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Marco de Pinto, Jörg Lingens

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54286 Trier
www.iaaeu.de

Unionization, Information Asymmetry and the De-location of Firms*

Marco de Pinto†
IAAEU Trier and Trier University

Jörg Lingens‡
University of Münster

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Abstract

We analyze the effects of unionization on the decision of a firm to either produce at home or abroad. We consider a model in which home and foreign workers are perfect substitutes and firms have an informational advantage concerning their productivity. The union offers wage-employment contracts to induce truthtelling. Because the firm's outside option (producing abroad) depends on its productivity, the problem is characterized by countervailing incentives. We find that, under fairly mild assumptions on the productivity distribution, the overstating incentive dominates in equilibrium. The contract offered by the union is then characterized by overemployment. Besides its effect on the intensive margin, the union also affects the extensive margin. The union forces firms to de-locate because this narrows the possibility to overstate productivity which saves rent payments to the firm.

Keywords: trade unions, information asymmetry, open economy, countervailing incentives, de-location

JEL Classification: J51, F2, D82

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†Institute for Labour Law and Industrial Relations in the European Union (IAAEU), Trier University, Behringstr. 21, D-54296 Trier, Phone: +49651/2014762, Email: depinto@iaaeu.de

‡University of Münster, Stadtgraben 9, D-48143 Münster, Phone: +49251/8322923, Email: joerg.lingens@wiwi.uni-muenster.de

1 Introduction

In the last two decades, offshoring has become a main characteristic of international integration. According to a survey conducted by Worldbank (2002), one of the more prominent reasons for firms to offshore their production facilities is the reduction in production costs. A large chunk of these costs consists of labor costs. Therefore, the labor market and the firms offshoring decisions are interlinked. In most western economies, unionization is a common factor in determining wage costs (see OECD, 2016). This begs the questions how union wage setting affects offshoring, but also how the threat to offshore alters the behavior of unions.

Empirical evidence suggests that labor unions increase offshoring (see Kramarz, 2008), which is in line with the argument that unions increase wages and hence firms' incentive to offshore. Moreover, there exists anecdotical evidence that unions use industry action or offer unfavorable contracts (in terms of for example wage hikes or employment guarantees) to firms that already plan to de-locate production.[1]

In unionized labor markets, the de-location of firms is driven by strategic considerations. In general, the contract that is agreed upon between the union and firms specifies the division of the pie (production value minus firm's and union's opportunity costs). If offshoring provides the firm or the union with a strategic edge, equilibrium de-location differs from that observed within competitive labor markets. In analyzing this strategic incentive, the literature focuses on the direct behavior of firms. Firms' opportunity to offshore dampens union wage demands by making labor demand at home more elastic (see, for instance, Zhao, 1995). This increases the offshoring incentive. If offshoring requires ex-ante fixed costs, an additional hold-up effect may result in higher wages despite the labor demand curve becoming more elastic. The effect of unionization on firms' offshoring incentive is then ambiguous, as illustrated by Koskela and Stenbacka (2009).

A point that, at least to our best knowledge, has not been discussed so far is that the union itself may have a generic incentive to affect the offshoring decision of firms. In situations in which the union strikes wage agreements with a pool of heterogeneous firms, as for example in case of

[1]See, for example, the plans of the financial service union (Unifi) against HSBC (Guardian, April 23rd, 2013) or of Unite's threat to take industrial action against the de-location plans of Rolls Royce (DailyRecord, June 17th, 2015).

industry level or nation wide wage bargains, which are relatively common in the OECD (see Visser, 2015), contracts with different firms are interrelated. This means that the contracting behavior with one firm affects the union's position in contract negotiations with other firms. Offering less favorable contracts to a subset of firms may result in more advantageous contracts with the rest. In line with the aforementioned anecdotical evidence, it is conceivable that a union could find it advantageous to force the de-location of some firms.

In this paper, we argue that one reason for the interrelatedness of contracts is the existence of asymmetric information between the union and firms. With this, the form of a contract to one firm is restricted by the structure of the contracts to all other firms. Information asymmetries are a crucial feature in labor relations.[2] As such, they are also key in understanding the union's effect on the offshoring decisions in the economy.

We consider a stylized open economy with a unionized labor market and assume that the firms' productivity is the source of the information asymmetry.[3] Firms (in the industry under investigation) are monopolists and endowed with a privately known productivity. They serve the world market employing labor as the only factor of production. Each firm can either produce at home or de-locate production technology and produce abroad. We assume that home and foreign workers are perfect substitutes. Labor costs abroad are lower than at home but de-location requires fixed costs which are independent of the firm's productivity. As a consequence, only high productivity firms are willing to de-locate production and serve the world market from abroad.

There is one labor union in the industry which sets a menu of wage-employment contracts conditional on the firms' productivity.[4] When con-

[2]The assumption of information asymmetry between the union and the firm is either legitimated from the nature of the firm, i.e. the firm generates and gathers information about revenue structures, productivity and (opportunity) costs. This endogenously puts it in a position of an informational advantage (see Kennan and Wilson, 1993). Or it is used (similar to our argument) to explain counterintiutive union behavior such as strikes (see Card, 1990, Hayes, 1984, Kennan and Wilson, 1990).

[3]This assumption is made for analytical simplicity. Likewise (and with the same qualitative results) we could have also assumed that the demand is private information to the firm.

[4]We implicitly assume that the (monopoly) union sets the wage rate as a function of the firm's employment. Corresponding to the taxation principle, this is equivalent to the assumption that the union sets wage-employment contracts.

structing the contracts, the union captures the highest possible fraction of the firms' quasi-rents defined as production value minus the firms' profits when producing abroad. The contracts will be designed such that firms truthfully report their productivities and self-select into 'their' contracts. This implies that the contracts include information rent payments to the firms. These payments depend on the firms' incentive structure which is characterized by countervailing incentives. On the one hand, firms have an incentive to understate their productivity because this signals lower production value. On the other hand, firms would also like to overstate their productivity because this signals a strong outside option. Both help firms to protect parts of their quasi-rents.

Within this framework, we analyze the effect of unionization on (home) employment, (home) wages and the de-location decision of firms.[5] Solving for the equilibrium wage-employment contracts, we find that, under fairly mild conditions on the distribution function of firm productivity, the overstating incentive dominates in equilibrium. As a consequence, information rent payments are highest for the least productive firm and decrease in firm's productivity. Additionally, the contracts imply overemployment (compared to the first-best situation) except for the least productive firm. Intuitively, the requirement to employ a large workforce decreases the incentive to overstate productivity, which implies that information rent payments can be reduced.

After determining the equilibrium menu of wage-employment contracts, the union excludes some firms from the contract. By assumption, firms then de-locate their production facilities abroad. Exclusion of firms is optimal for the union if the value of offering a contract was negative. In our model, this value becomes negative for high-productive firms. Moreover, a fraction of these firms would produce at home in the case of information symmetry between the union and firms. The union increases the number of de-locating firms under asymmetric information.

When deciding about the exclusion of high-productive firms, the union balances two effects. On the one hand, offering those firms a contract would, c.p., be beneficial for the union because their production value is largest.

[5]In line with the motivation, we assume that the union faces a mass of firms over the support of the productivity distribution. Hence, we interpret our results as industry wide averages.

On the other hand, including those firms into the contract would raise the overstating possibility of the incumbents and increase information rent payments to all other firms. This reduces the union's utility. A negative value of offering some firms a contract shows that the latter effect dominates such that it is optimal for the union to exclude these firms. A corollary of the overemployment and forced de-location result is that the effect of unions on industry employment remains ambiguous.

In order to get a grasp on the quantitative importance of the effects, we calibrate our model using parameter values prevalent in the literature. We find that unionization leads to a substantial decrease in the fraction of firms producing at home. In a specification in which the difference in labor costs between foreign and home is assumed to be 50%, the share of de-locating firms increases by 46 pp. Industry employment, however, increases with unionization (except for the case of a complete shutdown of the industry).

2 The Model

2.1 Structure of the Economy

The economy consists of two countries, home and foreign. Goods markets between both countries are fully integrated such that output is sold on the world market. We consider one particular industry in which different firms are active. We assume that each firm is a monopolist and endowed with a productivity θ, which is drawn from the density function $g(\theta)$ with support $\theta \in [1, \bar{\theta}]$ and which is the firms' private information. Given θ, each firm can either employ this technology at home or move it abroad, which comes at fixed costs of $K > 0$.[6]

In the home country, there is a mass of homogeneous workers $\bar{l}$ who are organized in a union. We assume that the union unilaterally sets wage-employment contracts on behalf of their members. The opportunity costs of working are denoted by b.

In the foreign country, there is a mass of $\bar{l}^F$ workers, where the superscript F indicates foreign variables. These workers are not unionized.

[6]We assume that moving a low-productivity (i.e. low-technology) production process is as costly/complicated as moving a high-productivity (i.e. high-technology) one. In reality, it seems more likely that moving costs depend on the technology. Ex-ante, however, the sign of the dependence is unclear. Therefore, we stick to the independence assumption.

Instead, we assume that labor markets abroad are perfectly competitive.[7] Workers infinitely elastic supply labor at the reservation wage b^F, where $b > b^F$ holds because, for example, the system of social protection or the unemployment insurance is less generous in the foreign country than at home. Workers are perfectly mobile across industries but immobile across countries.

2.2 The Union

The union sets a menu of wage-employment contracts ex-ante, i.e. before it meets the heterogeneous firms. The union's expected utility is given by

$$\mathbb{E}(V) = \int_{\theta_1}^{\theta_2} g(\theta) l (w - b) d\theta, \tag{1}$$

where $g(\theta)d\theta$ is the probability that the union meets a firm with productivity θ, w denotes the wage rate and l represents employment.

The union does not necessarily offer a contract to all firms in the economy. Including a firm maybe, for example, too costly because its outside option (profit when producing abroad) is too valuable or because including a firm affects the contracts that can be offered to other firms and hence has a detrimental effect on the union's expected utility. We denote the lower productivity bound of firms that are included by θ_1 and the upper bound θ_2. The union endogenously chooses these values based on the value that a marginal firm offers. Firms that are not included into the contract are explicitly (by not offering a contract) or implicitly (by offering a non acceptable contract) forced to produce abroad.

2.3 Firms

Each firm sells output x facing the (exogenously given) world market inverse demand function

$$p = x^{-\alpha}, \tag{2}$$

where p denotes the price and α the value of the reciprocal price elasticity of demand with $0 < \alpha < 1$. Output is produced using labor input l only. The production function is given by $x(\theta) = \theta l$, whereas profits are defined

[7] We adopt this assumption to abstract from competition between international unions so that we can exclusively focus on the 'pure' effects of unionization in the home country.

as

$$\pi(\theta) = (\theta l)^{1-\alpha} - wl. \tag{3}$$

Firms make two decisions. Due to the information asymmetry, they first decide about which contract (from the menu of all contracts) to choose. This is conceptually identical to the announcement of a productivity level. Second, firms decide whether to produce at home or abroad. When moving the technology abroad, production and profits are given by, respectively

$$x^F(\theta) = \theta l^F, \tag{4}$$

$$\pi^F(\theta) = (\theta l^F)^{1-\alpha} - w^F l^F - K. \tag{5}$$

Foreign labor supply implies $w^F = b^F$.

2.4 Timing

The timing is as follows:

1. The union sets the menu of wage-employment contracts for all firms and decides afterward about which firms to exclude from the optimal contract.

2. Firms choose a contract from the menu of contracts, i.e. firms announce a productivity level.

3. Firms start production. Depending on the contract, they either produce at home or de-locate production facilities abroad.

3 Equilibrium

3.1 Two Benchmark Scenarios

To disentangle the effects of unions per se and the consequences of information asymmetry, we consider two benchmark scenarios. In the first one, labor markets at home are perfectly competitive so that we completely abstain from unionization. In the second one, we assume that information is symmetrically distributed between the union and firms, i.e. the union observes the firms' productivity.

3.1.1 Competitive Labor Markets

If labor markets are competitive at home, labor supply implies $w = b$. Profit maximization over l leads to

$$(1-\alpha)(\theta l)^{-\alpha}\theta = w, \tag{6}$$

$$(1-\alpha)(\theta l^F)^{-\alpha}\theta = w^F. \tag{7}$$

Combining this with the labor supply situation at home and abroad determines equilibrium employment $\hat{l}(\theta)$ and $\hat{l}^F(\theta)$. Under the assumption $b > b^F$, we find that $\hat{l}(\theta) < \hat{l}^F(\theta)$.[8]

Equilibrium profits at home and abroad are then given by, respectively

$$\hat{\pi}(\theta) = \alpha(\theta\hat{l}(\theta))^{1-\alpha}, \tag{8}$$

$$\hat{\pi}^F(\theta) = \alpha(\theta\hat{l}^F(\theta))^{1-\alpha} - K. \tag{9}$$

The firm chooses to de-locate production if

$$\hat{\pi}(\theta) < \hat{\pi}^F(\theta) \Leftrightarrow \alpha(\theta\hat{l}(\theta))^{1-\alpha} < \alpha(\theta\hat{l}^F(\theta))^{1-\alpha} - K. \tag{10}$$

Proposition 1 *With competitive labor markets, there exists a threshold productivity $\hat{\theta}$ for which a firm is indifferent between producing at home and de-locating production. A firm characterized by a productivity $\theta > (\leq)\hat{\theta}$ de-locates its production technology abroad (produces at home).*

Proof 1 *The operating profit difference $\hat{\delta}(\theta) := \alpha\left((\theta\hat{l}^F)^{1-\alpha} - (\theta\hat{l})^{1-\alpha}\right)$ is increasing in θ because of*

$$\frac{d\hat{\delta}}{d\theta} = (1-\alpha)(\theta)^{-\alpha}\left((\hat{l}^F)^{1-\alpha} - \hat{l}^{1-\alpha}\right) > 0, \tag{11}$$

where we used the fact that the labor demand elasticity is independent of the location of production.

Firms with low productivities produce less output such that the average costs of de-location are high. With increasing productivity, we have a

[8] We only consider situations such that the resource constraint of the economy never becomes binding (there will always be unemployment), i.e. $\hat{l} < \bar{l}$ and $\hat{l}^F < \bar{l}^F$. We also maintain this assumption in the case of unionized labor markets with symmetric and asymmetric information.

degression of fixed de-location costs due to increased production. Thus, for high productivity firms, fixed de-location costs become increasingly irrelevant which makes it more attractive to produce abroad.

We assume that the profits of the least productive firm, i.e. $\theta = 1$, are higher at home than abroad: $\hat{\pi}(\theta = 1) > \hat{\pi}^F(\theta = 1)$. This ensures that the threshold productivity above which firms de-locate production is greater than one: $\hat{\theta} > 1$.[9] In addition, we assume that $\hat{\pi}^F(\theta = 1) \geq 0$. The reason for this assumption is that we do not want to interact the outside option of moving the technology with the outside option of stopping producing altogether which would be the reasonable threat of a firm that has negative profit opportunities abroad.

3.1.2 Unionization and Information Symmetry

With information symmetry, the union conditions the contract on *true* productivity. For later use, we express the union's expected utility in terms of employment l and profit π by inserting $wl = (\theta l)^\alpha - \pi$ (which holds due to the definition of profits) into (1). The union sets the path of employment l and profits π over θ to construct the optimal contracts. The problem reads

$$\max_{l(\theta),\pi(\theta)} \mathbb{E}(V) = \int_{\theta_1}^{\theta_2} g(\theta)((\theta l(\theta))^{1-\alpha} - \pi(\theta) - l(\theta)b)d\theta, \tag{12}$$

$$\text{subject to} \qquad \pi(\theta) \geq \hat{\pi}^F(\theta) \qquad \forall\theta \in [\theta_1, \theta_2].$$

Denoting by μ the shadow value associated with the firms' participation constraint[10], the Lagrangean for this problem is

$$\mathcal{L} = \int_{\theta_1}^{\theta_2} \left(g(\theta)((\theta l)^{1-\alpha} - \pi - lb) + \mu(\pi - \hat{\pi}^F)\right) d\theta, \tag{13}$$

[9] Without having this assumption, the solution to the problem is trivial because then every firm, independent of its productivity level, would choose to produce abroad.

[10] The participation constraint ensures that all firms will accept the contract after they are equipped with some productivity levels.

which results in first-order conditions

$$g(\theta)((1-\alpha)(\theta l)^{-\alpha}\theta - b) = 0, \tag{14}$$

$$-g(\theta) + \mu = 0, \tag{15}$$

$$\mu(\pi - \hat{\pi}^F) = 0. \tag{16}$$

From (14), we find that the union sets employment efficiently, i.e. $l^{IS}(\theta) = \hat{l}(\theta)$, where the superscript IS denotes the equilibrium under information symmetry. Moreover, (15) and (16) reveal that the equilibrium profit is given by $\pi^{IS}(\theta) = \hat{\pi}^F(\theta)$, i.e. the participation constraint is always binding. The equilibrium wage w^{IS} is directly determined by π^{IS} and l^{IS} and reads

$$w^{IS}(\theta) = \frac{(\theta\hat{l}(\theta))^{1-\alpha} - \hat{\pi}^F(\theta)}{\hat{l}(\theta)} = b + \frac{\hat{\pi}(\theta) - \hat{\pi}^F(\theta)}{\hat{l}(\theta)}. \tag{17}$$

The union offers wage-employment contracts if the surplus generated by the firm $S(\theta) = (\theta l^{IS})^{1-\alpha} - \pi^{IS} - l^{IS}b$, which is production value net of the outside options (=opportunity costs) of both the union (:=$l^{IS}b$) and the firm (:=$\pi^{IS} = \hat{\pi}^F$), is positive. Because employment l^{IS} is efficient, we can write the surplus as

$$S(\theta) = \hat{\pi}(\theta) - \hat{\pi}^F(\theta) = K - \hat{\delta}(\theta), \tag{18}$$

which is decreasing in productivity θ (see Proposition 1).

The form of the surplus function has important consequences for the union's choice of which firms it will include into the contract.

Proposition 2 *With unionization and information symmetry, there exists a threshold productivity θ^{IS}, for which the surplus is zero, i.e. $S(\theta^{IS}) = \hat{\pi}(\theta^{IS}) - \hat{\pi}^F(\theta^{IS}) = 0$. Lower (Higher) productivity firms provide a positive (negative) surplus and the union includes (excludes) them into (from) the contract. The de-location threshold is the same as under competitive labor markets, i.e. $\theta^{IS} = \hat{\theta}$.*

Proof 2 *For the first part note that $K - \hat{\delta}(\theta)$ is by assumption positive for $\theta = 1$. For the second part note that the condition for θ^{IS} is $S(\theta^{IS}) = K - \hat{\delta}(\theta^{IS}) = 0$, which is also true for $\hat{\theta}$.*

Summarizing, we find that under information symmetry, unionization has no allocative effect. Neither the intensive margin (employment) nor the extensive margin (de-location threshold) are affected – both remain efficient. As is standard with first-degree price discrimination, the union solely increases the wage and shifts rents from firms to workers, i.e. only has distributional effects.

3.2 Unionization and Information Asymmetry

3.2.1 The Union's Optimization Problem

To solve the union's optimization problem, we first of all derive the form of the contract for any inclusion interval $[\theta_1; \theta_2]$. To do so, it is useful to define the firms' quasi-rents as the difference between the profit at home and the best alternative which is producing abroad and earning the foreign profit: $\Delta(\theta) = \pi(\theta) - \pi^F(\theta)$. Using this definition, we can rewrite the union's expected utility as

$$\mathbb{E}(V) = \int_{\theta_1}^{\theta_2} g(\theta)((\theta l)^{1-\alpha} - \Delta - \pi^F - lb)d\theta. \tag{19}$$

The union sets employment, $l(\theta)$, and quasi-rents, $\Delta(\theta)$, such that the expected utility is maximized without violating the firms' participation constraint $\Delta(\theta) \geq 0 \; \forall \; \theta \in [\theta_1, \theta_2]$. Moreover, we focus on contracts that ensures the firms' self-selection, i.e. firms truthfully reveal their productivity. When designing the contracts, the union thus has to ensure that contracts are incentive compatible. The incentive compatibility restriction for all firms included in the contract boils down to a restriction on the form of the quasi-rent path which is given by (see Appendix A.1)

$$\frac{d\Delta}{d\theta} := \frac{d\pi}{d\theta} - \frac{d\pi^F}{d\theta} = (1-\alpha)(\theta l)^{-\alpha} l - (1-\alpha)(\theta \hat{l}^F)^{-\alpha} \hat{l}^F. \tag{20}$$

If the union constructs contracts which results in Δ paths characterized by (20), firms tell the truth. Therefore, $\Delta(\theta)$ is solely determined by (20). The incentive compatibility restriction also requires $dl/d\theta > 0$. This monotonicity constraint ensures that truthtelling leads to firms' profit maximum and must also be taken into account by the union.

Before the contract employment l is specified, the sign of $d\Delta/d\theta$ is ambiguous. Firms are hence confronted with *countervailing incentives* when they decide about their productivity announcement. On the one hand, firms have an incentive to overstate their true productivity because this signals c.p. a better outside option, i.e. a higher probability to de-locate production. On the other hand, firms have an incentive to understate their true productivity because this signals c.p. a lower production value. When designing the contract, the union does not know which firm to pay an information rent (if any) to prevent it from not telling the truth.

The union's optimization problem is given by

$$\max_{l(\theta),\Delta(\theta)} \mathbb{E}(V) = \int_{\theta_1}^{\theta_2} g(\theta)((\theta l(\theta))^{1-\alpha} - \Delta(\theta) - \pi^F(\theta) - l(\theta)b)d\theta,$$

$$\text{subject to} \qquad (20), \qquad \frac{dl(\theta)}{d\theta} > 0 \qquad \Delta(\theta) \geq 0 \qquad \forall\theta \in [\theta_1, \theta_2].$$

We solve for the optimal wage-employment contracts by employing dynamic optimization techniques identifying Δ as the state and l as the control variable and ignoring for the moment the monotonicity constraint, verifying it ex-post.

3.2.2 Wage-employment Contracts

The Hamilton-Lagrange function for the union's optimization problem reads

$$\mathcal{H} = g(\theta)((\theta l)^{1-\alpha} - \Delta - lb - \pi^F) + \lambda\left((1-\alpha)(\theta l)^{-\alpha} l - (1-\alpha)(\theta\hat{l}^F)^{-\alpha}\hat{l}^F\right), \tag{21}$$

$$\mathcal{L} = \mathcal{H} + \mu\Delta, \tag{22}$$

where λ is the 'intertypal' shadow value. The interpretation of λ is very similar to the costate variable in optimal control problems, i.e. the intertemporal shadow value (see e.g. Kaplow, 2010). This measures the effect on union's utility if the quasi-rent of a firm with specific productivity θ is marginally increased.

The first-order conditions for this problem are

$$g(\theta)((1-\alpha)(\theta l^{IAS})^{-\alpha}\theta - b) = -\lambda^{IAS}(1-\alpha)^2(\theta l^{IAS})^{-\alpha}, \tag{23}$$

$$\frac{d\lambda^{IAS}}{d\theta} = g(\theta) - \mu^{IAS}, \tag{24}$$

$$\mu^{IAS}\Delta^{IAS} = 0, \tag{25}$$

where the superscript IAS denotes the values of the endogenous variables along the equilibrium path under information asymmetry. Moreover, the problem is characterized by the transversality conditions $\lambda(\theta_1)\Delta(\theta_1) = 0$ and $\lambda(\theta_2)\Delta(\theta_2) = 0$.[11]

The first-order condition (23) shows an important difference to the benchmark case with information symmetry. The left-hand side can be interpreted as the union's marginal utility of an employment increase for the firm announcing θ. This marginal utility gain is due to an increase in production. Under information symmetry, the union would set employment such that this was zero (as in (14)). With asymmetric information, however, the change in employment for one firm requires an adjustment in the contracts for all other firms. The consequence for union utility is reflected by the right-hand side. Deciding about employment l for some firm with productivity θ implies that the union has to take the effect on self-selection for all other firms into account as well. With λ^{IAS} positive (negative), employment will be such that the net marginal gain is negative (positive) which results in overemployment (underemployment) compared to the first-best case.

Determining the equilibrium from the first-order conditions, the participation and the incentive compatibility constraint requires in a first step an expression for the equilibrium shadow value λ^{IAS}. In contrast to hidden information models without countervailing incentives, this is more demanding within the model at hand. The reason is that we do not know a.) for which productivities the participation constraint binds and b.) the form of the quasi-rent path. Both prevent us form just integrating (24) to find the equilibrium λ^{IAS} path.

To solve this problem, we apply a technique that was suggested by Maggi and Rodriguez-Clare (1995). As shown in Appendix A.3, the equilibrium employment path is

$$l^{IAS}(\theta) = \begin{cases} \left(\underbrace{\frac{\theta(1-\alpha)}{\theta^\alpha b}}_{\hat{l}^{-\alpha}} + \frac{\lambda(\theta)^{IAS}(1-\alpha)^2}{g(\theta)\theta^\alpha b} \right)^{\frac{1}{\alpha}} & \forall \quad \bar{\lambda}(\theta) \geq G(\theta) - G(\theta_1) \\ \hat{l}^F(\theta) \quad \forall \quad G(\theta) - G(\theta_2) \leq \bar{\lambda}(\theta) < G(\theta) - G(\theta_1), \end{cases} \tag{26}$$

[11] For any interior interval, these transversality conditions would be given by the continuity of the state variable Δ.

and the equilibrium co-state path is

$$\lambda^{IAS}(\theta) = \begin{cases} G(\theta) - G(\theta_1) & \forall \quad \bar{\lambda}(\theta) \geq G(\theta) - G(\theta_1) \\ g(\theta)\theta\frac{b-b^F}{(1-\alpha)b^F} & \forall \quad G(\theta) - G(\theta_2) \leq \bar{\lambda}(\theta) < G(\theta) - G(\theta_1) \end{cases} \tag{27}$$

with $\bar{\lambda}(\theta) = g(\theta)\theta\frac{b-b^F}{(1-\alpha)b^F}$. The first (second) line shows the employment/ co-state path over a non-binding (binding) interval of the firms' participation constraint.

The co-state variable $\lambda(\theta)$ depicts a marginal change in the incentive compatibility constraint. If higher $\Delta'(\theta)$ (which is like a hypothetical windfall gain for a firm with productivity θ) increases the union objective, the co-state will be positive. This will be the case if $\Delta' < 0$, because then an increase in this value 'flattens' the information rent path. The union pays less information rent.

In the equilibrium in our model, $\lambda^{IAS}(\theta)$ is positive throughout, i.e. $\Delta' < 0$ along the equilibrium $\Delta^{IAS}(\theta)$ path. The union concedes information rents to low productivity firms to prevent them from overstating, which is the dominating incentive in equilibrium.

Moreover, a positive λ^{IAS} implies that higher employment $l(\theta)$ not only increases production value, but also helps saving on information rent payments, because $\frac{\partial \Delta'(\theta)}{\partial l(\theta)} > 0$ (see (20)). The additional marginal gain of employment results in overemployment compared to the first-best allocation (see (23)). This equilibrium result somewhat resembles the anecdotal evidence that firms very openly threaten to de-locate production which, within our framework, could be interpreted as the result of an overstating incentive for which the union tries to compensate with an appropriate contract design.

We can summarize the results on contract employment by the following Proposition.

Proposition 3 *Under unionization and information asymmetry, the informational friction results in a deviation of employment from its efficient level. Due to the overstating incentive, the economy is characterized by overemployment. This is, however, not true for the least productive firm. Employment there is efficient (no distortion at the bottom).*

Proof 3 *See text above.*

Another property of the equilibrium is the fact that the wage w^{IAS} falls short of w^{IS}. Rewriting the definition of Δ yields

$$w^{IAS}(\theta) = \begin{cases} b + \frac{(\theta l^{IAS}(\theta))^{1-\alpha} - bl^{IAS}(\theta) - \Delta^{IAS}(\theta) - \hat{\pi}^F(\theta)}{l^{IAS}(\theta)} & \forall \quad \bar{\lambda}(\theta) \geq G(\theta) - G(\theta_1) \\ b^F + \frac{K}{\hat{l}^F(\theta)} \quad \forall \quad G(\theta) - G(\theta_2) \leq \bar{\lambda}(\theta) < G(\theta) - G(\theta_1), \end{cases} \tag{28}$$

which is smaller than w^{IS} for two reasons (see Appendix A.2). First, the union has to pay an information rent by giving wage discounts, thus the firm accrues a larger part of the production value. Second, employment is inefficient, thus the size of the pie is smaller than under information symmetry. The consequence of the information friction is that the union can only capture a smaller piece of a smaller pie with its wage demands.

3.2.3 Exclusion

Having discussed the employment and wage path for those firms that are included into the contract, we are now going to discuss the exclusion decision of the union. This implies the choice of the optimal θ_1 and θ_2 of firms that are offered a contract. Any firm that is included into the contract offers a virtual surplus to the union. For any type of firm in the inclusion interval $\theta \in [\theta_1; \theta_2]$, this is defined as

$$VS(\theta) := (\theta l^{IAS}(\theta))^{1-\alpha} - \pi^F(\theta) - l^{IAS}(\theta)b - \Delta^{IAS}(\theta), \tag{29}$$

which is the production value produced by the contract employment net of the opportunity costs of both parties involved in the contract (firm and union) minus the information rent that has to be conceded to the firm to incentivice truthtelling. The union will only want to offer contracts to those firms that generate at least a zero virtual surplus.

As shown in Appendix A.3, the virtual surplus is decreasing over types, which implies that low productivity firms are more valuable to the union. The larger net-production value (due to the worse outside option of those firms) compensates for the higher information rent payments. The union wants to start offering contracts starting from the lower bound of the productivity distribution, which is $\theta_1 = 1$ in our case. The upper bound of firms that are included into the contract is given by $\theta_2 = \theta^{IAS}$, where this is given by

$$(\theta^{IAS} l^{IAS}(\theta^{IAS}))^{1-\alpha} - \pi^F(\theta^{IAS}) - l^{IAS}(\theta^{IAS})b - \Delta^{IAS}(\theta^{IAS}) = 0. \quad (30)$$

Over the binding interval, the virtual surplus is negative (see Appendix A.3). Those firms will be excluded. This implies that those firms that produce at home are characterized by lower employment compared to firms that produce abroad (see (26)).

In the preceding sections, we have derived the threshold productivity θ^{IS} for which firms are excluded under information symmetry. To relate this to θ^{IAS}, we have to compare the union's value of a firm that is included into the contract under information symmetry and with that under information asymmetry.

Lemma 1 *The value of offering a wage-employment contract is strictly smaller under asymmetric information than under symmetric information.*

Proof 4 *The difference in this value is given by*

$$VS(\theta) - S(\theta) = (\theta l^{IAS}(\theta))^{1-\alpha} - (\theta l^{IS}(\theta))^{1-\alpha} + l^{IS}(\theta)b - l^{IAS}(\theta)b - \Delta(\theta) < 0 \quad (31)$$

which is negative, because l^{IS} is first-best employment and the information rent $\Delta(\theta)$ is positive.

Proposition 4 *Under Information asymmetry, the fraction of firms that are excluded from contracting is larger than under information symmetry.*

Proof 5 *The virtual surplus at θ^{IS}, $VS(\theta^{IS})$, is negative. This is because employment under information asymmetry is not efficient:*

$$(\theta^{IS} l^{IAS}(\theta^{IS}))^{1-\alpha} - \pi^F(\theta^{IS}) - l^{IAS}(\theta^{IS})b < 0.$$

Moreover, the information rent is positive. Because the virtual surplus is decreasing in types $VS'(\theta) < 0$, it must be true that the optimal inclusion choice of the union implies that $\theta^{IAS} < \theta^{IS}$.

The reason for this result is that under information asymmetry, production is inefficient and the union has to conceive an information rent. Both decline the value of having a contract with the given firm. From a welfare perspective, this forced de-location is inefficient because production at home would have occurred under competitive labor markets.

4 A Numerical Example

How much of the de-location of firms can we explain by unionization, i.e. how large is the fraction of moving firms, and what are the effects on employment at home? To answer these questions, we calibrate our model using data and information from the literature.

4.1 Calibration

When it comes to the numerical solution of the model, we have to take a stand concerning the form and parameters of the distribution function of firms' productivity. For robustness and to gain an insight into how different assumptions on this distribution impact the equilibrium, we pursue two different specifications. In the first one, we employ results from structural estimation of a model with firm heterogeneity as put forward in Balistreri et al. (2011), who employ a Pareto distribution for their estimation of a Melitz type trade model. Applying this to our context (with an upper truncation point), we have

$$G(\theta) = 1 - \frac{1 - \theta^{-c}}{1 - (\bar{\theta})^{-c}}, \tag{32}$$

where the shape parameter is assumed to be $c = 4.5$ in accordance with the estimation of Balistreri et al. (2011). Given our equilibrium specification, the upper bound $\bar{\theta}$ has no allocative effects (i.e. the equilibrium remains unaffected). With the choice of $\bar{\theta}$ having only quantitative effects, which cancel out when investigating the difference between the information asymmetry model and the competitive labor market benchmark, we are free to choose a value and arbitrarily set it to 4.

The second specification is based on the argument that the size of firms in terms of employment in the US is Zipf distributed (i.e. Pareto distributed with shape parameter 1), see Axtell (2001). Arguing that the US economy is basically characterized by competitive labor markets, our model allows us to infer the form of the productivity distribution based on the employment distribution for which we have data. Using (6) and the assumption that employment is Zipf distributed, we conclude that productivity is Pareto distributed[12] (as in (32)) with shape parameter $c = \frac{1-\alpha}{\alpha}$ and $\bar{\theta} = 10^{6\frac{\alpha}{1-\alpha}}$.[13]

The parameter α (i.e. the value of the inverse of the price elasticity of demand) measures the competitiveness of the industry under consideration and determines the size of the price-cost mark-up which is given by $(1-\alpha)^{-1}$. There is some variation in the literature concerning the size of this mark-up depending on data and the underlying production technology, see e.g. Rotemberg and Woodford (1999). In the following, we assume a value of $\alpha = 0.26$ which corresponds to a mark-up of 35%. The reasons for this choice are that it is reasonably close to what is assumed in the macroeconomic literature and that $1 - \alpha = 0.74$ depicts labor's share in a model where labor-capital complementary is the source of convex revenues as opposed to the monopoly situation of the firm.

The cost of setting up a firm abroad K is specified following the quantitative analysis in Coşar et al. (2016) who find that this cost is in the order of 25 times the (annual, competitive) wage, which is the service sector wage in their case. Since we do not consider different occupations, we assume this outside wage to be given by b^F, hence we have $K = 25b^F$.

The final assumptions concern the values for the opportunity costs of working at home and abroad, b and b^F, respectively. Specifying these values, we apply the following normalization approach. Concerning b^F, we focus exclusively on a situation in which the lowest productivity firm just makes zero profits when de-locating its production technology abroad.[14] Eq. (9) and the assumptions concerning K and α then specify the value b^F. The opportunity costs of working at home b are assumed to be a multiple of b^F where we consider some alternative values. The chosen parameter vector for the two specifications is summarized in Table 1.

[12] See Casella and Berger (2002), Theorem 2.1.2 p. 51 for the argument that the distribution of productivity mirrors that of the distribution of employment.

[13] The assumption concerning the truncation point of the Pareto distribution is based on the observation that in US data, the distance between the smallest and largest firm is of the order of 10^6. The assumption concerning $\bar{\theta}$ then generates this observed distance.

[14] This normalization is the largest opportunity costs difference between home and abroad without violating the positive profit assumption. We focus hence on a situation in which de-location is relatively attractive for the firm.

	Specification 1	Specification 2
c (Shape parameter)	4.5	$\frac{1-\alpha}{\alpha}$=2.8
$\bar{\theta}$ (Maximum productivity)	4	$10^{6\frac{\alpha}{1-\alpha}}$=78.76
α (Value of the inverse price elasticity)	0.26	0.26
b^F (Opportunity costs of working – abroad)	0.24	0.24
K (Fixed de-location costs)	25 b^F=6	25 b^F=6
b (Opportunity costs of working – home)	1.1 b^F 1.3 b^F 1.5 b^F	1.1 b^F 1.3 b^F 1.5 b^F

Table 1: Parameter values used in calibration

4.2 Results

The results shown in Table 2 depict the effects of unionization with information asymmetry on the fraction of firms producing at home, $G(\theta^{IAS})$, and on industry employment, L^{IAS}, compared to the outcomes of both under competitive labor markets, $G(\hat{\theta})$ and $\hat{L}$, respectively. The magnitude of the effects are based on the calculations of $D_G := G(\theta^{IAS}) - G(\hat{\theta})$ and $D_L := L^{IAS} - \hat{L}$.

Specification 1

b	$G(\hat{\theta})$	$\hat{L}$	$G(\theta^{IAS})$	L^{IAS}	D_G	D_L
1.1 b^f	0.9	83.68	0.87	108.41	-0.03	24.73
1.3 b^f	0.65	34.44	0.34	33.81	-0.31	-0.63
1.5 b^f	0.46	17.95	0	0	-0.46	-17,95

Specification 2

	$G(\hat{\theta})$	$\hat{L}$	$G(\theta^{IAS})$	L^{IAS}	D_G	D_L
1.1 b^f	0.77	92.37	0.72	118.54	-0.05	26.17
1.3 b^f	0.48	35.18	0.2	32.51	-0.28	-2.67
1.5 b^f	0.32	18.09	0	0	-0.32	-18.09

Table 2: Calibration results

As already shown above, unionization decreases the fraction of firms that produce at home. Concerning first the results of specification 1. These range from around 3 pp for a very low opportunity cost advantage abroad to 46 pp in the case in which unionization shuts down the industry. These magnitudes are in the same ballpark range between these two specifications. We can thus conclude that the results are robust against changes in the (form of the) productivity distribution function. The point here is that shutting down the industry will occur even for relatively modest differences between the opportunity costs of working at home and abroad (in our case of 50%).

The second point is that the effects of unionization on industry level employment are relatively weak (except obviously for the case in which the union completely shuts down the industry). For small opportunity cost advantages, it turns out that the firm-level overemployment effect even survives at the industry level resulting in excessive employment. Thus, when considering the impact of unionization, focusing on employment gives a biased picture on the allocation effect because the effects on de-location have to be taken into account, too.

5 Summary

The contribution of this paper is to analyze the effects of unionization on the location decision of firms in an open economy setting with asymmetric information between unions and firms. The information asymmetry is captured by the assumption that firms have superior knowledge regarding their revenues, which we assume is caused by private information of productivity. The union sets wage-employment contracts, but has to ensure that firms truthfully announce their productivity to the union. In doing so, the union must pay an information rent to the firm if it decides to offer this type of firm a contract. The open economy setting enables the firms to move their production technology abroad. The outside option of a firm is a function of its privately known productivity. We hence have a situation of countervailing incentives. When constructing the truthtelling contract, the union has to take into account that a firm simultaneously has the incentive to both under- and overstate its productivity to get a more favorable contract from the union.

We show that in equilibrium the overstating incentive dominates. Low-productivity firms receive high information rent payments from the union. We also find that employment is inefficiently large with the exception of the least productive firm (no distortion at the bottom). Intuitively, the union can save information rent payments because the requirement to employ a large workforce decreases the incentive to overstate productivity. As our main finding, we show that the union excludes high-productive firms from the contract. These firms are forced to de-locate production although they would have produced at home under information symmetry or perfectly competitive labor markets. Unionization leads to a higher share of de-locating firms (or makes de-location more likely). The reason is that excluding firms narrows the possibility of overstating productivity for the remaining firms; the union thereby saves information rent payments.

Calibrating the model shows that the effects of unionization on the fraction of de-locating firms is substantial. Even for relatively small differences in labor (opportunity) costs between home and abroad, the fraction of firms that are forced to de-locate increases by up to 46 pp compared to the first-best situation. The effect on average employment, however, is relatively modest and even positive. Thus, a de-location process that is enforced through unionization does not necessarily have to go hand-in-hand with a decrease in employment.

A Appendix

A.1 Incentive Compatibility

Consider the problem of the firm announcing its productivity to the union. True productivity is θ and announced productivity is θ'. The union has (at the first stage) designed a contract that is conditioned on the productivity announcement of the firm. When choosing θ', the objective of the firm is to maximize the quasi-rent

$$\Delta(\theta,\theta') := \pi(\theta,\theta') - \hat{\pi}^F(\theta) = (\theta l(\theta'))^{1-\alpha} - w(\theta')l(\theta') - \hat{\pi}^F(\theta). \tag{A.1}$$

In order to understand the incentives of the firm, consider for the moment a naive union that offers a contract as if it could observe the productivity. The quasi-rent can be written as

$$\Delta(\theta,\theta') := \pi(\theta,\theta') - \hat{\pi}^F(\theta) = (\theta\hat{l}(\theta'))^{1-\alpha} - (\theta'\hat{l}(\theta'))^{1-\alpha} + \hat{\pi}^F(\theta') - \hat{\pi}^F(\theta). \tag{A.2}$$

If the firm tells the truth (under the naive contract) the quasi-rent obviously will be zero. It is, however, not clear whether the firm would then have an incentive to overstate ($\theta' > \theta$) or understate ($\theta' < \theta$) its productivity. This is a variant of the classic Lewis and Sappington (1989) case. In our example, the countervailing incentives are driven by the fact that overstating its productivity, the firm is faced by a more favorable contract because of the better outside option. If the profit when de-locating production was not a function of the firm's productivity (i.e. if $\hat{\pi}^F(\theta') - \hat{\pi}^F(\theta) = \hat{\pi}^F$), then the firm obviously would have a (generic) incentive to understate its productivity because the union offered a more attractive contract for this case.

We now turn to the restriction that the union's contract has to obey to ensure truthtelling by the firm. The optimal productivity announcement is implicitly given by the first-order condition

$$\frac{d\Delta(\theta,\theta')}{d\theta'} = (1-\alpha)(\theta l(\theta'))^{-\alpha}\theta\frac{dl(\theta')}{d\theta'} - w(\theta')\frac{dl(\theta')}{d\theta'} - \frac{dw(\theta')}{d\theta'}l(\theta') = 0, \quad \text{(A.3)}$$

which gives θ' as a function of θ where this relation $\theta'(\theta)$ is shaped by the form of the contract. Let us only consider contracts under which telling the truth is optimal, $\theta'(\theta) = \theta$. Eq. (A.3) restricts then the form of the wage-employment contract. Differentiating this with respect to θ (under truthtelling), we find that

$$soc + (1-\alpha)^2(\theta l(\theta'))^{-\alpha}\frac{dl(\theta')}{d\theta'} = 0, \quad \text{(A.4)}$$

where soc denotes the second-order condition for the problem. With the optimal θ' resulting in a maximum, it must be true that the optimal contract is such that $\frac{dl(\theta')}{d\theta'} \geq 0$, which is the monotonicity constraint.

Moreover, in a truthtelling equilibrium the change in the quasi-rent over the different productivities is restricted to be

$$\frac{d\Delta}{d\theta} = (1-\alpha)(\theta l)^{-\alpha}l - (1-\alpha)(\theta\hat{l}^F)^{-\alpha}l^F, \quad \text{(A.5)}$$

where we used the first-order condition (A.3). Δ paths that obey this restriction imply that firms truthfully reveal their type. This is the second restriction that the union has to take into account when designing the contract.

A.2 w^{IAS} over the binding interval and w^{IS}

Using the expression for the wage over the binding interval, we can write

$$\begin{aligned}
w^{IAS} &= \frac{b^F \hat{l}^F + K}{\hat{l}^F}, \\
\Leftrightarrow w^{IAS} &= \frac{b^F \hat{l}^F + K - (\theta \hat{l}^F)^\alpha}{\hat{l}^F} + \frac{(\theta \hat{l}^F)^\alpha}{\hat{l}^F}, \\
\Leftrightarrow w^{IAS} &= \frac{\hat{\pi} - \hat{\pi}^F}{\hat{l}^F} + \frac{(\theta \hat{l}^F)^\alpha}{\hat{l}^F} - \frac{\hat{\pi}}{\hat{l}^F}, \qquad \text{(A.6)} \\
\Leftrightarrow w^{IAS} &= \frac{\hat{\pi} - \hat{\pi}^F}{\hat{l}^F} + \frac{(\theta \hat{l}^F)^\alpha}{\hat{l}^F} - \frac{\hat{\pi}}{\hat{l}^F} + w^{IS} - \frac{\hat{\pi} - \hat{\pi}^F}{\hat{l}} - b, \\
\Leftrightarrow w^{IAS} &= w^{IS} + \frac{\hat{\pi} - \hat{\pi}^F}{\hat{l}^F} - \frac{\hat{\pi} - \hat{\pi}^F}{\hat{l}} + \frac{(\theta \hat{l}^F)^\alpha - b\hat{l}^F - \hat{\pi}}{\hat{l}^F},
\end{aligned}$$

which implies that $w^{IAS}(\theta) < w^{IS}(\theta)$ because of $l(\theta) < l^F(\theta)$ and the profit $\hat{\pi}(\theta)$ is a maximum.

A.3 Equilibrium Derivation under Information Asymmetry

In order to find the equilibrium set of contracts, we need to determine the equilibrium path of the co-state variable $\lambda(\theta)$. The problem here is that without knowing where (and if) the participation constraint is binding, it is not straightforward to determine this path. In finding the equilibrium, we rely on an approach suggested by Maggi and Rodriguez-Clare (1995). The idea is to first characterize the form of the co-state paths over type intervals that are characterized either by $\Delta(\theta) = 0$ (i.e. binding) or by $\Delta(\theta) > 0$. If the participation constraint is not binding, we can moreover distinguish between a situation in which the overstating incentive ($\Delta'(\theta) < 0$) or the understating incentive ($\Delta'(\theta) > 0$) dominates. Having characterized the possible paths, we can then suggest the equilibrium path over the entire interval of types that will be included in the contract and show that this fulfills the sufficient conditions for an optimum.

A.3.1 Possible Co-state Equilibrium Paths

$\Delta(\theta) = 0$

First, assume that the participation constraint was binding over some interval. Then, it must be true that

$$\Delta(\theta) = 0 \Rightarrow \frac{d\Delta}{d\theta} = 0 \Rightarrow \bar{l}^{IAS}(\theta) = \hat{l}^{F}(\theta). \tag{A.7}$$

Over any binding interval, equilibrium contract employment is identical to (equilibrium) employment when the firm de-locates production. Using this, the resulting co-state path is given by

$$\bar{\lambda}(\theta) = -g(\theta)\frac{b^F - b}{(1-\alpha)\theta^{-1}b^F} = g(\theta)\theta\frac{b - b^F}{(1-\alpha)b^F} > 0, \tag{A.8}$$

where we used the fact that over the binding interval it is true that $(1 - \alpha)(\theta\hat{l}^F(\theta))^{-\alpha}\theta = b^F$ (by the optimality condition under de-location).

$\Delta(\theta) > 0$ **and** $\Delta'(\theta) < 0$
Second, we focus on an interval over which the participation constraint is not binding and the overstating incentive dominates. Consider for the moment that for the entire interval of included types this holds true. Integrating the first-order condition that describes $\lambda'(\theta)$ we can write

$$\lambda(\theta) = G(\theta) + \lambda_0, \tag{A.9}$$

where λ_0 is in this case determined by the fact that $\lambda(\theta_1) = 0$, hence

$$\lambda(\theta) = G(\theta) - G(\theta_1) > 0, \tag{A.10}$$

which then also describes the co-state path over sub-intervals with a non-binding participation constraint.

$\Delta(\theta) > 0$ **and** $\Delta'(\theta) > 0$
Finally, we consider an interval over which the participation constraint is not binding and the understating incentive dominates. Consider for the moment that for the entire interval of included types this holds true. As before, integrating the first-order condition that describes $\lambda'(\theta)$ we can write

$$\lambda(\theta) = G(\theta) + \lambda_0, \tag{A.11}$$

where λ_0 is in this case determined by the fact that $\lambda(\theta_2) = 0$, hence

$$\lambda(\theta) = G(\theta) - G(\theta_2) < 0, \tag{A.12}$$

which then also describes the co-state path over sub-intervals with a non-binding participation constraint.

A.3.2 The Equilibrium Co-state Path

Having determined the possible $\lambda(\theta)$ paths, we suggest the equilibrium path

$$\lambda^{IAS}(\theta) = \begin{cases} G(\theta) - G(\theta_1) & \forall \quad \bar{\lambda}(\theta) \geq G(\theta) - G(\theta_1) \\ g(\theta)\theta\frac{b-b^F}{(1-\alpha)b^F} & \forall \quad G(\theta) - G(\theta_2) \leq \bar{\lambda}(\theta) < G(\theta) - G(\theta_1) \\ G(\theta) - G(\theta_2) & \forall \quad \bar{\lambda}(\theta) < G(\theta) - G(\theta_2), \end{cases} \tag{A.13}$$

where since $\bar{\lambda}(\theta)$ is positive by definition, the part $\lambda^{IAS}(\theta) = G(\theta) - G(\theta_2)$ is irrelevant for this equilibrium. The equilibrium employment path given the suggested equilibrium co-state path is given by

$$l^{IAS}(\theta) = \begin{cases} \left(\left(\frac{G(\theta)-G(\theta_1)}{\theta g(\theta)} + \frac{1}{(1-\alpha)}\right)\frac{(1-\alpha)^2}{b}\theta^{1-\alpha}\right)^{\frac{1}{\alpha}} & \forall \quad \bar{\lambda}(\theta) \geq G(\theta) - G(\theta_1) \\ \hat{l}^F(\theta) \quad \forall \quad G(\theta) - G(\theta_2) \leq \bar{\lambda}(\theta) < G(\theta) - G(\theta_1). \end{cases} \tag{A.14}$$

By construction, the suggested path fulfills the sufficient conditions for an optimum if $\lambda^{IAS}(\theta)$ is such that

$$\mu^{IAS}(\theta) = g(\theta) - \frac{d\lambda^{IAS}(\theta)}{d\theta} > 0 \tag{A.15}$$

holds over a binding participation constraint interval. Using the expression from above, we get

$$\mu^{IAS}(\theta) = g(\theta) - \frac{\bar{\lambda}(\theta)}{\theta} - \frac{g'(\theta)\bar{\lambda}}{g(\theta)}. \tag{A.16}$$

Since we want the equilibrium path to fulfill the monotonicity constrain over the non-binding interval, a sufficient condition for this is

$$\frac{d\frac{(G(\theta)-G(\theta_1))}{g(\theta)\theta}}{d\theta} = \left(g(\theta) - \frac{G(\theta)-G(\theta_1)}{\theta} - \frac{(G(\theta)-G(\theta_1))g'(\theta)}{g(\theta)}\right)\frac{1}{g(\theta)\theta} > 0, \tag{A.17}$$

which by the equilibrium path $\bar{\lambda}(\theta) < G(\theta)$ ensures that $\mu^{IAS}(\theta) > 0$ and hence the suggested equilibrium path indeed fulfills the sufficient conditions for an optimum. It will turn out that $\theta_1 = 1$ in equilibrium such that the condition $\frac{d\frac{(G(\theta)-G(\theta_1))}{g(\theta)\theta}}{d\theta} > 0$ resembles the monoton hazard rate assumption in linear models. We apply this assumption and focus hence on a model without bunching.

A.3.3 Equilibrium Choice of the Contract Bounds

In the preceding subsection we have described ensuing equilibrium paths for a situation in which the union offers contracts to a subset of firms. Which firms are included in the contract, however, is an endogenous choice by the union. Note that we can write for the union's objective

$$\begin{aligned}
&\int_{\theta_1}^{\theta_2} g(\theta)((\theta l(\theta))^{1-\alpha} - \Delta(\theta) - \pi^F(\theta) - l(\theta)b)d\theta \\
\Leftrightarrow &\int_{\theta_1}^{\theta_2} g(\theta)((\theta l(\theta))^{1-\alpha} - \pi^F(\theta) - l(\theta)b)d\theta - \int_{\theta_1}^{\theta^2} \Delta(\theta)g(\theta)d\theta \\
\Leftrightarrow^1 &\int_{\theta_1}^{\theta_2} g(\theta)((\theta l(\theta))^{1-\alpha} - \pi^F(\theta) - l(\theta)b)d\theta - \left([\Delta(\theta)G(\theta)]_{\theta_1}^{\theta_2} - \int_{\theta_1}^{\theta^2} \Delta'(\theta)G(\theta)d\theta\right) \\
\Leftrightarrow &\int_{\theta_1}^{\theta_2} g(\theta)\left((\theta l(\theta))^{1-\alpha} - \pi^F(\theta) - l(\theta)b + \Delta'(\theta)\frac{G(\theta)}{g(\theta)}\right)d\theta - (\Delta(\theta_2)G(\theta_2) - \Delta(\theta_1)G(\theta_1))
\end{aligned}$$

where [1] follows by an integration by parts. Writing the first-order conditions for the choice for the optimal upper θ_1^* and lower type θ_2^*, we get

$$\begin{aligned}
&g(\theta_2^*)\left((\theta_2^* l(\theta_2^*))^{1-\alpha} - \pi^F(\theta_2^*) - l(\theta_2^*)b + \Delta'(\theta_2^*)\frac{G(\theta_2^*)}{g(\theta_2^*)}\right) - \left(\Delta'(\theta_2^*)G(\theta_2^*) + \Delta(\theta_2^*)g(\theta_2^*)\right) = 0 \\
&\qquad \Leftrightarrow \left((\theta_2^* l(\theta_2^*))^{1-\alpha} - \pi^F(\theta_2^*) - l(\theta_2^*)b - \Delta(\theta_2^*)\right) = 0 \\
&-g(\theta_1^*)\left((\theta_1^* l(\theta_1^*))^{1-\alpha} - \pi^F(\theta_1^*) - l(\theta_1^*)b + \Delta'(\theta_1^*)\frac{G(\theta_1^*)}{g(\theta_1^*)}\right) + \left(\Delta(\theta_1^*)g(\theta_1^*) + \Delta'(\theta_1^*)G(\theta_1^*)\right) = 0 \\
&\qquad - \left((\theta_1^* l(\theta_1^*))^{1-\alpha} - \pi^F(\theta_1^*) - l(\theta_1^*)b - \Delta(\theta_1^*)\right) = 0.
\end{aligned}$$

The exclusion decision of the union is based on the value of the virtual surplus

$$VS(\theta) := (\theta l(\theta))^{1-\alpha} - \pi^F(\theta) - l(\theta)b - \Delta(\theta),$$

which is the production value minus the opportunity costs of trade (for the union and the firm) minus the information rent. Note that

$$\frac{VS(\theta)}{d\theta} := (1-\alpha)\theta^{-\alpha}l(\theta)^{1-\alpha} + \theta^{1-\alpha}(1-\alpha)l(\theta)^{-\alpha}l'(\theta) - \frac{d\pi^F(\theta)}{d\theta} - l'(\theta)b - \Delta'(\theta)$$

$$\Leftrightarrow^1 \frac{VS(\theta)}{d\theta} := \left(\theta^{1-\alpha}(1-\alpha)l(\theta)^{-\alpha} - b\right) l'(\theta),$$

where ^{1} follows directly from $\Delta'(\theta) = (1-\alpha)(\theta l)^{-\alpha} l - \frac{d\pi^F(\theta)}{d\theta}$. By the first-order condition and the monotonicity constraint on $l(\theta)$, we have that $\frac{VS(\theta)}{d\theta} < 0$, i.e. the virtual surplus is decreasing over types. This implies that low-productivity firms are more 'valuable' to the union. This result is due to the fact that those firms' outside option is low and hence the net-trading value high.

Thus, for some optimal θ_2^* it must be true that $VS(\theta_1^*) > 0$ which implies that the union will include firms up to the lowest productivity measure into the contract, $\theta_1^* = 1$. Over the binding interval, we have that $VS(\theta) = \hat{l}^F(\theta)(b^F - b) < 0$, which means that no firm on the binding interval is offered a contract.

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