4: Baseline Regressions: Growth of Investment per Worker

Dependent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Growth of Investment per Worker	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg
Sunk Capital Intensity ×	-0.00791***	-0.00710***	-0.00610**	-0.00704***	-0.0101**	-0.00735***	-0.00740***
Union Coverage	(0.00241)	(0.00243)	(0.00257)	(0.00256)	(0.00451)	(0.00239)	(0.00237)
Sunk Capital Intensity ×			-0.00280				
Union Density			(0.00314)				
Sunk Capital Intensity ×				-0.00489			
High Wage Coordination				(0.23112)			
Sunk Capital Intensity ×				0.01933			
Med. Wage Coordination				(0.21183)			
Sunk Capital Intensity ×					0.537		
Unemployment Benefits					(0.645)		
Sunk Capital Intensity ×					0.00761		
EPL					(0.105)		
Sunk Capital Intensity ×						-0.0757	
FDI Regulation						(0.0913)	
Sunk Capital Intensity ×							0.107*
Rule of Law							(0.0627)
Initial Conditions	-0.0588***	-0.0602***	-0.0602***	-0.0602***	-0.0601***	-0.0602***	-0.0600***
	(0.00813)	(0.00820)	(0.00822)	(0.00829)	(0.00809)	(0.00818)	(0.00815)
Constant	0.609***	0.179	0.192	0.155	0.105	0.335	-0.511
	(0.152)	(0.214)	(0.216)	(0.323)	(0.342)	(0.269)	(0.481)
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	266	266	266	266	266	266	266
R-squared	0.743	0.750	0.751	0.750	0.752	0.751	0.753

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. All regressions include country and sector fixed effects.
Controls include interactions between sectoral human capital intensity and country level of schooling; sectoral external financial dependence and country financial development, sectoral physical capital intensity and country capital output ratio. Initial conditions is investment in 1980.
Sunk capital intensity is one minus the share of used capital investment in total capital investment outlays.
Union coverage, Union density, EPL and Rule of law are defined in Tables 1 and 2. Wage coordination is an index of coordination of wage bargaining. Fragmented bargaining, mostly at company level, is the omitted category.
Unemployment benefits is the share of benefit recipients over the total number of unemployed. FDI regulation is a measure of barriers to foreign direct investment from the OECD.

Table 5: Refinements: Growth of Investment per Worker

Dependent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Growth of Investment per Worker	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg
Sunk Capital Intensity ×	-0.00528**	-0.00533**	-0.00694***				-0.0132***	-0.00766***
Union Coverage	(0.00247)	(0.00266)	(0.00258)				(0.00355)	(0.00254)
R&D Intensity ×		-0.00332*						
Union Coverage		(0.00176)						
Physical Capital Intensity ×			-4.40e-05					
Union Coverage			(0.000150)					
Sunk Capital Intensity ×				-0.0112***				
Union Coverage 1980				(0.00404)				
Sunk Capital Intensity ×					-0.869***			
Change Union Coverage					(0.279)			
Sunk Capital Intensity ×						-0.186**		
Bargaining Power						(0.078)		
Sunk Capital Intensity ×							-0.091***	
Union Fragmentation							(0.0349)	
Sunk Capital Intensity ×								0.0483
Labour Relations								(0.0545)
Initial Conditions	-0.0599***	-0.0595***	-0.0603***	-0.0620***	-0.0623***	-0.0594***	-0.0627***	-0.0602***
	(0.00751)	(0.00944)	(0.00832)	(0.00869)	(0.00859)	(0.00823)	(0.00868)	(0.00829)
Constant	0.0528	0.110	0.169	0.618*	-0.426**	0.505	0.805	-0.0102
	(0.208)	(0.225)	(0.227)	(0.358)	(0.178)	(0.375)	(0.299)	(0.247)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	266	256	266	238	238	266	238	266
R-squared	0.750	0.732	0.750	0.752	0.752	0.745	0.762	0.751

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. All regressions include country and sector fixed effects.
Controls include interactions between sectoral human capital intensity and country level of schooling; sectoral external financial dependence and country financial development, sectoral physical capital intensity and country capital output ratio. Initial conditions is investment in 1980.
Sunk capital intensity is one minus the share of used capital investment in total capital investment outlays.
R&D intensity and Physical capital intensity are defined in Tables 1 and 2. Union coverage, Change in union coverage, Union density, Union fragmentation, Bargaining power and Labour relations are defined in Table 3.

Table 6: Baseline Regressions: Growth of Labour Productivity

Dependent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Growth of Labour Productivity	lpg	lpg	lpg	lpg	lpg	lpg	lpg
Sunk Capital Intensity ×	-0.00625***	-0.00582***	-0.00595***	-0.00666***	-0.00877**	-0.00592***	-0.00583***
Union Coverage	(0.00202)	(0.00190)	(0.00235)	(0.00219)	(0.00394)	(0.00193)	(0.00191)
Sunk Capital Intensity ×			0.000369				
Union Density			(0.00235)				
Sunk Capital Intensity ×				0.24916			
High Wage Coordination				(0.1783)			
Sunk Capital Intensity ×				0.21212			
Med. Wage Coordination				(0.1554)			
Sunk Capital Intensity ×					0.173		
Unemployment Benefits					(0.409)		
Sunk Capital Intensity ×					0.130**		
EPL					(0.0579)		
Sunk Capital Intensity ×						0.0522	
FDI Regulation						(0.0596)	
Sunk Capital Intensity ×							0.00381
Rule of Law							(0.0611)
Initial Conditions	-0.0373***	-0.0374***	-0.0375***	-0.0376***	-0.0374***	-0.0372***	-0.0374***
	(0.00282)	(0.00268)	(0.00269)	(0.00268)	(0.00265)	(0.00270)	(0.00265)
Constant	0.527***	0.533***	0.531***	0.380*	0.413**	0.429**	0.508
	(0.127)	(0.179)	(0.180)	(0.221)	(0.198)	(0.211)	(0.421)
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	347	347	347	347	347	347	347
R-squared	0.748	0.750	0.750	0.751	0.754	0.750	0.750

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. All regressions include country and sector fixed effects.
Controls include interactions between sectoral human capital intensity and country level of schooling; sectoral external financial dependence and country financial development, sectoral physical capital intensity and country capital output ratio. Initial conditions is productivity in 1980.
Sunk capital intensity is one minus the share of used capital investment in total capital investment outlays.
Union coverage, Union density, EPL and Rule of law are defined in Tables 1 and 2. Wage coordination is an index of coordination of wage bargaining. Fragmented bargaining, mostly at company level, is the omitted category.
Unemployment benefits is the share of benefit recipients over the total number of unemployed. FDI regulation is a measure of barriers to foreign direct investment from the OECD.

Table 7: Refinements: Growth of Labour Productivity

Dependent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Growth of Labour Productivity	lpg	lpg	lpg	lpg	lpg	lpg	lpg	lpg
Sunk Capital Intensity ×	-0.00425*	-0.00574***	-0.00644***				-0.00610***	-0.00613***
Union Coverage	(0.00242)	(0.00212)	(0.00207)				(0.00249)	(0.00187)
R&D Intensity ×		-0.000512						
Union Coverage		(0.000436)						
Physical Capital Intensity ×			0.000108					
Union Coverage			(0.000104)					
Sunk Capital Intensity ×				-0.00820***				
Union Coverage 1980				(0.00235)				
Sunk Capital Intensity ×					-0.129			
Change Union Coverage					(0.232)			
Sunk Capital Intensity ×						-0.0531		
Bargaining Power						(0.0589)		
Sunk Capital Intensity ×							0.00343	
Union Fragmentation							(0.0027)	
Sunk Capital Intensity ×								0.0367
Labor Relations								(0.0383)
Initial Conditions	-0.0373***	-0.0372***	-0.0372***	-0.0375***	-0.0381***	-0.0370***	-0.0387***	-0.0378***
	(0.00251)	(0.00288)	(0.00269)	(0.00263)	(0.00286)	(0.00283)	(0.00271)	(0.00264)
Constant	0.433**	0.521***	0.576***	0.781***	0.0430	0.394	0.498***	0.388
	(0.201)	(0.188)	(0.194)	(0.221)	(0.137)	(0.266)	(0.217)	(0.238)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	347	330	347	347	325	347	315	347
R-squared	0.749	0.749	0.751	0.754	0.736	0.742	0.743	0.751

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. All regressions include country and sector fixed effects.
Controls include interactions between sectoral human capital intensity and country level of schooling; sectoral external financial dependence and country financial development, sectoral physical capital intensity and country capital output ratio. Initial conditions is productivity in 1980.
Sunk capital intensity is one minus the share of used capital investment in total capital investment outlays.
R&D intensity and Physical capital intensity are defined in Tables 1 and 2. Union coverage, Change in union coverage, Union density, Union fragmentation, Bargaining power and Labour relations are defined in Table 3.

Table 8: The Effect of Strikes, Arbitration and Social Pacts: Growth of Investment per Worker

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg	inv_wrkg
	Stikes After Contract		Waiting Period for Strikes		Conciliation Procedures		Arbitration		Social Pact	
	Yes	No	No	Yes	No	Yes	No	Yes	No	Yes
Sunk Int. ×	-0.0143**	-0.00671***	-0.0117***	-0.00310*	-0.0115***	-0.00302*	-0.0122***	-0.00201	-0.00487**	0.00188
Un. Cov.	(0.00503)	(0.00241)	(0.00432)	(0.00186)	(0.00413)	(0.00151)	(0.00392)	(0.00180)	(0.00191)	(0.0155)
Init. Cond.	-0.000481	-0.0616***	-0.0627***	-0.0497***	-0.0646***	-0.0352***	-0.0643***	-0.0347***	-0.0326***	-0.0697***
	(0.0125)	(0.00819)	(0.0103)	(0.00354)	(0.00878)	(0.00491)	(0.00866)	(0.00629)	(0.00489)	(0.00882)
Constant	1.087*	0.115	0.414	0.509**	0.0418	0.294	0.956**	0.154	0.0209	-0.0634
	(0.510)	(0.225)	(0.461)	(0.199)	(0.237)	(0.206)	(0.415)	(0.216)	(0.184)	(1.337)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	48	218	138	128	166	100	192	74	170	96
R-squared	0.879	0.770	0.776	0.827	0.793	0.767	0.780	0.798	0.727	0.848

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. All regressions include country and sector fixed effects. Controls include interactions between sectoral human capital intensity and country level of schooling; external financial dependence and country financial development, physical capital intensity and country capital output ratio. Initial conditions is investment in 1980. Sunk intensity and Union coverage are defined in Tables 1,2 and 3. See the text for definitions of other variables.