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A Model of Unions, Two-Tier Bargaining and Capital Investment*

Gabriele Cardullo Maurizio Conti Giovanni Sulis

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Abstract

In this paper we present a search and matching model with unions in which firms invest in sunk capital equipment. By comparing two wage setting scenarios, we show that a two-tier bargaining scheme, where a fraction of the salary is negotiated at firm level, raises the amount of investment per worker in the economy compared to a one-tier bargaining scheme, in which earnings are entirely negotiated at sectoral level. In two-tier schemes wages depend on the labour productivity at firm level. This reduces the expected duration of a vacancy for capital intensive firms, as they attract a larger number of job seekers. Capital remains unused for less time, boosting investment in the first place. The model's main result is consistent with the positive correlation between investment per worker and the presence of a two-tier bargaining agreement that we find in a representative sample of Italian firms.

Keywords: Unions, Investment, Hold-up, Two-Tier Bargaining.
J.E.L. Classification: J51, J64, E22.

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1 Introduction

There is an important literature in labour economics that looks at the effects of unions on firm performance (see the recent contribution by Doucouliagos et al. (2017)). This body of research emphasises the role of the wage bargaining environment in which unions operate as a potential key determinant of firm behaviour and labour market outcomes.

Indeed, the role of unions is likely to be different in centralised versus decentralised bargaining systems, in coordinated versus non-coordinated environments or when bargaining takes place both at the sector (centralised) and firm (decentralised) level, the so-called two-tier bargaining system (Boeri, 2014), which grants some degree of flexibility to firms and unions to deviate from terms decided at higher level agreements (Garnero, 2020). Interestingly, despite the increasing importance over time of multi-level (two-tier) bargaining arrangements in a number of European countries, their economic effects on employment, productivity and investment are still poorly understood, as highlighted by Boeri (2014); Addison (2016); Hijzen et al. (2019). Survey data for a representative sample of Italian firms, which we discuss in more detail in Section 3, reveal the existence of a negative correlation between the level of investment per worker and the presence of unions within the firm, which is however fully offset by the presence of a two-tier wage bargaining agreement.[1]

To address these issues, in this paper we build up a model in which there are unions and labour markets present frictions. Firms, that differ in terms of total factor productivity, choose the amount of investment in capital equipment before a job vacancy is filled and the wage negotiation occurs. So an hold-up problem arises, whose effects on firms' investment decision are compounded by the presence of labour market frictions. Indeed, the longer the expected duration of a job vacancy, the larger is the opportunity cost of unused capital, and the lower the incentive to invest in the first place.

[1]In a seminal contribution, Grout (1984) provides a theoretical framework to study the role of unions in determining physical capital investment and the resulting hold-up mechanism. In Section 2 we discuss in more detail the previous literature on the effects of unions on investment and point out towards different mechanisms that link wages, productivity and investment in unionised labour markets.

We compare the effects on capital investment of two different wage mechanisms: a one-tier bargaining system, fully centralised, and a two-tier scenario, in which a fraction of the salary is negotiated at firm level.[2] We show that, if some conditions are fulfilled, the two-tier wage negotiation raises the level of investment per worker in the economy. The reason goes as follows. While under one-tier bargaining wages are affected by the average labour productivity in the sector, in a two-tier bargaining scenario the salary partially depends on the productivity of the single firm. More capital intensive firms, that pay higher wages, face a lower expected duration for a vacancy, as better earnings attract more job seekers. In turn, if job positions get filled more rapidly capital remains unused for less time. The hold up problem is less severe and investment increases. Of course, the same chain of effects, but with opposite sign, occurs for less capital intensive firms, that may decide to invest less under a two-tier bargaining scheme. However, we show that when the real interest rate is close to zero, the higher opportunity cost of capital for this type of firms is never strong enough to outweigh the increase in investment for capital intensive firms. In the end, the amount of capital equipment per worker in the economy goes up.

We contribute to the literature, which is surveyed in detail in the next section, in two main directions. First, we propose a theoretical model with unions and two-tier bargaining that is able to deliver general empirical predictions on capital investment. To the best of our knowledge, this is one of the very few attempts to model two-tier bargaining structures available in the literature. Second, we provide descriptive evidence on the effects of unions and two-tier wage bargaining on investment for the case of a country, Italy, traditionally characterized by high union power and highly centralised wage bargaining, while most of the available evidence is for the US or for a very limited number of EU countries, as the UK and Germany.

[2]This second scenario aims to represent that particular kind of two-tier wage schemes, widespread in Continental Europe, in which the so-called "favorability principle" applies (see (Boeri, 2014)). Under this framework, firm or plant-level agreements (the second tier of the negotiation) cannot envisage conditions that would make workers worse off than they are under the higher, sectoral, level of bargaining. In Section A.1 we present the Italian institutional background.

The remainder of the study is organized as follows. In Section 2 we discuss the relation of our paper to the previous literature, in Section 3 we provide motivating evidence, in Sections 4 and 5 we present the theoretical model, while Section 6 concludes. We gather information on the institutional background and the data in the Appendix, where we also include additional empirical results and theoretical proofs.

2 Related Literature

The paper is related to different strands of literature. First, it is related to studies that deal with the effects of unions on investment in physical and intangible capital (see Menezes-Filho and Van Reenen (2003) for a review). In this literature the impact of unions on firms' investment plays a central role, as the latter is one of the key mediating channels that might explain the existence of productivity differentials across unionised and non-unionised firms (Addison, 2018). From a theoretical point of view, if unions manage to increase the relative price of labour (by pushing up wages), investment per worker might increase following unionisation through a capital labour substitution type of effect, unless the price increase is large enough to drive down sales and profitability too much.[3] By way of contrast, it has been shown, using different theoretical frameworks, that, under certain conditions, the absence of complete contracts might lead firms to underinvest in both tangible and intangible assets when their nature is largely sunk.

The lack of a clear consensus on the theoretical effects of unions on firms' investment is matched by mixed evidence in the empirical literature as well. While Hirsch (2004) reports negative effects of unions on investment in physical capital in the case of the US, more recent

[3]A positive effect of unions on firms' investment may also arise through other channels. One of such channels is the impact of unions on employees behavior: indeed, better worker incentives and more cooperative industrial relations may be stimulated by the presence of unions (the voice effect of trade unions) and may indeed increase workers effort, which in turn can spur productivity as well as physical capital accumulation. Moreover, unions can favour training investment (Dustmann and Schönberg, 2009) either because they lead to more stable employment relationships, thereby incentivizing firms to invest in training, as explained by Acemoglu and Pischke (1999), or because they counteract the hold-up power of firms (Addison and Teixeira, 2019), leading workers to invest more in firm specific training: as long as human and physical capital are complements, unions' activity might also spur investments in physical capital.

research suggests mixed results. For instance, Addison et al. (2007) and Addison et al. (2017), in the case of Germany, find non-negative effects of unions on investment in physical and intangible capital, respectively. In a recent paper, Bryson and Dale-Olsen (2020) show that local union bargaining is positively associated with product innovations in both UK and Norway.[4] Similarly, a recent paper by Card et al. (2014), using Italian data, estimates a model of rent-sharing and finds that the empirical results suggest at best a very small role for the hold-up mechanism. Along the same lines, Jäger et al. (2019) find, for the case of Germany, that an exogenous increase in the boardroom seats for worker representatives is associated to larger capital per worker, with worker governance not raising wage premia or rent sharing. Conversely, Cardullo et al. (2015) identify the existence of an hold-up problem by testing whether investment per worker was reduced by powerful unions in sunk capital industries using a panel of cross-country cross-industry data.[5]

Second, the paper is also connected to theoretical studies that analyse the effects of different bargaining structures (centralised and decentralised) on labour market outcomes. The seminal work of Calmfors and Driffil (1988) has perhaps influenced the subsequent literature on the subject. In their paper, sectoral level bargaining implies higher wages and a lower employment level compared to a firm/local negotiation because competition across sectors is less fierce than competition within sectors. So, under sectoral bargaining, upward wage pressures have a weaker impact on firms' revenues. As de Pinto (2019) shows, this result can be offset once we consider heterogeneous firms and endogenous entry/exit. Under this richer setup, a unique wage decided at sectoral level raises average profits, as the increase in revenues for the more productive firms is larger than the decrease experienced by the less productive ones. In turn this attracts new firms into the market. Competition gets fiercer, productivity and labor demand increase, thereby outweighing the negative employment effect

[4] Bradley et al. (2016) report reductions on R&D expenditure and patenting activity following unionisation in the US using a regression discontinuity design framework.

[5] The recent meta-analyses in Doucouliagos et al. (2017, 2018) report that the presence of unions is typically associated to lower investment in physical capital (although their estimate is not statistically different from zero), while results for intangible capital point towards even more negative results.

outlined by Calmfors and Driffil (1988).

Third, our work contributes to the recent literature that uses a search and matching framework to analyse the role of unions and different mechanisms on firm and worker outcomes. In this context, Krusell and Rudanko (2016) analyse the effect of different bargaining agreements on unemployment. They show that, under centralisation, when there is commitment by firms and unions, unemployment is at the its efficient level. However, when there is no commitment, unions raise wages and unemployment is higher (and output is lower). Using the same theoretical framework, Jimeno and Thomas (2013) construct a model with firm level productivity shocks and find that unemployment is lower under the decentralised equilibrium than under sector level bargaining. Using a different theoretical framework, de Pinto (2019) analyses the effect of different unionisation structures on wages, employment and output. The model features firm heterogeneity with rent sharing and free entry. Under sector level bargaining, low productivity firms pay higher wages than under firm level bargaining, viceversa, high productivity firms pay lower wages. However, total profits increase as the gains of the high productivity firms are larger. With free entry, new firms enter the market with more competition thus making less productive firms to exit. Average productivity increases (firm selection effect) offsetting the markup effect (under sector level bargaining, higher markup is possible because there is less competition).[6]

Finally, the paper is connected with studies that explicitly analyse the role of two-tier bargaining.[7] Boeri (2014) analyses the effects of two-tier bargaining structures on wages, employment and productivity. He argues that two-tier bargaining, comprising a mixture of centralised and decentralised bargaining regimes, turns out to be inefficient. Under the centralised regime, worker and firms bargain using a right-to-manage mechanism, entailing inefficiency; on the other hand, fully decentralised structures allow for efficient contracts when bargaining over wages and employment. However, under two-tier regimes, first stage

[6]Related papers also include Braun (2011) and Haucap and Wey (2004).

[7]Barth et al. (2014) provide a theoretical framework to study the Scandinavian model of production and industrial relations. In their setting, two-tier bargaining structures and unions favour worker involvement and wage compression, with positive productivity effects related to workers effort and firm level investment.

centralised bargaining imposes wage floors that cannot be neutralized in the second stage, thus limiting the range of efficient contracts available to workers and firms. Moreover, decentralisation in the second tier can improve unions' but not firms' utility. The paper also provides some descriptive evidence in this respect. A recent study by Garnero et al. (2020) empirically analyses the effects of firm level agreements on wages and productivity using matched employer-employee panel data from Belgium. When there is rent sharing, wages are shown to increase more than productivity, thus partially reducing profitability, at least in manufacturing. They also point out towards heterogeneous effects of rent sharing across firms, depending on the sectoral degree of competition. Their bottom line is that two-tier systems, by increasing both wages and productivity, benefit both workers and firms.[8]

3 Motivating evidence

In order to evaluate the relationship between two-tier bargaining and firm level investment, we estimate various versions of the following reduced-form equation for investment per worker:

$$InvestmentWorker_i = \alpha + \beta Union_i + \gamma TTB_i + \delta X_i + u_{si} + u_{se} + u_{re} + \nu_i, \qquad (1)$$

where $InvestmentWorker$ is the level of investment per worker at firm i.[9] TTB is a dummy variable equal to 1 in the case of firms where a two-tier bargaining agreement was in place, $Union$ is a dummy variable equal to one for unionised firms (see Appendix A.1) and X_i is a set of controls at the firm level.[10] Finally, u_{si} is a firm size fixed effect, u_{se} is a sector fixed effect (77 sectors at Ateco 2007 level), u_{re} is a set of 20 region fixed effects, while ν_i is a

[8] Recently, Barth et al. (2020) find a positive effect of union density on firm productivity and wages using Norwegian firm data.

[9] We consider investment per worker, rather than the investment rate (i.e. investment per unit of capital) because in models of unions and hold-up (Cardullo et al., 2015) unions are expected to affect investment per worker (see also Cingano et al. (2010)).

[10] In the vector X_i we consider various firms characteristics that could be important to control for in a reduced-form investment equation, such as dummies for exporting firms or for firms that had already offshored some of their activities; dummies for workers human capital, etc. See section A.2 in the Appendix for a description of the data and main variables.

standard error term. Standard errors are clustered at the industry level and all regressions are run using sample weights in order to ensure that regression results are representative of the population of firms.

The estimation of (1) by OLS would raise an important econometric problem, associated to the presence of a mass point at zero in the distribution of investment per worker: indeed, about one third of firms in our sample reports a zero level of investment, a proportion that reaches 40 per cent in the case of firms in the 16-49 employees category. It is however well known that, when facing a corner solution outcome, using OLS might lead to biased and inconsistent parameter estimates.

Recently, a number of authors (see, for instance, Santos Silva and Tenreyro (2006) or Wooldridge, 2010 chapter 18) have proposed to deal with corner solution outcomes by assuming an exponential distribution for the conditional mean and estimating the model by Poisson quasi-maximum likelihood techniques. It is important to note that, in this case, it is not necessary that the dependent variable follows a Poisson distribution at all (provided the dependent variable is non negative and with no upper bound). What is needed for a Poisson quasi maximum likelihood model to deliver consistent parameter estimates is simply that the conditional mean of the outcome variable is correctly specified.

It is important to note at the outset that we refrain from interpreting our results as causal for a number of reasons. First, it is possible that firms with unobserved shocks to productivity and profitability are more likely to invest but also to have a decentralised agreement, introducing a possibly spurious positive correlation between TTB and investment per worker. Second, firms can be heterogeneous along various unobserved dimensions, which could be related to the propensity to invest and to sign a decentralised agreement. In the case of $Union$, in turn, endogeneity concerns might be perhaps less important. In fact, we tend to agree with Devicienti et al. (2017) who argue that, in the Italian institutional context, it is unlikely that unions target the most profitable firms, especially when firm heterogeneity has already being controlled for.[11] Similarly, union membership within the firm tends to be more related to particular sectors, area of the country and size of the firm, or historical reasons, rather than actual or perspective firm conditions.

We begin in column 1 of Table 1 with a parsimonious specification including a dummy equal to 1 for those firms where a two-tier bargaining was in place and a unionisation dummy.[12] The presence of unions is associated to a lower level of investment per worker of about 24%, while in firms with of a two-tier bargaining agreement we note that investment per worker is higher by a similar amount. In other words, because firms with a decentralised agreement are generally also unionised, these results suggest that the presence of a decentralised agreement tends to exactly counteract the negative effect that unions seem to exert on investment per worker.[13]

In the next regressions we probe the robustness of these results along various dimensions. First, in column 2 we include a full set of collective agreements fixed effects. Indeed, there is no exact correspondence between the industry a firm belongs to and the collective agreement a firm decides to apply; in other words, firms active in very different industries could apply the same national collective contract. Reassuringly, our main results are confirmed. In column 3 we include an interaction term between unionisation and the existence of a two-tier bargaining agreement: regression results suggest that the interaction term is positive and statistically significant. Unions seem to exert a negative effect on investment per worker only when there is no two-tier agreement within the firm; in turn, the positive effect of a two-tier agreement seems to exist only in unionised firms. In other words, decentralised agreements

[11] Indeed, in Italy setting up union representation just requires the willingness of a single employee to act as union representative; as a result, unionisation does not entail important fixed costs, as it happens in the US, where unions need to win a majority in a Certificate Election. We refer to section A.1 in the Appendix for an overview of the institutional background.

[12] Our results hold also when we measure union power with standard union density measures. In column 1 of Table A3 in Appendix A.3 we report our baseline regression with such measure of union power.

[13] Although our theoretical model presented below predicts a positive relationship of a two-tier bargaining structure on the amount of investment per worker, i.e. an effect on the intensive margin, in Table A2 of Appendix A.3 we also report probit and linear probability model regressions that confirm that two-tier bargaining is positively correlated also to the probability of investment. Moreover, this result holds also for tangible and intangible investment, with a slightly larger effect for investment in tangible capital.

Table 1: Poisson regression models for investment per worker

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
union	-0.237*	-0.349***	-0.315**	-0.271**	-0.272**	-0.229*	-0.327**	-0.578*
	(0.136)	(0.112)	(0.161)	(0.131)	(0.128)	(0.139)	(0.160)	(0.325)
two-tier bargaining (TTB)	0.246***	0.224**	-0.101	0.244**	0.241**	0.253**	-0.150	0.742
	(0.0956)	(0.105)	(0.197)	(0.111)	(0.111)	(0.112)	(0.256)	(0.677)
union × two-tier bargaining			0.474*				0.563*	
			(0.268)				(0.331)	
share of workers younger than 25				-0.126	-0.0780	-0.184	-0.165	
				(0.653)	(0.598)	(0.571)	(0.562)	
share of workers 26-34				0.0160	0.0363	0.00914	-0.00917	
				(0.349)	(0.341)	(0.326)	(0.331)	
share of workers 35-49				-0.145	-0.110	-0.0563	-0.0558	
				(0.360)	(0.349)	(0.339)	(0.344)	
share of high skilled				0.542	0.568	0.512	0.533	
				(0.385)	(0.376)	(0.391)	(0.395)	
share of medium skilled				-0.00913	0.00233	-0.0364	-0.0362	
				(0.253)	(0.245)	(0.228)	(0.225)	
share of female workers				-0.424	-0.451	-0.430	-0.414	
				(0.421)	(0.417)	(0.411)	(0.412)	
share of trained workers				0.265	0.255	0.256	0.255	
				(0.172)	(0.175)	(0.172)	(0.167)	
share of fixed term contracts				0.559*	0.554**	0.536**	0.533**	
				(0.290)	(0.268)	(0.263)	(0.260)	
national contract					-0.409	-0.390	-0.372	
					(0.390)	(0.393)	(0.389)	
employers' association					0.0201	0.0150	0.0137	
					(0.116)	(0.116)	(0.115)	
management						-0.134	-0.144	
						(0.133)	(0.130)	
offshoring						0.242	0.239	
						(0.274)	(0.278)	
export						0.121	0.119	
						(0.123)	(0.125)	
workers in *cassa integrazione*						-0.323**	-0.318**	
						(0.135)	(0.134)	
residual union								0.230
								(0.367)
residual two-tier bargaining								-0.403
								(0.694)
Size dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Collective contract dummies	No	Yes	No	No	No	No	No	No
Constant	9.390***	9.642***	9.370***	9.247***	9.584***	9.615***	9.585***	
	(0.293)	(0.435)	(0.292)	(0.547)	(0.806)	(0.787)	(0.781)	
Observations	5,986	5,515	5,986	3,955	3,946	3,912	3,912	3,009

Notes: Standard errors are cluster robust at the industry level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Dependent variable is the level of investment per worker. All regressions include sample weights. Number of sectors in column 8 is equal to 69. See Table A1 and Section A.2 in the Appendix for more details concerning the sample selection and definition of variables.

seem to affect investment per worker only by modifying the negative effects associated to the hold-up problems that might exist in unionised firms; by way of contrast, in the not-unionised firms the existence of a decentralised contract does not seem to have any significant effect on investment per worker.

In columns 4 to 7 we show that these results are robust to including additional control variables that could explain investment per worker. First, in column 4 we include controls related to the firm workforce composition, such as the share of workers by age group, education level, gender, training provisions and presence of fixed-term contracts. Then, in column 5 we add dummies equal to one for firms applying a national collective contract and for firms that belong to an employee confederation. Finally, we consider additional controls, such as a dummy for whether the firm has already off-shored some of its activities, a dummy for exporting firms, a dummy for firms that are run by a manager and not by family members and, finally, a dummy equal to one for firms where a "Cassa integrazione" schemes applies, which is a proxy for firms that have been facing tough economic and financial conditions.[14] As long as these variable are both correlated to investment per worker as well as to the firm unionisation status and/or the existence of a two-tier bargaining agreement within the firm, their omission might generate and omitted variable problem.[15] Regression results in column 6 show that these regressors are generally not statistically significant, with the exception of the "Cassa Integrazione" dummy which, unsurprisingly, displays a negative coefficient, and the share of workers under a fixed term contract, which in turn seems to be positively correlated to investment per worker.[16] Reassuringly, our coefficients of interest are barely altered,

[14]The "Cassa integrazione" (CIG) is a short-time work (STW) benefit scheme comprising a wage guarantee for redundant workers (about 80% of previous earnings) that covers both blue and white collar workers in both manufacturing and service sectors for firms facing restructuring, reorganization or bankruptcy procedures. Depending on the nature of the redundancy problem the firm is facing, there are different CIG categories. See Boeri and Bruecker (2011) for the effects of the STW during the economic crisis and further discussion.

[15]However, if they are endogenous, a bad control problem might arise and the bias could be transmitted to our regressors of interest. It is for this reasons that our baseline regressions do not include these firms characteristics.

[16]In column 2 of Table A3 in Appendix A.3 we consider the role of financial variables for investment decisions. Unfortunately our survey data does not allow us to recover relevant information on the financial structure of the firm. However, using information on operating profits (over sales and/or fixed assets) as an admittedly very raw inverse proxy for the existence of financial constraints, we try to investigate this

both in magnitude as well as statistical significance.[17]

Finally, in column 8 we address possible endogeneity concerns discussed above by using a control function approach.[18]. Unfortunately, we do not have clear cut exclusion restrictions for TTB and $Union$ following from a quasi natural experiment deriving from the institutional rules: therefore, the ensuing results should be taken with extreme care. Following Devicienti et al. (2018) and Jirjahn and Mohrenweiser (2016), we have experimented using, as instruments, the average probability of union presence in each industry-region cell as of 2007, and the average probability of a firm applying a two-tier decentralised agreement in each industry-region cell as of 2007. The rationale of using these instruments is that past two-tier decentralised agreements (presence of a union) in a given industry-region cell positively predict current presence of a two-tier decentralised agreement (union) within the firm and affect investment only indirectly by influencing current unionisation and presence of a two-tier agreement.

Regression results confirm that unionisation has a negative and statistically significant impact on investment per worker, while the coefficient of the two-tier bargaining agreement dummy is positive but imprecisely estimated. However, the two residual terms are individually and jointly statistically insignificant, possibly suggesting that the both the unionisation and two-tier bargaining dummies might be exogenous in our model. All in all, we think that these results provide at least suggestive empirical evidence on a possible positive correlation between the existence of a two-tier bargaining agreement and the firm propensity to invest in capital.[19]

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issue. As expected, the regressor of interest is positively correlated with investment per worker and, more importantly, our results for two-tier bargaining and unions are mostly unaltered.

[17] In column 7 we report results for regressions in which we include all controls and the interaction term between unions and two-tier bargaining: our results are broadly confirmed.

[18] Wooldridge (2010) shows that a two step control function approach is easy to implement. First, one needs to regress using OLS each endogenous variable on the exogenous variables plus one or more instruments; second, the residuals are added to the original Poisson regression. If the exclusion restrictions are valid and the instruments are significant in the "first stage" regressions, the presence of the residuals should correct for possible endogeneity. Moreover, if one cannot reject the null hypothesis that residuals are equal to zero, this is sign that regressors might not be endogenous

[19] In Section A.3 in the Appendix we discuss further correlations in the data that are related to our theoretical model.

4 The Model

4.1 Production and Matching Technology

Consider a continuous-time model with a continuum of infinitely-lived and risk-neutral workers who have perfect foresight and a common discount rate r. The economy is composed by one final consumption good sold in a perfectly competitive market and whose price is normalised to 1.

There are two types of firms supplying the consumption good: type a and type b. They have the following production function:

$$y_i \;=\; (1+\ell)\, a_i\, k_i^{\alpha} \quad \text{with } i \in \{a, b\}. \tag{2}$$

The only exogenous difference between them is in total factor productivity a_i, with a_a assumed to be greater than a_b. As in a standard Pissarides (2000, chapter 1) search and matching model we impose that each firm can hire at most one worker. The term $1+\ell$ denotes the number of hours worked by any employee in the economy. The reason for this particular formulation will be clear as we present the two different wage scenarios assumed in the paper. Each firm also optimally chooses a certain amount of capital investment, k_i. Such an investment is done before the firm-worker match is formed and the wage negotiation takes place. We assume firms cannot re-let k_i and there is no second hand market, so capital is sunk and a hold-up problem arises, as employees can reap parts of the benefits of a more capital intensive production (in terms of higher wages) without paying the costs.

Labour force is normalized to 1. There are two labour markets in the economy, one for type a and the other for type b jobs. Both present frictions. Each worker may be hired either by type a firms or by type b firms. We assume random search, so an arbitrage condition implies that, at steady state, unemployed workers are indifferent to choose between these two markets. With u_a and u_b we respectively denote the measure of job seekers in a and

b. On-the-job search is ruled out. The matching functions give the measure of matches for certain values of unemployment u_i and vacancies v_i: $m_i = m(v_i, u_i)$, for $i \in \{a, b\}$. As usual in the search and matching literature (see Petrongolo and Pissarides, 2001), function $m(.,.)$ has constant returns to scale and it is increasing and concave in each argument. Labour market tightness 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 $q(\theta_i) \equiv m_i/v_i$, $q'(\theta_i) < 0$, for $i \in \{a, b\}$. A job-seeker gets employed at rate $f(\theta_i) \equiv m_i/u_i = \theta_i q(\theta_i)$, increasing in θ_i for $i \in \{a, b\}$. The elasticity of the expected duration of a vacancy $1/q(\theta_i)$ with respect to tightness is denoted by η. At a certain exogenous rate δ, capital equipment is destroyed, the firm exits the market and the employee, if any, loses his/her job.

Let ϕ denote the share e_a/e, with e_i denoting the employment level of type $i \in \{a, b\}$ and $e = e_a + e_b$ being the total level of employment in the economy. In steady-state, in each labour market the amount of new jobs created must be equal to the number of jobs destroyed: $\phi e \cdot \delta = u_a \cdot f(\theta_a)$ and $(1-\phi)e \cdot \delta = u_b \cdot f(\theta_b)$. Knowing that $1 = e + u_a + u_b$, the steady state level of employment is equal to:

$$e = \frac{f(\theta_a)f(\theta_b)}{f(\theta_a)f(\theta_b) + \phi\delta f(\theta_b) + (1-\phi)\delta f(\theta_a)}. \tag{3}$$

4.2 Investment decision and free-entry condition

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

$$r\Pi_i^E = (1+\ell)\, a_i\, k_i^\alpha - w_i - r \cdot k_i - \delta \Pi_i^E \tag{4}$$

for $i = \{a, b\}$. Firms' revenues are equal to the amount of the final good produced, net of the real wage w_i and the rental cost of capital. Notice that we are assuming a fixed price for investment, the real interest rate r. Recall also that at a rate δ, the equipment is destroyed and the firm exits the market. The expected discounted value of a firm with a job vacancy reads as:

$$r\Pi_i^V \;=\; \max_{k_i} \; - r \cdot k_i \,+\, q(\theta_i)\left[\,\Pi_i^E - \Pi_i^V\,\right] - \delta \Pi_i^V \tag{5}$$

for $i \,=\, \{a, b\}$. The term $r \cdot k_i$ is the flow cost of investment incurred when a firm is searching for a worker.[20] The firm's problem is to choose the optimal level k_i that maximizes $r\Pi_i^V$.[21]

Inserting the expression for $r\Pi_i^E$in equation (4) into equation (5) and computing the first order condition yields:

$$\frac{q(\theta_i)}{r \,+\, \delta \,+\, q(\theta_i)} \left[\; (1+\ell)\, a_i\alpha \cdot k_i^{\alpha-1} \;-\; w_i' \,\right] \;=\; r \tag{6}$$

for $i \in \{a, b\}$ and in which $w_i' \;\equiv\; d\, w_i / d\, k_i$. At the equilibrium, the marginal cost of capital - the RHS of (6) - must be equal to its marginal revenue - the LHS of (6). Notice that the presence of w_i' helps to clarify why in our model the assumption on sunk capital is key. As long as $w_i' \,>\, 0$, wages affect the investment decision, as firms realize that a higher level of k_i drives wages up, thereby reducing marginal revenues. So different bargaining schemes, insofar as they bring about different wage equations, lead to different choices in terms of investment. On the contrary, in a model in which capital and labour are chosen simultaneously, wages do not influence the optimal value for k_i and opting for a two-tier negotiation instead of a one-tier one has no effect on firms' investment.

There is free-entry of vacancies. Firms enter the labour market as long as expected profits are nonnegative: $\Pi_i^V \;=\; 0$. From equation (5) this implies:

$$\Pi_i^E \;=\; \frac{r \cdot k_i}{q(\theta_i)} \qquad \text{for } i \in \{a, b\}. \tag{7}$$

[20]As in Acemoglu and Shimer (1999) and Acemoglu (2001), we assume for simplicity that there are no flow vacancy costs. This does not imply that keeping a vacancy open is for free, as firms face the cost of idle capital equipment, $r\, k_i$.

[21]The model abstracts from time-to-build considerations and there is instantaneous capital adjustment. This formulation is coherent with the regression analysis we have seen in the empirical part, where the dependent variable is the level of investment per worker.

Then, rearranging equations (4) and (5) in order to get rid of Π_i^E and Π_i^V yields:

$$\frac{(1+\ell)\, a_i k_i^{\alpha} \,-\, w_i}{r \,+\, \delta \,+\, q(\theta_i)} \;=\; \frac{r \cdot k_i}{q(\theta_i)} \quad \text{for } i \in \{a, b\}. \tag{8}$$

Equation (8) says that the expected cost of filling a vacancy (the term at the RHS) is equal to the expected revenues obtained from a job (the term at the LHS).

4.3 Workers' preferences and no arbitrage condition

The expected discounted value of being unemployed and searching for a job in firms of type $i \in \{a, b\}$ is equal to:

$$rJ_i^U \;=\; z \,+\, f(\theta_i) \left[\, J_i^E \,-\, J_i^U \,\right]. \tag{9}$$

Being unemployed is like holding an asset that pays you a dividend z, the value of home production, and at a rate $f(\theta)$ ensures a capital gain $J_i^E \,-\, J_i^U$. The term J_i^E denotes the expected discounted value of working in a firm of type $i \in \{a, b\}$ and it reads as follows:

$$rJ_i^E \;=\; w_i \,+\, \delta \left[\, J_i^U \,-\, J_i^E \,\right]. \tag{10}$$

The term w_i stands for the real wage paid by firms of type $i \in \{a, b\}$. Its precise formulation will be explained in the next section. At a rate δ capital gets destroyed and the worker becomes unemployed.

Since we assume random search between labour markets, an arbitrage condition ensures that $J_a^U \;=\; J_b^U$.[22] Using (9) and (10) we have:

$$\frac{f(\theta_a)}{r \,+\, \delta \,+\, f(\theta_a)} \,(w_a \,-\, z) \;=\; \frac{f(\theta_b)}{r \,+\, \delta \,+\, f(\theta_b)} \,(w_b \,-\, z) \tag{11}$$

The fractions in both sides of the equation are increasing in $f(\theta_i)$, $i \in \{a, b\}$. A labour market cannot exhibit both a higher job finding rate and better earnings, otherwise the

[22] For further details see Wright et al. (2019).

arbitrage condition would not be satisfied.

4.4 Wage formation

The purpose of this paper is to evaluate the effects on investment of two different wage setting processes: a two-tier set-up, and a one-tier scheme.

We convey this difference in a quite simple manner, by assuming that the real wage is given by

$$w_i \equiv \omega + d_i \cdot \ell, \tag{12}$$

for $i \in \{a, b\}$. Recall we assume employees work $1 + \ell$ hours. Firms pay an amount equal to ω for a fraction (normalized to 1) of the working hours. The term d_i denotes the hourly remuneration employees receive for the remaining ℓ working hours. The fraction ω of the total salary is negotiated at sectoral level by workers' union and the confederation of firms. This is the case for both the one-tier and the two-tier scenario.[23]

The two settings differ in the determination of the term d_i. In the one-tier setup, d_i is also decided at sectoral level, so that $d_a = d_b$. On the contrary, in the two-tier scheme, d_i is bargained at firm level after the sectoral negotiation has taken place. To this respect, an important point deserves to be stressed. One of the crucial features of two-tier bargaining schemes that are common in Continental Europe is the so-called "favorability principle" (see Boeri, 2014). Under this framework, firm or plant-level agreements (the second tier of the negotiation) cannot envisage conditions that would make workers worse off than they are under the higher, sectoral, level of bargaining. To maintain this feature in our model, we impose that under the two-tier scenario a single firm-worker pair negotiates over d_i but cannot change the fraction of the salary ω decided at sectoral level.[24]

[23]Of course the fact that ω is decided at sectoral level in both scenarios does not imply that it would take the same value. The choice of d_i affects the value of ω.

[24]We refer to Section A.1 for details concerning the institutional framework of wage bargaining in Italy.

5 Equilibrium

5.1 One-Tier Wage Bargaining Scenario

Under one-tier wage bargaining, sectoral unions negotiate simultaneously over ω and d. This is equivalent to state that firms and workers bargain over the entire wage w, as for them it is just the total remuneration that matters and not how it is split between its components, ω and d. We assume that unions behave in a utilitarian way.[25] Workers' union utility U^W is the sum of the utilities of all employees in the same sector, working either for firms producing the intermediate good a or good b:

$$rU^W = e_a w + e_b w. \tag{13}$$

Similarly, the utility function for the confederation of firms, U^F, is just the sum of the revenues raised by firms of type a and b:

$$rU^F = e_a \left[(1+\ell)\, a_a k_a^\alpha - w - rk_a \right] + e_b \left[(1+\ell)\, a_b k_b^\alpha - w - rk_b \right]. \tag{14}$$

The fall-back positions for each player are chosen by following the approach of Hall and Milgrom (2008). They construct a bargaining game in which a disagreement in the negotiation implies a delay in production and strikes, but not massive lay-offs or quits.

In our setup, this means that, in case of disagreement, workers enjoy an instantaneous utility equal to the value of home production, z, while firms do not produce and sell anything but they still have to pay the rental cost of equipment rk_i, for $i \in \{a, b\}$. Then, the fall-back position of workers' union and the confederation of firms read respectively as $r\bar{U}^W = z \cdot e$ and $r\bar{U}^F = -rk_a e_a - rk_b e_b$.

[25] This assumption also means that unions do not pursue their own agenda. Conversely one could imagine that, for any given level of revenues and wages, sectoral unions are worse off under a two-tier negotiation than in a entirely centralized bargaining structure because this implies a loss of power for them. We discuss this point, which is left for future research, more in detail in the Conclusions.

The value of w is determined by assuming axiomatic Nash bargaining, that takes the following form:

$$\max_{w} \left[U^W - \bar{U}^W \right]^{\beta} \cdot \left[U^F - \bar{U}^F \right]^{1-\beta}$$

Parameter β stands for the bargaining power of the workers' union. At the equilibrium, the negotiation always ends up in an agreement. The F.O.C. is equal to:

$$(1-\beta) \left[U^W - \bar{U}^W \right] = \beta \left[U^F - \bar{U}^F \right]$$

Using equations (13), (14), and the expressions for $\bar{U}^W$ and $\bar{U}^F$ yields:

$$w \cdot e = \beta (1+\ell) \left[e_a \, a_a k_a^{\alpha} + e_b \, a_b k_b^{\alpha} \right] + (1-\beta) \, z \cdot e \tag{15}$$

Unions at sectoral level choose a value for w such that the total wage bill (the LHS of 15) is a weighted average between total revenues and the aggregate amount of home production (the RHS of 15). The weight is given by workers' union bargaining power β. Dividing both sides of (15) by e, we have:

$$w = \beta (1+\ell) \left[\phi \, a_a k_a^{\alpha} + (1-\phi) \, a_b k_b^{\alpha} \right] + (1-\beta) \, z \tag{16}$$

In a one-tier scenario, the wage depends on the average output produced in the economy.

Thanks to equation (16), we are able to close the one-tier bargaining model. Indeed, we can insert the value for the wage in (16) into the zero profit conditions (8). Moreover, differentiating w with respect k_i (for $i \in \{a, b\}$) yields:

$$\frac{d\,w}{d\,k_a} = \beta (1+\ell) \, \phi \, a_a \alpha k_a^{\alpha-1} \quad \text{and} \quad \frac{d\,w}{d\,k_b} = \beta (1+\ell) (1-\phi) \, a_b \alpha k_b^{\alpha-1} \tag{17}$$

Inserting these values in the F.O.Cs for investment (6), we get:

$$(1+\ell)\, a_a \alpha \cdot k_a^{\alpha-1}\, [1 \,-\, \beta\, \phi\,] \quad = \quad r\, \frac{r \,+\, \delta \,+\, q(\theta_a)}{q(\theta_a)} \tag{18}$$

$$(1+\ell)\, a_b \alpha \cdot k_b^{\alpha-1}\, [1 \,-\, \beta\, (1-\phi)\,] \quad = \quad r\, \frac{r \,+\, \delta \,+\, q(\theta_b)}{q(\theta_b)} \tag{19}$$

Notice that marginal revenues for type a (resp. type b) firms are negatively affected by ϕ (resp. $1-\phi$), the share of type a (resp. b) firms in the economy. This effect occurs via the wage derivative (17). An increase in k_a leads to higher wages, thereby dampening the employers' incentive to invest. Such a negative impact is obviously stronger the larger the share of firms that are marginally adjusting k_a, ϕ, as the wage pressures are more accentuated. The same occurs for investment k_b. This aggregate effect is captured by each single firm that makes its investment decision.

Substituting the value for w in (16) into the zero profit conditions (8) and the no arbitrage condition (11), we get a system of five equations in five unknowns, k_a, k_b, ϕ, θ_a and θ_b. If this system admits at least one solution, all the remaining endogenous variables (the level of employment e and the discounted utilities for workers and firms) are trivially obtained. The following Proposition summarizes the results.

Proposition 1 *There exists a unique steady-state equilibrium for the one-tier bargaining model if and only if* $\frac{a_a}{a_b} \,<\, (1-\beta)^{-\alpha}\left(1 \,+\, \frac{\alpha\,\beta}{1-\alpha}\right)^{\alpha-1}$.
At the equilibrium, $k_a \,<\, k_b$, $a_a k_a^{\alpha} \,<\, a_b k_b^{\alpha}$, $\phi > \frac{1}{2}$, *and* $\theta_a \,=\, \theta_b$.

The proof is in Appendix B. Here we simply present the main intuitions behind the results. First, the equality $\theta_a \,=\, \theta_b \,=\, \theta$ stems from the no arbitrage condition (11). If workers are paid the same ($w_a \,=\, w_b \,=\, w$), then labour market tightness must also be the same. Proposition 1 also states that $k_a \,<\, k_b$. Firms with a higher total factor productivity a_a end up buying a lower amount of capital k_a. This result seems odd. In a perfectly competitive market, firms with higher TFP invest more. If in our model the opposite is true, it is because of two key elements: the zero profit conditions in vacancy creation and sunk capital. Notice first that at the equilibrium firms with different levels of TFP face similar expected costs: the rental cost of capital r, the wage w, and the expected duration of a vacancy $1/q(\theta)$ are the same. The only difference is in the opportunity cost of unused capital, rk_i. For both free-entry zero profit conditions to hold, even expected revenues for type a and type b firms must not differ too much. This is possible only if a high TFP is accompanied by lower capital deepening.

Such a negative relationship is reached via a larger share of type a firms entering the market (that is $\phi > 1/2$). As the equations in 17 illustrate, the hold-up problem gets worse the larger the number of active firms of the same kind. With $\phi > 1/2$, a marginal increase in capital investment has a stronger positive impact on wages in high TFP jobs. In turn, this means that type a firms decide to invest less in the first place.[26]

This also helps to explain the condition in Proposition 1. That inequality states that the ratio in total factor productivity must not be too high for an equilibrium to exist. As we have just seen, a high a_a/a_b ratio must entail a low k_a/k_b ratio for both zero profit conditions to hold. A low value for k_a is obtained by a large share of type a firms present in the market, ϕ. However, ϕ cannot exceed 1. If the ratio $\frac{a_a}{a_b}$ is too high, the endogenous difference between ϕ and $1-\phi$ and k_a and k_b could not be large enough to ensure that both F.O.C.s on capital investment and free-entry conditions are fulfilled.

This inequality is more likely to be respected when α, the elasticity of output w.r.t. capital investment, and β, the labour union's bargaining power, take large values. A larger β means that the negative effect of a wage increase on investment decision is more accentuated. The compensating mechanism just explained is stronger, as high TFP firms choose a lower level of capital k_a. Similarly, with α close to 1, the production function $(1+\ell)a_i k_i^{\alpha}$ becomes

[26] Such result is line with the estimates of Autor et al. (2007). By looking at the adoption of wrongful-discharge protection by state courts in the US from 1970 to 1999, they found that firing costs push firms to substitute capital for labour, increasing the amount of investment per worker and raising labour productivity. At the same time, they also find evidence of a reduction in TFP, as employers retain unproductive workers, driving down technical efficiency. Even if our paper does not look at the effects of changes in the employment protection legislation over time and differences in TFP are exogenously assumed, in Section A.3 we report some additional findings that are broadly consistent with the above results.

less concave. Any marginal adjustment in capital investment results in a larger variation in output. A smaller difference between k_a and k_b has a stronger effect on firms' revenues.

In Appendix B we present in a graph the condition in Proposition 1 for different values of α and β. In our model, reasonable values of α should be in the range [0.4, 0.5].[27] With $\alpha = 0.4$, and a value of β in the range [0.5, 0.7], Proposition 1 is fulfilled if the productivity gap a_a/a_b is lower than 1.1 or 1.3, respectively. Instead, if we impose $\alpha = 0.5$ and take the same range of values for β, the TFP ratio a_a/a_b must be lower than 1.15 or 1.4, respectively.

Empirical analysis has found even larger values for the productivity gap between firms within the same sector. However, a TFP ratio between 1.2 and 1.4 (that we obtain with values of α in the interval [0.4, 0.5] and β close to 0.7) is not unreasonable and it is in line with the estimates of Foster et al. (2016), that report an interquartile TFP ratio of 1.2-1.4 for the US case. On the contrary, imposing a value for β lower than 0.5 implies a TFP ratio much smaller than the one found in the empirical literature.

Moreover, note that in some calibrations of matching models β takes values significantly higher than 0.5 (in Shimer (2005) it is equal to 0.72).[28] Still, our numerical exercises concerning the necessary and sufficient condition for the existence of an equilibrium indicate that our model is mostly suited to the analysis of sectors in which TFP differentials are relatively small.

5.2 Two-Tier Wage Bargaining Scenario

Under the two-tier wage scenario, the employers' confederation and the workers' union negotiate over ω. In a second stage, after the sectoral negotiation has been successful, each firm-worker pair bargains over d_i for $i \in \{a, b\}$.

We proceed backward and consider first the negotiation at firm level. The value of d_i is

[27] As equation (6) makes clear, in our setting the price of capital r is not equal to its marginal productivity, so α is not equal to the capital share in the economy. It can also be shown (details are available on request) that a value of α in the interval [0.4, 0.5] is necessary to get the standard value for the capital share of about 0.3.

[28] Note also, in addition, that in our setting β stands for the bargaining of sectoral unions, which is usually assumed to be higher than individual bargaining power, at least in highly unionised labour markets.

determined via Nash bargaining:

$$d_i \;=\; \text{argmax}\, \left[\, J_i^E \,-\, \bar{J}_i^E \,\right]^{\epsilon} \cdot \left[\, \Pi_i^E \,-\, \bar{\Pi}_i^E \,\right]^{1-\epsilon},$$

for $i \in \{a, b\}$. Parameter ϵ stands for the worker's exogenous bargaining power at local level and it is different from β, that captures the strength of employees' union at sectoral level. The terms $\bar{J}_i^E$ and $\bar{\Pi}_i^E$ are the expected utilities for workers and firms respectively, in case of disagreement. They are equal to:

$$r\bar{J}_i^E \;=\omega \,+\, \delta \left[\, J^U \,-\, \bar{J}_i^E \,\right], \qquad r\bar{\Pi}_i^E \;=\; a_i\, k_i^{\alpha} \,-\, \omega \,+ \delta \left[\, \Pi_i^V \,-\, \bar{\Pi}_i^E \,\right] \tag{20}$$

for $i \in \{a, b\}$. These formulations for workers' and firms' threat points align our setup to the aforementioned "favorability principle", that is widespread in two-tier systems in Continental Europe. The second tier of the negotiation cannot change the decisions made in the first tier. This means that, when bargaining for d_i, each player cannot credibly threaten to break up the match if his/her demands are not met.[29] Rather, the fall-back positions in case of disagreement are a lower production ($a_i\, k_i^{\alpha}$, as employees work just 1 hour) for the employers and a lower salary (ω instead of $\omega + d_i \ell$) for workers.

The F.O.C. of the above problem is:

$$\epsilon \cdot \left(\, \Pi_i^E \,-\, \bar{\Pi}_i^E \,\right) \;=\; (1 \,-\epsilon) \cdot \left(\, J_i^E \,-\, \bar{J}_i^E \,\right) \tag{21}$$

for $i \in \{a, b\}$. Using eqs. (4), (10), and (20), we get:

$$d_i \;=\; \epsilon\, a_i k_i^{\alpha} \tag{22}$$

[29]Of course, there is a legal obligation for the employers, that cannot fire workers simply because there is no agreement on the pay for extra time hours. Workers, on the contrary, can always quit if the second tier of the negotiation does not end up as expected. It must be said however that, at least in Italy, it is quite infrequent to observe large quits out of job positions in such circumstances. Thus, it seems more reasonable to rule out the expected utility on unemployment, rJ^U, as a threat point for employees in this bargaining problem.

for $i \in \{a, b\}$. The hourly wage d_i is a share ϵ of firms' output per hour worked.

At the first tier of the bargaining scheme, unions of workers and firms negotiate over ω. The Nash bargaining problem is identical to the one studied in the one-tier scheme:

$$\omega \;=\; \text{argmax} \left[U^W \;-\; \bar{U}^W \right]^{\beta} \cdot \left[\; U^F \;-\; \bar{U}^F \; \right]^{1-\beta}$$

Computing the F.O.C. and using equations (13), (14), and the expressions for $\bar{U}^W$ and $\bar{U}^F$, we get:

$$e_a \, w_a \;+\; e_b \, w_b \;=\; \beta \, (1+\ell) \left[\, e_a \, a_a k_a^{\alpha} \;+\; e_b \, a_b k_b^{\alpha} \, \right] \;+\; (1-\beta) \, z \cdot e \tag{23}$$

As in the one-tier scenario, unions at sectoral level choose a value of ω such that the total wage bill is a weighted average between total revenues and the aggregate amount of home production. Dividing both sides of equation (23) by e and using equations (12) and (22) we get:

$$w_a \;=\; \beta \, (1+\ell) \, [\, \phi \, a_a k_a^{\alpha} \;+\; (1-\phi) \, a_b k_b^{\alpha} \,] \;+\; (1-\beta) \, z \;+\; \epsilon (1-\phi) \, \ell \; (\, a_a k_a^{\alpha} - \, a_b k_b^{\alpha} \,) \tag{24}$$

$$w_b \;=\; \beta \, (1+\ell) \, [\, \phi \, a_a k_a^{\alpha} \;+\; (1-\phi) \, a_b k_b^{\alpha} \,] \;+\; (1-\beta) \, z \;+\; \epsilon \, \phi \, \ell \; (\, a_b k_b^{\alpha} - \, a_a k_a^{\alpha} \,) \tag{25}$$

The first two terms at the RHS in (24) and (25) are identical and coincide with the wage equation (16) obtained under the one-tier bargaining scenario. This is the result of the equalizing role played by unions in the first tier of the negotiation.[30] Wage differences depend on the third terms at the RHS of (24) and (25). Workers employed in firms of type b (respectively, a) are paid more than workers in a (resp. b) if and only if they produce a higher amount of output per hour: $a_b k_b^{\alpha} > a_a k_a^{\alpha}$ (resp. $a_b k_b^{\alpha} < a_a k_a^{\alpha}$). The second level of the negotiation creates a wedge in workers' earnings. Such a gap is wider the stronger is the workers' bargaining power at firm level ϵ and the larger the amount of hours worked ℓ whose pay is decided at firm level.

[30] Indeed, it is easy to see that the average wage in the economy, $\phi \, w_a \;+\; (1-\phi) \, w_b$, is equal to the sum of the first two terms in (24) and (25).

As in the previous scenario, we can differentiate the wage equations with respect to k_i, $i \in a, b$:

$$\frac{d\,w_a}{d\,k_a} = [\,(\beta\,(1+\ell) - \epsilon\ell)\,\phi\, + \epsilon\ell\,]\; a_a\,\alpha k_a^{\alpha-1} \tag{26}$$

$$\frac{d\,w_b}{d\,k_b} = [\,(\beta\,(1+\ell)\, -\, \epsilon\,\ell\,)\,(1-\phi)\, + \epsilon\ell]\; a_b \alpha k_b^{\alpha-1} \tag{27}$$

Under this scenario, wages are influenced by capital investment in two ways. First, as in the one-tier setting, there is the aggregate effect: a marginal change in k_i has an impact on salaries, that is stronger the larger the share of employers of type i. In this scenario the strength of such a mechanism depends on the relative importance for the employees of sectoral bargaining compared to the decentralised one (the term $\beta(1+\ell) - \epsilon\ell$). If the value for $\beta(1+\ell)$ is large compared to $\epsilon\ell$, wages in equation (24) and (25) are more dependent on the average productivity of the sector, that of course depends on shares ϕ and $1-\phi$. The cumulative decisions of all firms of the same kind attain large aggregate effects. In this two-tier setting, the firm-level bargaining outcome is the second channel by which capital investment affects wages (the term $\epsilon\ell$ inside the square brackets). A higher individual worker's bargaining power ϵ simply means that a larger fraction of the beneficial effects of investment accrues to worker in terms of more generous remunerations.

We find convenient to put together the system of five main equations of the model, the F.O.C.s on capital investment (18) and (19), the two zero profit conditions (8), and the no arbitrage condition (11):

$$\begin{aligned}
a_a\alpha\, k_a^{\alpha-1}\left[(1+\ell)(1-\beta\phi)-\epsilon\ell(1-\phi)\right] &= r\,\frac{r+\delta+q(\theta_a)}{q(\theta_a)}\\
a_b\alpha\, k_b^{\alpha-1}\left[(1+\ell)(1-\beta(1-\phi))-\epsilon\ell\phi\right] &= r\,\frac{r+\delta+q(\theta_b)}{q(\theta_b)}\\
(1+\ell)\,a_a k_a^{\alpha}-w_a &= rk_a\,\frac{r+\delta+q(\theta_a)}{q(\theta_a)}\\
(1+\ell)\,a_b k_b^{\alpha}-w_b &= rk_b\,\frac{r+\delta+q(\theta_b)}{q(\theta_b)}\\
\frac{f(\theta_a)}{r+\delta+f(\theta_a)}\,(w_a-z) &= \frac{f(\theta_b)}{r+\delta+f(\theta_b)}\,(w_b-z)
\end{aligned} \tag{28}$$

,

in which the expressions for w_a and w_b are in equations (24) and (25). The following Lemma and Proposition summarize the main properties of the system.

Lemma 1 *If $\beta(1+\ell) > \epsilon\ell$, any possible solution of system* (28) *exhibits the following features: $k_a < k_b$, $a_a k_a^{\alpha} < a_b k_b^{\alpha}$, $\phi > \frac{1}{2}$, $w_a < w_b$, $\theta_a > \theta_b$.*

Computations are presented in Appendix C. Lemma 1 just states that many properties of the equilibrium in a two-tier bargaining scenario are not different from those obtained in a one-tier setting, provided that $\beta(1+\ell) > \epsilon\ell$. Such an inequality measures the relative importance of the sectoral negotiation compared to the decentralised one for the employees, expressed in terms of bargaining power and hours worked.[31]

The only differences compared to the one-tier setting concern wages and labour market tightness. Salaries are no longer identical in the entire sector, as they depend on the labour productivity at firm level. In equilibrium, type b firms are more productive, so they end up paying more generous wages. For the no arbitrage condition, the expected duration of unemployment in type b labour market must be higher.

[31] This seems a very reasonable assumption. Indeed, unionisation at central level usually allows workers to gain a higher leverage in the negotiations. With $\beta > \epsilon$ condition in Lemma 1 is met *a fortiori*.

Proposition 2 *If the condition in Proposition 1 is fulfilled, then there exists one steady-state equilibrium for the two-tier bargaining model in the neighborhood of* $\epsilon = 0$*.*

The non linearity of system in (28) does not allow to find a global solution for the two-tier scheme. A local analysis is however possible, by noticing that the equations in the two-tier setting coincide with the ones in the one-tier scenario when $\epsilon = 0$. Computing the Jacobian matrix of system (28) at $\epsilon = 0$, we get that its determinant is different from 0. Results are presented in Appendix D. If the condition in Proposition 1 is fulfilled, there exists a solution for $\epsilon = 0$. Then, applying the implicit function theorem, a unique equilibrium exists in the neighborhood of $\epsilon = 0$.

5.3 Two-Tier vs One-Tier Bargaining

Each worker is associated with k_i units of capital, so the average level of investment per worker is: $\bar{k} \equiv \phi\, k_a + (1-\phi)\, k_b$. The following Proposition summarizes the results.

Proposition 3 *If* $r \to 0$ *and* $\frac{a_a}{a_b} < \left[\alpha(2-\alpha)\left(1 + \frac{\beta^2}{4(1-\beta)}\right)\right]^{\alpha}$*, the average level of investment per worker is greater under a two-tier than under a one-tier wage bargaining setting.*

The proof is in Appendix E. Here we provide the basic intuition behind the result and an interpretation for the sufficient conditions above. There are three different channels through which a two-tier wage setting affects the average level of investment: wage, labour supply, and marginal decisions on capital. The first two mechanisms determine the level of tightness in both labour markets. In turn, changes in θ_a and θ_b affect firms' choices on investment, k_a and k_b. The first effect is the most intuitive. In a one-tier bargaining scheme all workers are paid the same, according to the average productivity in the sector. On the contrary, as Lemma 1 shows, under two-tier bargaining type b firms (resp. type a), that are more (resp. less) capital intensive, pay higher (resp. lower) wages. It is important to stress that the changes in w_a and w_b have not the same magnitude. From equations (24) and (25), the pay increase for type b jobs positively depends on the share of type a firms, ϕ, whereas workers in less capital intensive firms suffer from a larger wage reduction the greater $1-\phi$ is. Since from Lemma 1 we know that $\phi > \frac{1}{2}$, the surge in w_b is larger in absolute value than the decrease in w_a. Because of this first wage effect, vacancy creation tends to be lower for type b firms and higher for type a firms.

Yet the model exhibits a second, labour supply, effect that goes in the opposite direction. For the no arbitrage condition, the wage gap within the sector changes the share of job seekers between the labour markets. There will be more (resp. less) unemployed workers searching for a job in more (resp. less) capital intensive firms. Under at two-tier wage setting, capital investment for type b firms remains unused for a shorter period, as vacancies are filled more quickly. On the contrary, such a shift in the labour supply composition worsens the hold up problem for type a firms, raising their investment costs.

In short, the two effects just exposed raise the wage bill but lower the costs of investment for capital intensive firms, whereas the opposite occurs for less capital intensive firms. The final effect on vacancy creation and labour market tightness depends on the relative strength of these two mechanisms. In Appendix E we show that, if the real interest rate in the economy, r, is close to 0 (the first condition in Proposition 3), the magnitude of the change in the investment costs is sufficiently large that it outweighs the decrease in labour costs for type a firms but it is not enough to make up for the larger increase in the wage bill experienced by type b firms. In the end both θ_a and θ_b go down, as a two-tier setting dampens vacancy creation for all firms. Such a decrease in tightness sets in motion the third mechanism of the model. As the F.O.C.s on investment make clear, a lower θ_i raises the amount of capital chosen by any single firm, as marginal costs are now lower (the expected duration of a vacancy is shorter).[32] Under a two-tier wage bargaining, each firm buys more capital. Both k_a and k_b increase, and we have a higher level of investment per worker $\bar{k}$.

The second sufficient condition in Proposition 3 also deserves a few comments. As the

[32]Notice that this result chimes well with empirical evidence presented in column 6 of Appendix A.3, where we document a negative relationship between the adoption of a two-tier wage mechanism and the difficulty of recruiting new employees.

one imposed in Proposition 1 for the existence of an equilibrium in a one-tier scenario, it imposes an upper bound on the gap in total factor productivity between firms.[33] It is difficult to have a clear-cut explanation on the effects that a too large gap in TFP could have on the model. However, a tentative interpretation goes as follows. If the ratio a_a/a_b were too high, wage differences stemming from two-tier bargaining would be too large. Thus it would be possible that the benefits of lower wages for type a firms would be always greater than the disadvantages of higher investment costs. Vacancy creation and tightness for type a firms could increase, with negative effects on investment for less capital intensive productions.

6 Concluding Remarks

In this paper, we have analysed the relationship between unions, two-tier bargaining and investment in capital investment. Although two-tier wage bargaining schemes have become one of the most common features in labour markets of Continental Europe, with a changing role of unions in such negotiations, recent research has put into question their efficiency. While most of the criticism concerns the effects of this kind of negotiation on employment and wages, our paper looks at the relation between wage formation and investment, the latter being one of the key mediating channels that might explain the existence of productivity differentials across unionised and non-unionised firms. We show that, in presence of sunk capital investment, a two-tier wage mechanism may indeed raise the level of investment per worker by pushing a larger number of firms to increase their capital endowment.

The results of the model are also corroborated by some evidence that shows, for a representative sample of Italian firms, the existence of a positive and robust correlation between the level of investment per worker and the presence of a two-tier bargaining agreement within the firm which tends to exactly counterbalance the negative correlation between investment and unionisation (proxied by the presence of a work council).

[33]Since both depend on α and β, it could be the case that for some parametric spaces the second inequality in Proposition 3 is less binding than the one in Proposition 1. In that case, it is sufficient to have $r \to 0$ for a higher $\bar{k}$ in a two-tier wage setting equilibrium.

Further research might investigate two related avenues of study. On the one hand, it might analyse in detail the theoretical determinants of the adoption of two-tier bargaining schemes, with particular emphasis on the welfare effects and the related empirical implications. On the other hand, it might analyse the role of unions and different bargaining structures on the efficient allocation of resources. Indeed, previous literature has shown that other labour market institutions, as employment protection legislation, have relevant effect on the (mis)allocation of labour inputs, with non negligible implications for productive efficiency. In this sense, the behaviour of sectoral unions should be analysed further. One could imagine a utility loss for them as the second level of the negotiation gains strength. If they act strategically, this would have non-negligible effects on employment and wages.

A Institutional Background, Data and Additional Correlations

A.1 Institutional Background

The Italian industrial and labour relations system is characterized by a two-tier bargaining (TTB) structure. The first level of bargaining is the national collective one, with contractual labour agreements that extend virtually *erga omnes* at the sectoral level; the second level is the decentralised one, with firm (or establishment) level agreements that supplement the national collective contracts. Decentralised agreements cannot prevail on national collective contracts, that constitute the minimum requirements (floors) in terms of wage agreements and working conditions. Still, when a decentralised contract is signed, it extends to all workers at the firm level. Second level bargaining has the main scope of increasing flexibility with a more direct link between wages and productivity; in this respect, decentralised contracts deal with other aspects of the employment relation that are not considered in collective contracts as for example the introduction of performance related pay schemes, work organization practices, hours of work arrangements and investment in training for workers. Most importantly, second level bargaining has asymmetric effects on wage flexibility, with the national collective contracts imposing a wage floor which cannot be overcome by downward wage adjustments at the decentralised level.

In this context, unions play a relevant role. The Italian law does not impose particular rules on the formation of unions and their organization structure, and workers can join them on individual voluntary basis. Moreover, for the union to be recognized, it is not necessary the approval of any employer (or of employers' associations), although management at the firm level can decide not to negotiate with them (except in cases explicitly required by the law, as for example in case of collective dismissals in firms above 50 employees). Still, the industrial relation system is very much structured along a corporatist regime, with the main national representative unions (CGIL, CISL and UIL) playing a predominant role in negotiating and signing national collective agreements at the sectoral level.[34]

Union representation at the firm level takes place through the set up of RSA (Rappresentanze Sindacali Aziendali) or, more recently, RSU (Rappresentanze Sindacali Unitarie). Although the latter partially resemble traditional works councils (see Devicienti et al. (2018)), sharing with them some organizational arrangements, as for example the electoral rules for their constitution within the firm (which extends the right to vote to all employees), they also differ along some important dimensions. In fact, RSA and RSU can be set up in firms/establishments with more than 15 employees following the initiative of workers and support of unions that signed the national collective agreement taking place at the firm level. Moreover, members elected in RSA/RSU boards are chosen from different lists provided by the most representative union organizations at the local and national level, turning in a very strict connection between union representatives and works councils. As a matter of fact, the coordination of activities of works councils and unions is not formally shaped by the law, resulting in a single representation channel comprising both union and employees instances. In this context, both union and workers representatives are actively involved in bargaining with firm management on various aspects of the business activities that are not already covered by national collective agreements.

Although RSA and RSU have the possibility to sign decentralised firm level agreements, this has to be done in conjunction with local union representatives within the framework of the national collective agreement adopted at the firm level. Note also that second level bargaining may also take place at the individual level without considering union representatives.

A.2 Data

We use data from the ISFOL-RIL (Rilevazione Longitudinale su Imprese e Lavoro) Survey. The sample for year 2010 comprises about 22 thousands firms, extracted from the universe of Italian firms ASIA (Archivio Statistico Imprese Attive), which is made available by IS-

[34]Typically, unions are mostly organized at the sectoral level, with union members having industry specific affiliations. Similar structure arrangements are established by employers' associations.

TAT (Italian Statistical Insitutute). The sampling procedure is based on firm size and it is representative of the population of both the limited liability companies and partnerships in the private (non-agricultural) sectors.

Table A1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Investment per worker	5,986	8119.205	17959.32	0	182942.8
Unions (RSA-RSU)	5,986	.494	.500	0	1
Two-Tier bargaining	5,986	.277	.447	0	1
National contract	5,982	.980	.140	0	1
Employers' association	5,970	.764	.424	0	1
Family firm	5,832	.687	.464	0	1
Management	5,942	.277	.448	0	1
Offshoring	5,986	.026	.160	0	1
Export	5,986	.372	.483	0	1
Workers in *cassa integrazione*	5,980	.283	.451	0	1
Share of high skilled	4,351	.136	.196	0	1
Share of medium skilled	4,341	.403	.247	0	1
Share of low skilled	4,339	.461	.312	0	1
Share of female workers	5,986	.346	.268	0	1
Share of trained workers	5,727	.289	.354	0	1
Share of fixed term contracts	5,986	.111	.170	0	1
Size between 16 and 49	5,986	.566	.496	0	1
Size between 50 and 249	5,986	.320	.466	0	1
Size between 250 and above	5,986	.114	.318	0	1

Notes: Descriptive statistics have been calculated on the sample used in regression reported in column 1 in Table 1. See Section A.2 for more details. Investment per worker is expressed in euros. Unions is a dummy for firms with a RSA-RSU in place; National contract is a dummy for firms applying a national collective contract; Two-tier bargaining is a dummy for firms with a second level bargaining agreement in place; Employers' association is a dummy for firms belonging to those associations; Family firm is a dummy for firms run by families, while Management is a dummy for firms run by external managers; Offshoring and Export are dummies for firms that are offshoring and exporting; Workers in *cassa integrazione* is a dummy for firm with a short-work programme in place; Shares are calculated over total number of employees and firms for size dummies respectively.

We begin with 24,459 observations for the year 2010. We first drop firms that have negative sales, those that have zero (or below) employees (4,262 observations). From the 20,197 observations we drop 13,509 firms below 15 employees, then we are left with a potential sample of 6,688 observations. In our regressions we also exclude firms whose investment per worker is missing or above or equal the 99th percentile, are not operating in the market and have some missing union information. The above restriction criteria correspond to about six thousands observations with non missing investment information. Main regressions run on a sample of 5,986 observations (or less) depending on missing data. Note also that when we include information for the year 2007, the sample size drops to 4,057 observations.

A.3 Additional Correlations

In this Appendix we report a few additional regressions that either qualify our main result on the relationship between investment per worker and the existence of a two-tier bargaining agreement or are consistent with other key predictions of our theoretical model.

In relation to the first point, we test, by running a set of probit (Panel A) and linear probability model (Panel B) regressions, the existence of a relationship between the presence of a two-tier bargaining agreement and the investment extensive margin, i.e. the probability that a firm invests, broken down by type of investment expenditure.[35] In the first two columns of Table A2 we report the correlation between the presence of a two-tier agreement and the probability that the firm undertakes any investment; in turn, in the remaining columns we focus on the probability of investment into tangible (columns 3 and 4) and intangible (columns 5 and 6) capital. The empirical results suggest that a two-tier agreement is always positively correlated with the probability of investment, with a broadly similar magnitude across investment categories, which reinforces the empirical results reported in the main text.

In Table A3 we report additional correlations that are consistent with further predictions of our theoretical model. In columns 3 (and 4) we show the existence of a positive correlation, conditional on controls, between the log of unit labour costs (gross wages, respectively) and the log of capital intensity, measured by the ratio of the total capital stock to the number of employees.[36] This result suggests that, in the cross section, more capital intensive firms tend to pay higher wages, as our theoretical model predicts.[37]

Our model also predicts that a larger capital stock should lead to higher labour productivity. In column 5 we test this prediction and we find evidence of a positive and statistically significant correlation between the degree of capital intensity (proxied by the capital-to-labour

[35]Unfortunately, we do not have information on the amount of expenditure for each category of investment. To construct our dependent variables we use information on total investment; investment in tangible assets (lands and buildings; industrial plants, machinery and equipment; computers; automation) and in intangible assets (marketing & advertising, research & development, patents, software).

[36]We computed the ratio between fixed assets and the number of workers (i.e. the capital-to-labour ratio) as a proxy of capital intensity; instead, total amount of labour costs includes gross wages, social security contributions and other labour costs, and it is divided by the number of employees.

[37]Results are confirmed when we use gross wages as our dependent variable in column 4.

Table A2: Probit and linear probability models for investment

dependent variable	(1) total investment	(2)	(3) tangible investment	(4)	(5) intangible investment	(6)
Panel A: Probit models						
union	-0.0290	-0.0536	0.0332	0.00493	-0.0638	-0.108*
	(0.0774)	(0.0878)	(0.0716)	(0.0875)	(0.0669)	(0.0627)
two-tier bargaining (TTB)	0.344***	0.341***	0.293***	0.282***	0.209**	0.253***
	(0.105)	(0.118)	(0.0841)	(0.0960)	(0.0933)	(0.0705)
Size Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Sector Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Collective contract dummies	No	Yes	No	Yes	No	Yes
Observations	5,979	5,425	5,982	5,435	5,982	5,451
Panel A: Linear probability models						
union	-0.0123	-0.0216	0.0100	-4.44e-05	-0.0233	-0.0384*
	(0.0276)	(0.0316)	(0.0263)	(0.0322)	(0.0246)	(0.0229)
two-tier bargaining (TTB)	0.107***	0.106***	0.0984***	0.0943***	0.0738**	0.0871***
	(0.0331)	(0.0385)	(0.0291)	(0.0341)	(0.0343)	(0.0262)
Size Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Sector Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Collective contract dummies	No	Yes	No	Yes	No	Yes
Observations	5,986	5,515	5,986	5,515	5,986	5,515

Notes: Standard errors are cluster robust at the industry level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Dependent variable is a dummy equal to one for total (cols. 1 and 2), tangible (cols. 3 and 4) and intangible (cols. 5 and 6) investment, respectively. All regressions include sample weights. See Section A.3 for more details concerning the sample selection and definition of variables. See text for further details.

ratio) and labour productivity.[38]

In turn, column 6 tests a key prediction of the theoretical model, namely that firms with a two-tier agreement pay higher wages, which in turn tends to reduce the time spell a firm takes to fill a vacancy, which alleviates the hold up problem and leads firms to invest more. Unfortunately, we do not have information on the time spell a firm needs to fill a vacancy; however, we do have information on the fraction of job positions the firms was experiencing difficulties to fill.[39] Therefore, large values of this variable should indicate that the firm was experiencing, on average, a longer time to fill its vacancies. Empirical results displayed in column 6 suggest, conditional on controls, that firms with a two-tier agreement experienced, on average, shorter vacancy durations. Such a correlation is clearly fully consistent with the

[38] As mentioned, we computed the ratio between fixed assets and the number of workers (i.e. the capital-to-labour ratio) as a proxy of capital intensity; instead, data limitations force us to use the log of sales per employee as a measure of labour productivity. We are aware that the latter is extremely sensitive to the degree of vertical integration of the firm (i.e. it heavily depends on the make-or-by decision of firms, unlike a definition of labour productivity as valued added per employee).

[39] The variable Difficulty of recruitment is calculated, for the firms that were recruiting at the time of the interview, as the ratio between the number of employees the firm was experiencing problems while recruiting and the total number of employees the firm was trying to recruit (the number of vacancies at the firm level).

Table A3: Additional correlations

dependent variable	(1) inv. per worker	(2) inv. per worker	(3) ln(labour costs)	(4) ln(gross wages)	(5) ln(labour productivity)	(6) difficulty recruitment	(7) $\ln(K/L)$
union density	-0.522***						
	(0.168)						
union		-0.244*				-0.132***	-0.0124
		(0.139)				(0.0453)	(0.0886)
two-tier bargaining (TTB)	0.216**	0.169*				-0.0973*	0.203
	(0.0954)	(0.0922)				(0.0548)	(0.144)
financial constraint		0.00264**					
		(0.00123)					
$\ln(K/L)$			0.0814***	0.0764***	0.148***		
			(0.0147)	(0.0141)	(0.0215)		
Size Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	9.435***	9.529***	10.29***	9.995***	7.677***	0.0819	11.91***
	(0.266)	(0.292)	(0.182)	(0.169)	(0.627)	(0.420)	(0.335)
Observations	5,981	5,334	5,860	5,803	5,866	994	5,681
R-squared			0.215	0.199	0.227	0.296	0.207

Notes: Standard errors are cluster robust at the industry level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. In col. 1, the dependent variable is the level of investment per worker, union density is calculated as union members over total employees. In col. 2 financial constraint is operating profits over sales. In cols. 3 and 4 the dependent variables are the natural logarithm of total labour costs and gross wages over employees respectively. In col. 5, labour productivity is calculated as natural logarithm of sales over employees. In col. 6 difficulty recruitment is the ratio of vacancies that were reported as difficult to fill over the total number of vacancies. In col. 7 capital labour ratio is fixed assets over total employees. All regressions include sample weights. See section A.3 for more details concerning the sample selection and definition of variables. See text for further details.

theoretical mechanism identified by our model.

Moreover, in column 7 of Table A3 we investigate the existence of a correlation between a two-tier agreement and the log of capital per worker (instead of investment per worker): the empirical result confirm the positive correlation, albeit the coefficient of interest is slightly noisily estimated.

Finally, as mentioned in the main text, our theoretical model implies, in sectors with high sunk capital and collective bargaining, a negative correlation between the level of TFP and capital investment. Unfortunately, the main limitation of our data is that we cannot calculate TFP because we do not have access to an exhaustive set of balance sheet items. Indeed, in order to compute TFP, we would need to have information on sales, the capital stock, number of workers and expenditure on intermediate inputs; however, we do not have information on the latter. Therefore, we cannot test whether the negative correlation between TFP and capital intensity predicted by our model holds true in our data.

B Existence of the Equilibrium in the One-Tier Wage Bargaining Case

Notice first that, for the no arbitrage condition (11), an identical pay ($w_a = w_b = w$) leads to an identical labour market tightness: $\theta_a = \theta_b = \theta$.

Then, using the F.O.Cs (18) and (19) we get that:

$$\frac{a_a \, k_a^{\alpha-1}}{a_b \, k_b^{\alpha-1}} = \frac{1-\beta\,(1-\phi)}{1-\beta\,\phi} \tag{B1}$$

The term at the RHS is increasing in ϕ. So equation (B1) states that $\phi > \frac{1}{2}$ implies $a_a \, k_a^{\alpha-1} > a_b \, k_a^{\alpha-1}$ and vice versa. The marginal cost of investment is identical for both types of firms, as they pay the same price for capital and face the same expected vacancy duration. We have also noticed that the type i of firm that is prevalent in the economy is more affected by the negative effects of a wage increase on investment. So $a_i\, k_i^{\alpha-1}$ must be higher for the marginal revenues to be equal too.

For the F.O.C for k_a (18) and the free-entry condition in labour market a, (8), we also have that: $w \;=\; (1+\ell)\, a_a \cdot k_a^{\alpha}\, [1 \,-\, \alpha\,(1-\beta\,\phi)\,]$. Doing the same for sector b, we also get $w \;=\; (1+\ell)\, a_b \cdot k_b^{\alpha}\, [1 \,-\, \alpha\,(1-\beta\,(1-\phi)\,)\,]$. Putting the RHS of these two equations together, we have that:

$$\frac{a_a\, k_a^{\alpha}}{a_b\, k_b^{\alpha}} \;=\; \frac{1 \,-\, \alpha\,(1-\beta\,(1-\phi)\,)}{1 \,-\, \alpha\,(1-\beta\,\phi)} \tag{B2}$$

The term at the RHS is decreasing in ϕ. This implies that the type of firms prevalent in the economy produces a lower amount of output per hour (the ratio at the LHS).

Rearranging equations (B1) and (B2), we get an implicit function of ϕ:

$$\Gamma^{\alpha}\;(1-\alpha\,\Gamma)^{1-\alpha} \;-\; \frac{a_b}{a_a}\,\Omega^{\alpha}\;(1-\alpha\,\Omega)^{1-\alpha} \;=\; 0 \tag{B3}$$

in which $\Gamma \;\equiv\; 1-\beta\phi,\;\; \frac{d\,\Gamma}{d\phi} \;<\; 0$ and $\Omega \;\equiv\; 1-\beta(1-\phi),\;\; \frac{d\,\Omega}{d\phi} \;>\; 0$. It is easy to check that the expression at the LHS is increasing in Γ and decreasing in Ω. So the term at the LHS is decreasing in ϕ. There is a unique solution of (B3) if and only if that expression is positive for some value of ϕ, and it is negative at $\phi \,=\, 1$.

Substituting $\phi \;=\; 1/2$ in (B3), the term at the LHS becomes equal to $1 \,-\, \left(\frac{a_b}{a_a}\right)^{\frac{1}{1-\alpha}}$, which is greater than 0. This results also means that, if an equilibrium for ϕ exists, it must be larger than 1/2. So the necessary and sufficient condition for a unique equilibrium is that, with $\phi = 1$, the term at the LHS of (B3) is negative. This is equivalent to:

$$\frac{a_a}{a_b} \;<\; \left(\frac{1-\alpha}{1-\alpha(1-\beta)}\right)^{1-\alpha}\;(1-\beta)^{-\alpha}$$

Rewriting the first term at the RHS, we easily get the condition in Proposition 1.

Figure 1 presents in the vertical axis the value for the ratio a_a/a_b that satisfies such condition for different values of α and β. It appears clear that the inequality gets less binding as β and α become larger. When both parameters are close to 1, the TFP ratio

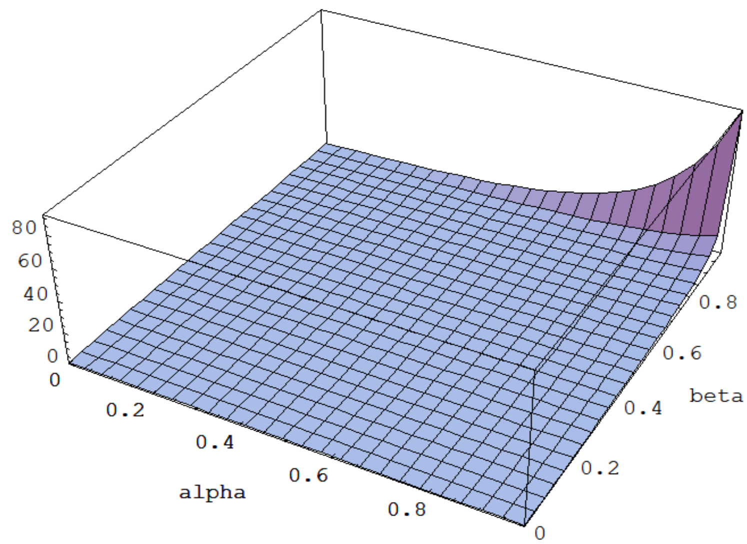

Figure 1: Condition 1 for different values of α and β

a_a/a_b must be lower than 80 for an equilibrium to exist. Conversely, when β and α tend to 0, a_a/a_b must be lower than 1, that means the model has no equilibrium, as $a_a > a_b$ by assumption. As explained in Section B, reasonable calibrated values for α should be in the range [0.4, 0.5]. So, in order to get empirically plausible TFP differences (about $1.2 - 1.4$), the values for β should be close to $0.6 - 0.7$, which are in line with related values obtained by Shimer (2005).

Finding the values for the other endogenous variables is just a matter of appropriate substitutions. For instance, we can use equation (B1) to express k_a as a function of k_b and ϕ. Then we insert such an expression into the zero profit condition for type a firms, (8). Together with the zero profit condition for type b firms, we get the following system:

$$\begin{aligned}(1+\ell)\, a_a k_b^{\alpha}\, \Phi \; - \; w \; &= \; \frac{r \cdot k_b\, \Phi\; [r+\delta+q(\theta)]}{q(\theta)} \\ (1+\ell)\, a_b k_b^{\alpha} \; - \; w \; &= \; \frac{r \cdot k_b\; [r+\delta+q(\theta)]}{q(\theta)}\end{aligned} \tag{B4}$$

in which $\Phi \equiv \left(\frac{a_b}{a_a}\frac{\Omega}{\Gamma}\right)^{\frac{1}{\alpha-1}}$ and the wage w is expressed as in equation (16). Rearranging such a system, we are able to express k_b as a function of ϕ only:

$$(1+\ell)\, k_b^{\alpha}\; \{a_a \Phi^{\alpha}\, [1-\beta\phi(1-\Phi)] \,-\, a_b\, [\Phi+\beta(1-\phi)(1-\Phi)]\} = (1-\beta) z (1-\Phi) \tag{B5}$$

Since ϕ is uniquely defined, equation (B5) also allows us to uniquely determine the equilibrium value for k_b. In turn, we get the solution for k_a and θ via equations (B1) and (8) respectively. Once these endogenous variables are determined, all the remaining expressions (utility functions and wage) are trivially obtained using their corresponding equations.

C Proof of Lemma 1

To prove Lemma 1 we first rearrange some of the equations in (28) to get two expressions of the ratio k_a/k_b in terms of the other endogenous variables. We first denote the following variables:

$$\Gamma \,\equiv\, 1-\beta\phi,\;\; \Gamma' \,\equiv\, \frac{d\Gamma}{d\phi} < 0 \quad \text{and} \quad \Omega \,\equiv\, 1-\beta(1-\phi),\;\; \Omega' \,\equiv\, \frac{d\Omega}{d\phi} > 0 \tag{C1}$$

Rearranging the F.O.C for k_a and the free-entry condition in labour market a (the first and the third equation in system 28) we get:

$$w_a \,=\, a_a k_a^{\alpha}\, \{(1+\ell)\; [1 \,-\, \alpha\,\Gamma\,] - (1-\alpha)\epsilon(1-\phi)\ell\} \,+\, a_b k_b^{\alpha} \epsilon(1-\phi)\ell \tag{C2}$$

proceeding the same way with the the second and the fourth equation in system (28):

$$w_b \,=\, a_b k_b^{\alpha}\, \{(1+\ell)\; [1 \,-\, \alpha\,\Omega)\,] - (1-\alpha)\epsilon\phi\ell\} \,+\, a_a k_a^{\alpha} \epsilon\phi\ell \tag{C3}$$

Putting the RHS of equations (C2) and (C3) together, we have :

$$\frac{a_a\, k_a^{\alpha}}{a_b\, k_b^{\alpha}} \,=\, \frac{(1+\ell)\,[1 \,-\, \alpha\,\Omega] \,-\, \epsilon\ell(1-\alpha\phi)}{(1+\ell)\,[1 \,-\, \alpha\,\Gamma] \,-\, \epsilon\ell(1-\alpha(1-\phi))} \tag{C4}$$

It is easy to see that such a ratio is decreasing in ϕ, if $\beta(1+\ell) > \epsilon\ell$. This seems a quite reasonable condition, since the decentralised level of the negotiation usually deals with a small fraction of the total remuneration and workers have less bargaining strength.

The second expression for the ratio k_a/k_b is obtained by combining the F.O.Cs for capital investment (the first and the second equation in system 28):

$$\frac{a_a\, k_a^{\alpha-1}}{a_b\, k_b^{\alpha-1}} = \frac{r+\delta+q(\theta_a)}{q(\theta_a)} \frac{q(\theta_b)}{r+\delta+q(\theta_b)} \frac{\mathbb{A}}{\mathbb{B}} \tag{C5}$$

in which $\mathbb{A} \equiv (1+\ell)\Omega - \epsilon\phi\ell$ and $\mathbb{B} \equiv (1+\ell)\Gamma - \epsilon(1-\phi)\ell$. Combining equations (C4) and (C5) to get rid of the ratio k_a/k_b we have:

$$\frac{r+\delta+q(\theta_a)}{q(\theta_a)} \frac{q(\theta_b)}{r+\delta+q(\theta_b)} = \left(\frac{a_a}{a_b}\right)^{\frac{1}{\alpha}} \frac{\mathbb{B}}{\mathbb{A}} \left[\frac{1+\ell(1-\epsilon)-\alpha\,\mathbb{A}}{1+\ell(1-\epsilon)-\alpha\,\mathbb{B}}\right]^{\frac{\alpha-1}{\alpha}} \tag{C6}$$

Notice that $\phi = \frac{1}{2}$ implies $\mathbb{A} = \mathbb{B}$. Moreover, as $\phi < \frac{1}{2}$ (resp. $\phi > \frac{1}{2}$) we have $\mathbb{A} < \mathbb{B}$ (resp. $\mathbb{A} > \mathbb{B}$) if $\beta(1+\ell) > \epsilon\ell$. Under such a condition it is also easy to get that the term at he RHS of (C6) is decreasing in ϕ. As far as it concerns the term at the LHS, it is increasing in θ_a and decreasing in θ_b. The following inequalities summarize our results on equation (C6):

$$\begin{aligned}
&\text{If } \phi = \frac{1}{2} \quad \frac{r+\delta+q(\theta_a)}{q(\theta_a)} \frac{q(\theta_b)}{r+\delta+q(\theta_b)} = \left(\frac{a_a}{a_b}\right)^{\frac{1}{\alpha}} \text{ then } \theta_a > \theta_b \\
&\text{If } \phi < \frac{1}{2} \quad \frac{r+\delta+q(\theta_a)}{q(\theta_a)} \frac{q(\theta_b)}{r+\delta+q(\theta_b)} > \left(\frac{a_a}{a_b}\right)^{\frac{1}{\alpha}} \text{ then } \theta_a > \theta_b \\
&\text{If } \phi > \frac{1}{2} \quad \frac{r+\delta+q(\theta_a)}{q(\theta_a)} \frac{q(\theta_b)}{r+\delta+q(\theta_b)} < \left(\frac{a_a}{a_b}\right)^{\frac{1}{\alpha}} \text{ then } \theta_a \gtreqless \theta_b
\end{aligned} \tag{C7}$$

Now we wonder whether it is possible that, at the equilibrium, $\theta_a = \theta_b$. For the no arbitrage condition (the fifth equation in system 28), that would imply $w_a = w_b$. In turn, from the wage equations (24) and (25), we would get $a_a k_a^\alpha = a_b k_b^\alpha$. Since $a_a > a_b$, this would mean $k_a < k_b$. But this would be in contradiction with the free-entry zero profit conditions (the third and the fifth equations in system 28), that with $w_a = w_b$, $\theta_a = \theta_b$, and

$a_a k_a^\alpha = a_b k_b^\alpha$ would imply $k_a = k_b$. So at the equilibrium, $\theta_a \neq \theta_b$.

Suppose now that $\theta_a < \theta_b$. The no arbitrage condition implies that $w_a > w_b$. Then, from the wage equations (24) and (25), we should have $a_a k_a^\alpha > a_b k_b^\alpha$ or $\left(\frac{k_a}{k_b}\right)^\alpha > \frac{a_a}{a_b}$. For equation (C4) to hold, this would be possible only if $\phi < \frac{1}{2}$ that, for the inequalities in (C7), would imply $\theta_a > \theta_b$, that is in contradiction with our initial assumption.

All the possible equilibria present the following feature: $\theta_a > \theta_b$ that, for the no arbitrage condition also means $w_a < w_b$. In turn, the wage equations (24) and (25) imply that $a_a k_a^\alpha < a_b k_b^\alpha$. The ratio in (C4) tells us that $\phi > \frac{1}{2}$, that is not in contradiction with the third inequality in (C7).

D Existence of the Equilibrium in the Two-Tier Wage Bargaining Case

We linearize system (28) around $\epsilon = 0$. At $\epsilon = 0$, the model coincides with the one-tier bargaining scenario, in which a unique solution exists if the condition in Proposition 1 is respected. We denote with subscript ^{O} the equilibrium value of the endogenous variables under a one-tier wage setting scenario. We express the system in terms of variations with respect to the one-tier wage bargaining equilibrium. So, for instance, Δk_a is the difference between the value of k_a under a two-tier negotiation and the value under one-tier bargaining.

We get:

$$-(1-\alpha)\frac{\Theta}{k_a^O}\cdot\Delta k_a - \frac{\beta}{\Gamma}\Theta\cdot\Delta\phi - \Theta'\cdot\Delta\theta_a = \frac{\ell}{1+\ell}\frac{1-\phi^O}{\Gamma}\Theta\cdot\epsilon$$

$$-(1-\alpha)\frac{\Theta}{k_b^O}\cdot\Delta k_b + \frac{\beta}{\Omega}\Theta\cdot\Delta\phi - \Theta'\cdot\Delta\theta_b = \frac{\ell}{1+\ell}\frac{\phi^O}{\Omega}\Theta\cdot\epsilon$$

$$-\beta\frac{(1-\phi^O)\Theta}{\Omega}\cdot\Delta k_b + \beta(k_b^O - k_a^O)\Theta\cdot\Delta\phi - \Theta' k_a^O\cdot\Delta\theta_a = -\frac{\ell}{1+\ell}(1-\phi^O)\Theta(k_b^O - k_a^O)\cdot\epsilon$$

$$-\beta\frac{\phi^O\Theta}{\Gamma}\cdot\Delta k_a + \beta(k_b^O - k_a^O)\Theta\cdot\Delta\phi - \Theta' k_b^O\cdot\Delta\theta_b = \frac{\ell}{1+\ell}\phi^O\Theta(k_b^O - k_a^O)\cdot\epsilon$$

$$\frac{(1-\eta)q(\theta^O)(r+\delta)(w^O-z)}{(r+\delta+f(\theta_a))^2}(\Delta\theta_a - \Delta\theta_b) = \frac{f(\theta^O)}{r+\delta+f(\theta_a)}\frac{\ell}{1+\ell}\Theta(k_b^O - k_a^O)\cdot\epsilon$$

$$\text{in which } \Theta \equiv \frac{r\left[r+\delta+q(\theta^O)\right]}{q(\theta^O)}, \quad \Omega \equiv 1-\beta(1-\phi^O) \quad \text{and} \quad \Gamma \equiv 1-\beta\phi^O \tag{D1}$$

Moreover, $\Theta' \equiv \frac{d\Theta}{d\theta^O} > 0$. To prove that such a system admits a solution, we first make some substitutions. From the fifth equation of the system, $\Delta\theta_b$ can be expressed in terms of $\Delta\theta_a$:

$$\Delta\theta_b = \Delta\theta_a - \frac{\ell}{1+\ell}\Theta(k_b^O - k_a^O)\frac{\theta^O(r+\delta+f(\theta^O))}{(1-\eta)(r+\delta)(w^O-z)}\epsilon \tag{D2}$$

We substitute such an expression in all the other four equations of the system. Then, after some manipulations, we sum the first and the fourth equation to express $\Delta\theta_a$ as a function of Δk_a only:

$$\Delta\theta_a = \frac{-\frac{\Delta k_a}{k_a^O}\left(1-\alpha+\frac{\phi^O}{\Gamma}\frac{1-\alpha\Omega}{2\phi^O-1}\right) - \Psi}{\frac{\Theta'}{\Theta}\left(1+\frac{\Omega(1-\alpha\Gamma)}{\Gamma\beta(2\phi^O-1)}\right)} \tag{D3}$$

in which

$$\Psi \equiv \frac{\epsilon}{\Gamma}\frac{\ell}{1+\ell}\left[1-\Theta'(k_b^O-k_a^O)\frac{\theta^O(r+\delta+f(\theta^O))}{(1-\eta)(r+\delta)(w^O-z)}\frac{\Omega(1-\alpha\Gamma)}{\beta(2\phi^O-1)}\right]$$

Now we can substitute the expression for $\Delta\theta_a$ in equation (D3) in all the first three equations of system (D1). After some manipulations (details are available on request), we get an expression for $\Delta\phi$ as a function of Δk_a only:

$$\Delta\phi = \frac{\Gamma\left(\beta-1+\alpha(2-\alpha)\Omega\Gamma\right)}{\beta k_a^O\left[(1-\alpha)\Omega\Gamma+\Omega-\Gamma^2\right]}\Delta k_a - \frac{\Gamma^2(2\phi^O-1)\left[\frac{\ell}{1+\ell}\frac{1-\phi^O}{\Gamma^2}\frac{(1-\alpha)\Omega\Gamma+\Omega-\Gamma^2}{\beta(2\phi^O-1)}\epsilon-\Psi\right]}{(1-\alpha)\Omega\Gamma+\Omega-\Gamma^2} \quad \text{(D4)}$$

Substituting this expression in the first two in (D1) we end up with a system of two equations and two unknowns:

$$\begin{aligned}
&-(1-\alpha)\left[(1-\alpha)\Omega\Gamma+\Omega-\Gamma^2\right]\Delta k_b + \\
&+\frac{k_b^O}{k_a^O}\left[\frac{\Gamma}{\Omega}\left[\beta-1+\alpha(2-\alpha)\Omega\Gamma\right]+1-\Gamma-\alpha\Omega+\Omega\Gamma-(1-\alpha)\Gamma^2\right]\Delta k_a = \\
&= k_b^O\frac{\ell}{1+\ell}\left[(1-\alpha)\Omega\Gamma+\Omega-\Gamma^2\right]\left[\frac{\phi^O}{\Omega}-\Theta'(k_b^O-k_a^O)\frac{\theta^O(r+\delta+f(\theta^O))}{(1-\eta)(r+\delta)(w^O-z)}\right]\epsilon + \\
&+k_b^O\left\{-\Psi\Gamma\beta(2\phi^O-1)+\frac{\Gamma}{\Omega}\frac{\ell}{1+\ell}\frac{1-\phi^O}{\Gamma}\left[(1-\alpha)\Omega\Gamma+\Omega-\Gamma^2\right]\epsilon-\frac{\beta\Gamma^2(2\phi^O-1)}{\Omega}\Psi\right\}
\end{aligned}$$

$$\begin{aligned}
&-\frac{\beta(1-\phi^O)}{\Omega}\left[(1-\alpha)\Omega\Gamma+\Omega-\Gamma^2\right]\Delta k_b + \\
&+\left[\frac{\Gamma(k_b^O-k_a^O)}{k_a^O}\left[\beta-1+\alpha(2-\alpha)\Omega\Gamma\right]+1-\Gamma-\alpha\Omega+\Omega\Gamma-(1-\alpha)\Gamma^2\right]\Delta k_a = \\
&= -k_a^O\,\beta(2\phi^O-1)\Gamma\Psi\left(1+\Gamma\frac{k_b^O-k_a^O}{k_a^O}\right)
\end{aligned} \quad \text{(D5)}$$

After some computations (available on request), we get that the determinant of such a system is equal to:

$$\left[(1-\alpha)\Omega\Gamma + \Omega - \Gamma^2\right] \left[\beta - 1 + \alpha(2-\alpha)\Omega\Gamma\right] \left[\frac{1-\Omega}{\Omega}(1-\alpha\Gamma) + \frac{1-\Gamma}{\Gamma}(1-\alpha\Omega)\right] \tag{D6}$$

Since $\Omega,\, \Gamma \in \{\, 0,\, 1\,\}$, $\Omega \neq \Gamma$, such an expression is different from 0. So, the system (D5) admits a solution in $(\Delta k_a,\, \Delta k_b)$. In turn, the equilibrium values for $\Delta\phi$, $\Delta\theta_a$, and $\Delta\theta_b$ are easily obtained via equations (D4), (D3), and (D2) respectively.

E Proof of Proposition 3

We are interested in evaluating the effect on on $\bar{k} \equiv \phi k_a + (1-\phi)k_b$ of a change from a one-tier to a two-tier wage system. Put in other terms, we want to check the sign of the following expression:

$$\Delta\bar{k} \;\cong\; (1-\phi^O)\Delta k_b \,+\, \phi^O \Delta k_a \,+\, \left(k_a^O - k_b^O\right)\Delta\phi \tag{E1}$$

Consider the first two equations in system (D1). After some simple manipulations, we can re-write them as follows:

$$\begin{aligned} (1-\alpha)\Gamma\cdot\Delta k_a + \beta k_a^O\cdot\Delta\phi + \frac{\Theta'}{\Theta}k_a^O\Gamma\cdot\Delta\theta_a &= -\frac{\ell}{1+\ell}(1-\phi^O)k_a^O\cdot\epsilon \\ (1-\alpha)\Omega\cdot\Delta k_b - \beta k_b^O\cdot\Delta\phi + \frac{\Theta'}{\Theta}k_b^O\Omega\cdot\Delta\theta_b &= -\frac{\ell}{1+\ell}\phi^O k_b^O\cdot\epsilon \end{aligned} \tag{E2}$$

Similarly, the third and the fourth equation in system (D1) can be rewritten as:

$$\beta(1-\phi^O)\cdot\Delta k_b \,-\beta\Omega(k_b^O-k_a^O)\cdot\Delta\phi+\frac{\Theta'}{\Theta}k_a^O\Omega\cdot\Delta\theta_a \;=\; +\frac{\ell}{1+\ell}(1-\phi^O)(k_b^O-k_a^O)\Omega\cdot\epsilon$$

$$\beta\phi^O\cdot\Delta k_a \,-\beta\Gamma(k_b^O-k_a^O)\cdot\Delta\phi+\frac{\Theta'}{\Theta}k_b^O\Gamma\cdot\Delta\theta_b \;=\; -\frac{\ell}{1+\ell}\phi^O(k_b^O-k_a^O)\Gamma\cdot\epsilon \tag{E3}$$

If we sum the two equations in (E3) and rearrange, we get:

$$\begin{aligned}\Delta\bar{k} \;&=\; (1-\phi^O)\Delta k_b \,+\, \phi^O\Delta k_a \,+\, \left(k_a^O-k_b^O\right)\Delta\phi \;= \\ &= -\frac{1}{\beta}\frac{\Theta'}{\Theta}\left(k_a^O\Omega\Delta\theta_a \,+\, k_b^O\Gamma\Delta\theta_b\right) \,+\, \frac{\ell}{1+\ell}\frac{1}{\beta}\left(k_b^O-k_a^O\right)(\Omega-\Gamma)\epsilon \,+(1-\beta)\left(k_b^O-k_a^O\right)\Delta\phi\end{aligned} \tag{E4}$$

Moreover, the sum of the equations in system (E2) yields:

$$\begin{aligned}(1-\beta)\left(k_b^O-k_a^O\right)\Delta\phi \;&=\; \frac{(1-\alpha)\Gamma(1-\beta)}{\beta}\Delta k_a \,+\, \frac{(1-\alpha)\Omega(1-\beta)}{\beta}\Delta k_b \,+ \\ &+\frac{1-\beta}{\beta}\frac{\Theta'}{\Theta}\left(k_a^O\,\Gamma\,\Delta\theta_a \,+\, k_b^O\,\Omega\,\Delta\theta_b\right) \,+\, \frac{\ell}{1+\ell}\frac{1-\beta}{\beta}\,\bar{k}\,\epsilon\end{aligned} \tag{E5}$$

Notice that $1-\alpha$, Γ, $1-\beta$, and Ω take values from 0 to 1. So, for simplicity we assume that the first two terms at the RHS of equation (E5) are equal to 0. Then, inserting the expression at the RHS of equation (E5) into the RHS of equation (E4) yields:

$$\begin{aligned}\Delta\bar{k} \;&=\; (1-\phi^O)\Delta k_b \,+\, \phi^O\Delta k_a \,+\, \left(k_a^O-k_b^O\right)\Delta\phi \;= \\ &= \frac{1}{\beta}\frac{\Theta'}{\Theta}\left\{k_a^O\left[\Gamma(1-\beta)-\Omega\right]\Delta\theta_a \,+\, k_b^O\left[\Omega(1-\beta)-\Gamma\right]\Delta\theta_b\right\} \;+ \\ &+\frac{\ell}{1+\ell}\frac{\epsilon}{\beta}\left[\left(k_b^O-k_a^O\right)(\Omega-\Gamma)\,+\,(1-\beta)\bar{k}\right]\end{aligned} \tag{E6}$$

Notice that $\Gamma(1-\beta)-\Omega \;=\; \beta\phi^O(2-\beta)$ and $\Omega(1-\beta)-\Gamma \;=\; \beta(1-\phi^0)(2-\beta)$. Moreover, substituting $\Delta\theta_b$ with the expression at the RHS of (D2), equation (E6) becomes:

$$\begin{aligned} \Delta\bar{k} \;=\; & -(2-\beta)\,\frac{\Theta'}{\Theta}\bar{k}\,\Delta\theta_a \;+ \\ & +(2-\beta)\,\Theta'\,k_b^O(1-\phi^O)\,\frac{\ell}{1+\ell}(k_b^O-k_a^O)\frac{\theta^O(r\,+\,\delta\,+\,f(\theta^O))}{(1-\eta)(r+\delta)(w^O-z)} \;+ \\ & +\;\frac{\ell}{1+\ell}\frac{\epsilon}{\beta}\left[\left(k_b^O-k_a^O\right)(\Omega-\Gamma)\;+\;(1-\beta)\bar{k}\right] \end{aligned} \tag{E7}$$

From Lemma 1 we know that $k_b^O > k_a^O$ and $\phi^O > \frac{1}{2}$, so that $\Omega > \Gamma$. Moreover, recall that $\Theta' > 0$. Therefore, the second and the third term at the RHS of (E7) are positive. Then, for $\Delta\bar{k}$ to be positive, a sufficient condition is that the first term at the RHS is positive. Using equation (D3) and after some algebra, we have that

$$\begin{aligned} -(2-\beta)\,\frac{\Theta'}{\Theta}\bar{k}\,\Delta\theta_a \;\;=\;\; & (2-\beta)\frac{\bar{k}}{k_a^O}\left(1-\alpha+\frac{\phi^O}{\Gamma}\frac{1-\alpha\Omega}{2\phi^O-1}\right)\left[1+\frac{\Omega(1-\alpha\Gamma)}{\Gamma\beta(2\phi^O-1)}\right]^{-1}\Delta k_a \;+ \\ +\,\frac{\epsilon\bar{k}}{\Gamma}\,\frac{\ell}{1+\ell}\,(2-\beta)\, & \left[1+\frac{\Omega(1-\alpha\Gamma)}{\Gamma\beta(2\phi^O-1)}\right]^{-1} \;+ \\ -\,\epsilon\,(2-\beta)\,\bar{k}\, & \frac{\Omega\,(1-\alpha\Gamma)}{\Omega\,(1-\alpha\Gamma)\;+\;\Gamma\beta(2\phi^O-1)}\,\frac{\ell}{1+\ell}(k_b^O-k_a^O)\frac{r\,+\,\delta\,+\,f(\theta^O)}{(1-\eta)(r+\delta)(w^O-z)}\,\Theta'\theta^O \end{aligned} \tag{E8}$$

We want the expression at the RHS of (E8) to be positive. Notice first that

$$\Theta'\,\theta^O \;=\; \frac{-r(r+\delta)q'(\theta^O)\,\theta^O}{\left(q(\theta^O)\right)^2} \;=\; \frac{r\,(r+\delta)\,\eta}{q(\theta^O)},$$

since $\eta \;=\; -\frac{q'(\theta^O)\,\theta^O}{q(\theta^O)}$. So as $r\to 0$, we have $\Theta'\,\theta^O \cong 0$ and we can neglect the third term at the the RHS of (E8).

The term in the second line of (E8) is positive, as $2\phi^O > 1$ for Lemma 1. Therefore, if Δk_a is positive, we have that $-(2-\beta)\,\frac{\Theta'}{\Theta}\bar{k}\,\Delta\theta_a \;>\; 0$ and $\Delta\bar{k} \;>\; 0$.

Solving system (D5) (details are available on request), we get that:

$$\Delta k_a = \epsilon \frac{\ell}{1+\ell} \frac{(1-\alpha)(\Omega-\Gamma)\frac{1-\alpha\Omega+\Omega-\Gamma}{1-\alpha\Omega} k_a^O + \frac{1-\Omega}{\Omega}\left[1-\Omega+(1-\alpha)\Gamma\right] k_b^O}{\left[\beta-1+\alpha(2-\alpha)\Omega\Gamma\right]\left[\frac{1-\Omega}{\Omega}(1-\alpha\Gamma) + \frac{1-\Gamma}{\Gamma}(1-\alpha\Omega)\right]} + $$
$$+ \epsilon \frac{\ell}{1+\ell}(k_b^O - k_a^O) \frac{r + \delta + f(\theta^O)}{(1-\eta)(r+\delta)(w^O - z)} \Theta'\theta^O \cdot \tag{E9}$$
$$\cdot \frac{-(1-\alpha)\Omega(1-\alpha\Gamma)\frac{1-\alpha\Omega+\Omega-\Gamma}{1-\alpha\Omega} k_a^O + \frac{1-\Omega}{\Omega}\left[1-\Omega+(1-\alpha)\Gamma\right]\Gamma k_b^O}{\left[\beta-1+\alpha(2-\alpha)\Omega\Gamma\right]\left[\frac{1-\Omega}{\Omega}(1-\alpha\Gamma) + \frac{1-\Gamma}{\Gamma}(1-\alpha\Omega)\right]}$$

Since with $r \to 0$ we have $\Theta'\theta^O \cong 0$, so we can neglect the second term at the RHS of (E9). The numerator of the first term at the RHS is positive, since $\Gamma, \Omega \in \{0, 1\}$ and $\Omega > \Gamma$ with $\phi^O > \frac{1}{2}$. So Δk_a is positive if the denominator at the RHS is positive. In turn, this means imposing that

$$\alpha(2-\alpha)\Omega\Gamma > 1-\beta \tag{E10}$$

Using equation (B3), we get that:

$$\Omega\Gamma = \left(\frac{a_b}{a_a}\right)^{\frac{1}{\alpha}} \left(\frac{1-\alpha\Omega}{1-\alpha\Gamma}\right)^{\frac{1-\alpha}{\alpha}} \Omega^2 \tag{E11}$$

It can be shown (computations are available on request) that the expression at the RHS is increasing in ϕ^0. Since $\phi^O > \frac{1}{2}$, then we have that $\Omega\Gamma$ is always greater than the value taken by the term at the RHS of (E11) at $\phi = \frac{1}{2}$:

$$\Omega\Gamma > \left(\frac{a_b}{a_a}\right)^{\frac{1}{\alpha}} \left(\frac{2-\beta}{2}\right)^2 \tag{E12}$$

Replacing $\Omega\Gamma$ in (E10) with the term at the RHS of (E12) and rearranging, we get:

$$\frac{a_a}{a_b} < \left[\alpha(2-\alpha)\left(1 + \frac{\beta^2}{4(1-\beta)}\right)\right]^{\alpha}$$

If $r \to 0$ and such inequality is verified, Δk_a is positive. In turn, from equation (E8), $\Delta\theta_a > 0$. Finally, this implies that $\Delta\bar{k}$ is positive for equation (E7).

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