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## Unionization, information asymmetry and the de-location of firms

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

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

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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 of a firm's productivity dependent outside option (producing abroad), the problem is characterized by countervailing incentives. We find that, under fairly mild assumptions on the distribution of firm's productivity, the overstating incentive always dominates. The equilibrium contract offered by the union is then characterized by overemployment. Besides its effect on the intensive margin, the union also affects the extensive margin (i.e. de-location). The union forces firms to de-locate because this narrows the possibility to overstate productivity which then 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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# 1 Introduction

## 1.1 Unions and firm de-location

What is the effect of unionization on the decision of a firm where to locate its production? In the public debate, the prevailing concern is that high wages paid to workers (advocated *inter alia* with the help of labor unions) are not sustainable, since this has been an important reason for firms to de-locate production.<sup>1</sup> Within this line of reasoning, unions pushing for too high a wage may encourage the de-location activities of firms. When looking at OECD data, we can establish this correlation between union density and de-location (measured using the stock of outbound foreign direct investment (FDI)). The data shows that an increase of unionization by 1 pp is associated with an increase in FDI per employee by around 752 US-Dollar.<sup>2</sup>

When it comes to economic theory, however, the effect of unionization on the de-location decision is far from clear. In textbook models of unionized labor markets, the union acquires parts of the firm's rents and redistribute them to its members, i.e. bargains a higher wage rate. This obviously has allocative effects. However, it is ambiguous whether the intensive margin (i.e. firm's employment) and/or the extensive margin (i.e. the de-location decision) of firm's behavior are affected.

In a globalized economy, FDI helps the firm to escape the union threat. The union's wage increase is thus restricted because it can only capture (parts of) the firm's quasi-rents.<sup>3</sup> The marginal firm which is just indifferent between producing at home and producing abroad earns no quasi-rents. This firm is hence not affected by union wage setting. As such, in a simple textbook framework, union wage setting only influences the intensive margin (home firms employ less workers), but the extensive margin remains unaffected.

Obviously, the simple textbook model is too restrictive and lacks explanatory power when it comes to the relation between unionization and de-location. An important consideration for overcoming this shortage is

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<sup>1</sup>See on this the feature issue of the Economist, Jan. 2013. An important topic here is that with a convergence of production costs between industrialized and emerging markets, the offshoring trend has reversed. Companies are moving production facilities back home.

<sup>2</sup>For the data sources, the estimation and some discussion on this point, see appendix A.1.

<sup>3</sup>The quasi-rents are here the difference between the profit at home and the best alternative which is producing abroad and earning the foreign profit.

asymmetric information between the union and the firm. With firms having private information, the optimal contract offered by the union must conceive information rents. In light of these information rent payments, the union may want to exclude some firms from the contract. This forced exclusion then results in de-location of production facilities, thereby helping to explain the observed relation between unionization and FDI (as a measure for de-location).<sup>4</sup>

The asymmetric information framework is our point of departure. We consider a stylized open economy with a unionized labor market in which the information concerning its revenues is private to the firm.<sup>5</sup> The economy consists of many industries such that the firm's and union's behavior in one industry do not alter macroeconomic variables. The firm (in the industry under investigation) is a monopolist who is endowed with a (privately known) productivity and serves a world market, employing labor as the only factor of production. The monopolist 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. As such, every firm, independent of its productivity, would prefer producing abroad over producing at home. De-location, however, requires fixed costs which are independent of the firm's productivity. Only high productivity firms de-locate production and serve the world market from abroad.

Unionization implies that wage-employment contracts are offered to firms which are conditional on reported productivity. By constructing these contracts, the union tries to capture a fraction of quasi-rents as high as possible, ensuring, however, truthtelling by the firm. Due to the possibility of producing abroad, the incentive structure of the firm is characterized by countervailing incentives. The firm has a generic incentive to understate its productivity, but would also like to overstate its productivity (because this

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<sup>4</sup>Considering asymmetric information between the union on the one hand and the firm on the other deserves some justification. Kennan and Wilson (1993) argue that although the union might have pay-off relevant information, these could be manipulated by the firm and be incomplete because e.g. opportunity costs are usually not accessible. Moreover, some authors (see, for instance, Card (1990), Hayes (1984) and Kennan and Wilson (1990)) claim that information asymmetry is an important explanation for the prevalence of strikes. Observing strikes one might induce the existence of information asymmetry.

<sup>5</sup>We consider in the following the firm's productivity as the source of the information asymmetry. Likewise (and with the same qualitative results) we could have also assumed that the demand is private information to the firm.

signals a strong outside option). Both helps the firm to protect parts of its quasi-rents.

Within this framework, we analyze the effect of unionization on (home) employment, (home) wages, the de-location decision of firms and (expected) home productivity.<sup>6</sup> To this end, we solve for the equilibrium wage-employment contract using dynamic optimization techniques. Under fairly mild conditions on the distribution function of firm productivity, the overstating incentive always dominates. Given this incentive structure, the information rent payment of the union is highest for the least productive firm and decreases in the firm's productivity. Additionally, we find that the union offers contracts which imply overemployment (compared to the first-best situation) except for the least productive firm. The intuition for this is that the requirement to employ a large workforce decreases the incentive to overstate productivity implying that the information rent payments to induce truthtelling can be reduced.

Along the extensive margin, the union excludes high productivity firms. This is because a.) the net gain of a high productivity firm (production value minus opportunity costs of working) is low due to overemployment and b.) excluding those firms narrows the overstating possibility of low productivity firms and hence saves on information rent payments to those firms. As a result, more firms are expected to de-locate (or are forced to de-locate, respectively) their production process under asymmetric information compared to the first-best case. This forced de-location under unionized labor markets may be a hint for the observed correlation between unionization and FDI found in the data. A corollary of the overemployment and forced de-location result in the unionized economy is that the effect on industry employment (or alternatively expected 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-

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<sup>6</sup>We have framed the model description such that a union faces a firm that is drawn from a pool of productivities. We could argue equally well that the union faces a mass of firms over the support of the productivity distribution. In the first case, we derive results on expected values, in the latter case, we could interpret results as industry wide averages.

locating firms increases by 46 pp. Expected/average employment, however, increases with unionization (except for the case of a complete shutdown of the industry).

## 1.2 Related literature

Our paper is concerned with the effect of unionization on the firm's choice where to locate its production. Hence, we focus on a peculiar variety of FDI in an economy without bilateral trade (there exists only one world market which can be accessed without costs) in which home and foreign workers are perfect substitutes. The usual notion of FDI in the literature is more complex, see e.g. Helpman (2014) and the literature cited therein. Firms either de-locate production facilities in order to save on trade costs when accessing a foreign market (horizontal FDI) or they de-locate (parts of) their supply chain in order to profit from lower production costs abroad (vertical FDI). Consequently, papers which study the effect of unionization on FDI usually integrate union wage setting/bargaining into these type of FDI models.

Eckel and Egger (2009) is a study in this spirit. They analyze the effects of unionization in a situation in which the domestic firm can serve the foreign market either through trade or through a foreign subsidiary. Unionization affects the trade-off between the trade and the de-location decision, favoring the latter. FDI then not only saves on trade costs (when serving the foreign market) but also imposes a threat to cross-haul (i.e. serving the home market from abroad). This lowers the bargained wage at home and increases the attractiveness of FDI. Additionally, they show that the wage dampening effect of FDI increases employment at home.

The effect of unionization on vertical FDI is analyzed e.g. by Koskela and Stenbacka (2009). In their model, output is produced using home and foreign labor and is sold in the home market. Home and foreign employment are (imperfect) substitutes, but only home labor is represented by a union bargaining the wage. The ability of the firm to substitute home by foreign labor makes home labor demand more elastic. As a result, bargained wages decrease (which is a standard result in the literature on unionized labor markets). However, FDI generates a hold-up (because the firm decides ex-ante on the amount of foreign labor) which has a wage increasing effect. If the wage dampening effect dominates (which is the case for high union bargain-

ing power), FDI implies wage moderation and home employment increases. Unionization hence enforces the incentive to engage in FDI.<sup>7</sup> Lommerud et al. (2009) also consider the effects of unionization on vertical FDI. They come to the somewhat surprising result that more unionization decreases vertical FDI (i.e. decreases fragmentation). The argument in their model is that more FDI makes home labor more 'important', i.e. the marginal product increases which in turn raises wage demands. Thus, taming unions requires less vertical FDI.

Our approach in modeling FDI is deliberately simpler than the one pursued in the literature. We do not consider bilateral trade, have no hold-up effects, no strategic effects on the product market and no imperfect substitutability between home and foreign labor. The reason is that we want to focus as clearly as possible on a mechanism of unionization on FDI (and vice versa) that is important, but has not received very much attention in the literature: Information asymmetries between unions and firms, where firms are assumed to have private information concerning their productivities.<sup>8</sup>

The combination of unionization, FDI and information frictions adds an important twist to the aforementioned studies. As argued above, the firm's incentive structure is then characterized by countervailing incentives as e.g. analyzed by Lewis and Sappington (1989) or Maggi and Rodriguez-Clare (1995). Thus, the union's effect on firm-level employment, on (expected) employment as well as on FDI when information is asymmetrically distributed between the firm and the union remains to be analyzed. This is the contribution of our paper to the literature.

The remainder of our paper is structured as follows. Section 2 presents the model and solves for the benchmark contract under information symmetry (which is trivial but nevertheless informative). Section 3, the heart of our analysis, presents the equilibrium contract under asymmetric information and discusses equilibrium properties. In section 4, we put forward a numerical calibration to gain some insights into the potential quantitative effects of unionization on de-location/FDI and (expected) employment.

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<sup>7</sup>A somehow related albeit earlier study is Zhao (1995). This paper assumes home and foreign labor to be perfect substitutes, but that both home and foreign labor are represented by a (national) union. The hold-up effect of Koskela and Stenbacka (2009) is not present. Consequently, the wage dampening effect dominates and employment increases.

<sup>8</sup>Information asymmetries between unions and firms have been analyzed before (see e.g. Oswald (1986)), however, in a closed economy setting and with a different focus.



Eventually, section 5 summarizes the findings.

## 2 The Model

### 2.1 The Firm

In the industry under investigation, there is a monopolistic firm that sells output  $x$  facing the (world market) inverse demand function

$$p = x^{-\alpha}, \quad (1)$$

where  $p$  denotes the price and  $\alpha$  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

$$x = \theta l, \quad (2)$$

where  $\theta$  denotes the (exogenously) given productivity of labor input. We assume that the firm is endowed with a level of technology which is drawn from the density function  $g(\theta)$  with support  $\theta \in [1, \bar{\theta}]$ .

Given  $\theta$ , the firm can decide whether to employ this technology at home or moving it abroad (and hence de-locate production). Moving the technology, however, comes at a fixed cost of  $K > 0$ .<sup>9</sup> The foreign production function reads  $x^F = \theta l^F$ , where the superscript  $F$  indicates foreign variables.

When producing at home, the profit of the firm  $\pi$  is given by

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

where  $w$  denotes the wage level at home, whereas the profit when moving the technology abroad  $\pi^F$  is given by

$$\pi^F = (\theta l^F)^{1-\alpha} - w^F l^F - K. \quad (4)$$

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<sup>9</sup>Thus, 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. However, ex-ante the sign of the dependence is unclear. Therefore, we stick to the independence assumption.

## 2.2 Two benchmark scenarios

The aim of this paper is to analyze the implications of unionization in a world where information between firms and unions is asymmetrically distributed. 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 and abroad are perfectly competitive so that we completely abstain from unionization. In the second one, we assume that workers at home are organized in a union but that information is symmetrically distributed. Abroad, however, labor markets are perfectly competitive.<sup>10</sup> 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.

### 2.2.1 Competitive labor markets

In the first benchmark case of perfectly competitive labor markets, labor supply is characterized as follows. At home, we assume that a mass of  $\bar{l}$  workers supplies labor infinitely elastic at the exogenously given reservation wage  $b$  (i.e. the opportunity costs of working). Labor supply is hence given by

$$w = b. \quad (5)$$

Likewise abroad, a mass of  $\bar{l}^F$  workers supplies labor infinitely elastic at the reservation wage  $b^F$  as well. This results in foreign labor supply

$$w^F = b^F. \quad (6)$$

We assume that the foreign reservation wage is smaller than that at home, i.e.  $b > b^F$ , because e.g. the system of social protection or the unemployment insurance is less generous in the foreign country than at home.<sup>11</sup> Note that workers are perfectly mobile across industries but immobile across countries.

Under competitive labor markets, the firm has to make two decisions. It chooses first where to start production and then decides how much to produce. Regarding the labor demand decision, profit maximization leads

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<sup>10</sup>Note that we also maintain this assumption in the baseline model with information asymmetry.

<sup>11</sup>It is clear that without this labor cost advantage there will be no de-location.

to

$$(1 - \alpha)(\theta l)^{-\alpha} \theta = w, \quad (7)$$

$$(1 - \alpha)(\theta l^F)^{-\alpha} \theta = w^F, \quad (8)$$

for home and abroad, respectively. 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  $\hat{l}(\theta) < \hat{l}^F(\theta)$ , i.e. a firm with a given technology  $\theta$  employs more labor abroad than at home.<sup>12</sup>

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

$$\hat{\pi}(\theta) = \alpha(\theta \hat{l}(\theta))^{1-\alpha}, \quad (9)$$

$$\hat{\pi}^F(\theta) = \alpha(\theta \hat{l}^F(\theta))^{1-\alpha} - K. \quad (10)$$

The firm chooses to de-locate production if

$$\hat{\pi}(\theta) < \hat{\pi}^F(\theta) \Leftrightarrow \alpha(\theta \hat{l}(\theta))^{1-\alpha} < \alpha(\theta \hat{l}^F(\theta))^{1-\alpha} - K. \quad (11)$$

**Proposition 1** *With competitive labor markets, there exists some 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  $\hat{\delta}(\theta) := \alpha((\theta \hat{l}^F)^{1-\alpha} - (\theta \hat{l})^{1-\alpha})$  is increasing in  $\theta$  because of*

$$\frac{d\hat{\delta}}{d\theta} = (1 - \alpha)(\theta)^{-\alpha} \left( (\hat{l}^F)^{1-\alpha} - (\hat{l})^{1-\alpha} \right) > 0, \quad (12)$$

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

The intuition behind this result is as follows: Firms with low productivities produce less output such that the average costs of de-location are high. With increasing productivity, we have a degression of fixed de-location costs due to increased production. Thus, for high productivity firms, fixed costs

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<sup>12</sup>Note that 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.

become more and more irrelevant when deciding on de-location which makes it more attractive to produce abroad.

Note that 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:  $\hat{\theta} > 1$ .<sup>13</sup> 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).

### 2.2.2 Unionization and information symmetry

Consider now a situation in which workers at home are organized in a union. We assume that the union sets wage-employment contracts on behalf of their members  $\bar{l}$ .<sup>14</sup> The union is utilitarian such that its utility is given by

$$U^{Union} = lw + (\bar{l} - l)b = l(w - b) + \bar{l}b. \quad (13)$$

For notational convenience, we focus in the following exclusively on the rent maximization part of the union's utility

$$V^{Union} := U^{Union} - \bar{l}b. \quad (14)$$

We assume that the union can (credibly) offer ex-ante contracts, i.e. before it meets a firm (from the mass of all firms) with some productivity  $\theta$ . Since we have information symmetry in this setting, the union conditions the contract on *true* productivity.<sup>15</sup> Upon meeting with the union, the firm can accept or reject the contract. In case of acceptance, the contract is executed and production starts. In case of rejection, the firm de-locates production.

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<sup>13</sup>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.

<sup>14</sup>At this stage, one might argue that it is more sophisticated to assume that the union sets the wage rate while the firm has the right to manage employment. When it comes to the information asymmetry setting, however, the union must have the right to set a contract – otherwise, the information friction cannot be solved (this is a very standard result from contract theory). Per definition, the contract has to consist of two instruments, and from the union's perspective the most plausible instruments are wages and employment.

<sup>15</sup>Information symmetry is reflected by the fact that once the firm is endowed with its productivity, it will become common knowledge.

From (13) and (14), we can formulate the union's expected utility as

$$\mathbb{E}(V^{Union}) = \int_1^{\bar{\theta}} g(\theta)l(w - b)d\theta, \quad (15)$$

where  $g(\theta)d\theta$  is the probability that the union meets a firm with productivity  $\theta$ . To set ex-ante the wage-employment contracts for the different types of firms, the union chooses the path of  $l$  and  $w$  over  $\theta$  subject to the participation constraint of the firms which is given by  $\pi \geq \hat{\pi}^F \forall \theta \in [1, \bar{\theta}]$ .<sup>16</sup>

By the definition of the profit  $\pi$  we can rewrite union's expected utility in terms of employment  $l$  and profit  $\pi$

$$\mathbb{E}(V^{Union}) = \int_1^{\bar{\theta}} g(\theta)((\theta l)^{1-\alpha} - \pi - lb)d\theta, \quad (16)$$

which implies that the union can likewise choose the path of employment  $l$  and profits  $\pi$  over  $\theta$  subject to the firms' participation constraint. The Lagrangean for this problem is

$$\mathcal{L} = \int_1^{\bar{\theta}} (g(\theta)((\theta l)^{1-\alpha} - \pi - lb) + \mu(\pi - \hat{\pi}^F)) d\theta, \quad (17)$$

which results in first-order conditions given by

$$g(\theta)((1-\alpha)(\theta l)^{-\alpha} - b) = 0, \quad (18)$$

$$-g(\theta) + \mu = 0, \quad (19)$$

$$\mu(\pi - \hat{\pi}^F) = 0. \quad (20)$$

From (18), we find that the union sets employment efficiently, i.e. equilibrium employment will be the same as under competitive labor markets  $l^{IS}(\theta) = \hat{l}(\theta)$  (where the superscript  $IS$  denotes the equilibrium under information symmetry). Moreover, (19) and (20) 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  $\pi^{IS}$  and  $l^{IS}$

$$w^{IS}(\theta) = \frac{(\theta \hat{l}(\theta))^{1-\alpha} - \hat{\pi}^F(\theta)}{\hat{l}(\theta)} = b + \frac{\hat{\pi}(\theta) - \hat{\pi}^F(\theta)}{\hat{l}(\theta)}. \quad (21)$$

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<sup>16</sup>The participation constraint ensures that all firms will accept the contract after they are equipped with some productivity levels.

Eq. (21) shows that the wage rate set by the union exceeds the wage under competitive labor markets  $b$  if and only if  $\hat{\pi}(\theta) > \hat{\pi}^F(\theta)$ . From proposition 1, we obtain  $w^{IS}(\theta) > b \Leftrightarrow \theta < \hat{\theta}$ . For firms which would de-locate under competitive labor markets ( $\theta > \hat{\theta}$  respectively  $\hat{\pi}(\theta) < \hat{\pi}^F(\theta)$ ), we have  $w^{IS}(\theta) < b$ . To keep these firms indifferent between producing at home and moving abroad, the union would have to increase the firms' quasi-rent which can be interpreted as a wage 'subsidy' from the union to the firm. Confronted with these firms, however, workers would be better off taking up their outside option, which could lead to a collapse of the union.

The last scenario points out that the union – besides choosing the path of  $l$  and  $\pi$  (or equivalently  $w$ ) over  $\theta$  – must also choose with which firm it should strike an agreement and which firm it should exclude from the contract (i.e. offering a null-contract). By assumption, the excluded firms have to de-locate and produce abroad while the other firms start production at home. The union offers a firm with some productivity  $\theta$  the optimal wage-employment contract if and only if the marginal gain of including this firm into the contract is non-negative. Inserting  $l^{IS}$  and  $\pi^{IS}$  into (16) and differentiating with respect to  $\theta$  (employing the appropriate envelope conditions) yield:

$$g(\theta)((\theta l^{IS})^{1-\alpha} - \pi^{IS} - l^{IS}b) \geq 0. \quad (22)$$

The left-hand side reflects the marginal gain of including a firm with productivity  $\theta$  and equals the production value net of the outside options (=opportunity costs) of both the union ( $:=l^{IS}b$ ) and the firm ( $:=\pi^{IS} = \hat{\pi}^F$ ). With efficient employment, this gain is given by the difference between  $\hat{\pi}(\theta)$  and  $\hat{\pi}^F(\theta)$ . Using the assumption concerning this difference for  $\theta = 1$  (see before) and proposition 1, we arrive at the following proposition:

**Proposition 2** *With unionization and information symmetry, there exists some (unique) threshold productivity  $\theta^{IS}$ , for which the marginal gain of including a firm is zero. Lower (Higher) productivity firms provide a positive (negative) marginal gain and hence are included in (excluded from) the contract. Moreover, this de-location threshold is the same as as under competitive labor markets, i.e.  $\theta^{IS} = \hat{\theta}$ .*

**Proof 2** *For the first part note that the marginal gain can be rewritten as  $g(\theta)(K - \hat{\delta}(\theta))$ . By assumption, this is positive for  $\theta = 1$  and decreasing in  $\theta$ .*

*For the second part note that the condition for  $\theta^{IS}$  is  $g(\theta^{IS})(K - \hat{\delta}(\theta^{IS})) = 0$  which is also true for  $\hat{\theta}$ .*

Summarizing, we find that under information symmetry, unionization (in the form of offering wage-employment contracts to firms) has no allocative effect. Neither the intensive margin (employment) nor the extensive margin (de-location) are affected – both remain efficient.<sup>17</sup> Intuitively, the union has no incentive to keep a higher fraction of firms at home (relative to the case of competitive labor markets) because this would imply the payment of a wage ‘subsidy’ – the marginal gain of including these firms into the contract is negative. For the remaining firms, unionization solely increases the wage and shifts quasi-rents from the firm to workers, i.e. only has distributional effects (except for the marginal firm with  $\theta = \theta^{IS} = \hat{\theta}$ ).

### 2.3 Unionization and information asymmetry

Let us now turn to our baseline model with asymmetric information between the union and the firm. Here, we refrain from the assumption that the union can perfectly observe the firm’s productivity after the contract has been set-up. Instead, we assume that the firm’s productivity is private information. When constructing ex-ante the wage-employment contracts, the union anticipates this information friction and hence only constructs contracts which result in self-selection of the firm. The set of viable contracts is smaller than before. The union not only has to take participation of the firms, but also incentive compatibility (to ensure self-selection) into account. The timing is similar to the one put forward under information symmetry with the exception that the firm cannot only accept or reject the contract, but also decides on which contract to choose.

In appendix A.3, we illustrate the firm’s optimization problem when it decides about choosing the contract which conceptually is identical to the announcement of a productivity level. In particular, we show that the incentive compatibility constraint requires a specific form of the profit and

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<sup>17</sup>Appendix A.2 shows that even with firms having the right to manage employment, the extensive margin is not affected. Employment of the home firms decreases compared to the first-best solution. The de-location threshold, however, remains unaffected.

of the employment path. Denoting the quasi-rent for the firm by  $\Delta$ , we have

$$\frac{d\Delta}{d\theta} := \frac{d\pi}{d\theta} - \frac{d\pi^F}{d\theta} = (1 - \alpha)(\theta l)^{-\alpha} l - (1 - \alpha)(\theta \hat{l}^F)^{-\alpha} \hat{l}^F, \quad (23)$$

$$\frac{dl}{d\theta} \geq 0. \quad (24)$$

Eq. (23) can be interpreted as a 'slope' restriction. If the union constructs contracts that represent this  $\Delta$  path, firms will truthfully reveal their productivity and hence self-select into 'their' contracts. The monotonicity constraint (24) ensures that truthtelling leads to firm's profit maximum and must also be taken into account by the union.

Inspection of (23) shows that ex-ante, i.e. before the contract employment  $l$  is specified, the sign of  $d\Delta/d\theta$  is ambiguous. This reflects that firms are confronted with *countervailing incentives* when they decide about their productivity announcement (see appendix A.3). On the one hand, the firm has an incentive to overstate its true productivity because this signals c.p. a better outside option (i.e. a higher probability to de-locate production). On the other hand, the firm has an incentive to understate its true productivity because this signals c.p. a lower production value. Both could imply that the union sets a more favorable contract from the firm's perspective. A priori, i.e. before the union pins down the optimal contract, it is, however, not clear which of these incentives dominate. Hence, when designing the optimal contract, the union does not know which firm to pay a rent (if any) to prevent it from not telling the truth.

Moreover, as was already foreshadowed by the information symmetry case, the union decides on excluding firms from the contract. The problem here, however, is that as long as we do not know the path of the quasi-rent,  $\Delta$ , in equilibrium, we do not know the gain of including a firm into the contract. To circumvent these problems, we apply a two-step procedure. First, we solve for the equilibrium employment and quasi-rent path as if all firms were included into the contract. Second, we derive which firms will be excluded from the contract. This approach is legitimate because exclusion is decided conditionally, depending on the optimality of employment and the quasi-rent.



### 3 Equilibrium

#### 3.1 The optimal contract

The objective of the union is very similar to that under information symmetry. In the information asymmetry setting, however, the union also needs to take the incentive compatibility constraint (23) into account. The problem of the union is again to construct a  $w$ - $l$ -path. Inserting the firm's profit (3) into the definition of the quasi-rent,  $\Delta = \pi - \pi^F$ , implies  $(\theta l)^\alpha - \Delta - \pi^F = wl$ . Plugging this into the union's expected utility (15), we eliminate the wage  $w$  and get a modified version of the union's objective:

$$\mathbb{E}(V^{Union}) = \int_1^{\bar{\theta}} g(\theta)((\theta l)^{1-\alpha} - \Delta - \pi^F - lb)d\theta. \quad (25)$$

The union maximizes expected utility by choosing the path of employment  $l$  over  $\theta$  subject to the required path of  $\Delta$  over  $\theta$  given by (23) (ensuring firms' self-selection) and subject to the participation constraint of all firms  $\Delta \geq 0 \forall \theta \in [1, \bar{\theta}]$ .<sup>18</sup> We solve for the equilibrium by a.) employing dynamic optimization techniques identifying  $\Delta$  as the state and  $l$  as the control variable and b.) ignoring for the moment the constraint on form of the control path  $l(\theta)$  (the monotonicity constraint (24)), verifying it ex-post.

The Hamilton-Lagrange function for the full problem (i.e. including all firms) reads

$$\mathcal{H} = g(\theta)((\theta l)^{1-\alpha} - \Delta - lb - \pi^F) + \lambda \left( (1-\alpha)(\theta l)^{-\alpha}l - (1-\alpha)(\theta \hat{l}^F)^{-\alpha}\theta \right), \quad (26)$$

$$\mathcal{L} = \mathcal{H} + \mu\Delta, \quad (27)$$

where  $\lambda$  is the 'intertypal' shadow value and  $\mu$  is the shadow value of the participation constraint (in the case it is binding). The interpretation of  $\lambda$  is very similar to the costate variable in optimal control problems, i.e. the intertemporal shadow value (see e.g. Kaplow (2010)). Basically, this measures the effect on union's utility if the quasi-rent of a firm with specific productivity  $\theta$  is marginally increased.

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<sup>18</sup>As in the information symmetry case, the participation constraint ensures that all firms – irrespective of their productivity level – accept the contract.

The first-order conditions for this problem are given by

$$g(\theta)((1 - \alpha)(\theta l^{IAS})^{-\alpha}\theta - b) = -\lambda^{IAS}(1 - \alpha)^2(\theta l^{IAS})^{-\alpha}, \quad (28)$$

$$\frac{d\lambda^{IAS}}{d\theta} = g(\theta) - \mu^{IAS}, \quad (29)$$

$$\mu^{IAS}\Delta^{IAS} = 0, \quad (30)$$

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 that  $\lambda(1) = \lambda(\bar{\theta}) = 0$  (which is implied by the fact that the union is free to choose the rent at the 'corners' of the productivity support).<sup>19</sup>

The first-order condition (28) 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  $\theta$ . 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 (18)). With asymmetric information, however, the change in employment for one firm requires an adjustment in the contract for all other firms. The consequence for union utility is reflected by the right-hand side. Hence, deciding about employment  $l$  for some firm with productivity  $\theta$  implies that the union has to take the effect on self-selection for all other firms into account as well. With  $\lambda^{IAS}$  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.

In standard problems (without countervailing incentives), the solution procedure implies solving for the path of  $\lambda^{IAS}$  which then in turn defines optimal employment. If we knew the sign of  $d\Delta/d\theta$  this procedure would be straightforward. In our case, however, countervailing incentives imply that ad-hoc we do not know the path of the quasi-rent  $\Delta$  and hence do not know for which firms (if any) the participation constraint is binding. Solving for the  $\lambda^{IAS}$  path is then a bit tricky.

In the appendix A.4, we provide a detailed description of the solution strategy. In particular, we are able to define a threshold productivity level

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<sup>19</sup>Note that for any interior interval, these transversality conditions would be given by the continuity of the state variable  $\Delta$ .

$\check{\theta}$  as the solution to

$$g(\check{\theta})\check{\theta} \frac{b - b^F}{(1 - \alpha)b^F} = G(\check{\theta}). \quad (31)$$

This threshold productivity can be used to identify for which type of firm the participation constraint is (not) binding so that we can solve for the equilibrium contract. The intuition for the fact that there may exist firms (with  $\theta \geq \check{\theta}$ ) which earn no quasi-rent, hence are offered a contract that makes them indifferent between producing at home and abroad, is the following. The marginal product of labor is decreasing. The efficiency loss of deviating from the first-best situation is low for firms that employ a large workforce, i.e. high productivity firms. When designing the contract, the union is not willing to offer wage discounts, but ensures truth-telling by requiring large deviations from first-best employment. No information rents are being paid. The same line of reasoning can be applied for low productivity firms. There, deviations from the first-best are very costly, which the union is willing to avoid by paying high information rents and not accepting (in the extreme) a deviation from the first-best.

Let us suppose that  $\check{\theta} \notin [1, \bar{\theta}]$ . As shown in appendix A.4, the participation constraint is never binding in this scenario and the equilibrium is then given by

$$\begin{aligned} \lambda^{IAS}(\theta) &= G(\theta), \\ l^{IAS}(\theta) &= \left( \frac{g(\theta)(1 - \alpha)\theta^{1-\alpha} + G(\theta)(1 - \alpha)^2\theta^{-\alpha}}{g(\theta)b} \right)^{\frac{1}{\alpha}}, \\ \Delta^{IAS}(\theta) &= \Delta^{IAS}(1) + \int_1^\theta (1 - \alpha)(\tilde{\theta}l^{IAS})^{-\alpha} l^{IAS} d\tilde{\theta} - (\hat{\pi}^F(\theta) - \hat{\pi}^F(1)), \\ w^{IAS}(\theta) &= \frac{(\theta l^{IAS}(\theta))^{1-\alpha} - \Delta^{IAS}(\theta) - \hat{\pi}^F(\theta)}{l^{IAS}}, \\ \mu^{IAS} &= 0. \end{aligned}$$

Given the optimal contract, we must control for the monotonicity constraint  $\frac{dl}{d\theta} \geq 0$ . To ensure that this constraint is fulfilled, we focus in the following on productivity distributions such that the 'realization elasticity' of the probability function  $\eta(\theta) := g(\theta) \frac{\theta}{G(\theta)}$  is decreasing in  $\theta$ .<sup>20</sup>

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<sup>20</sup>This restriction is in the same spirit as the monotone hazard assumption (i.e. that  $\frac{G(\theta)}{g(\theta)}$  is strictly de-/increasing depending on the type of model) that is usually put forward in standard textbook models of adverse selection.

The equilibrium path of  $\lambda$  indicates that if  $\check{\theta} \notin [1, \bar{\theta}]$  the overstating incentives dominate, see (29). Hence, the union pays information rents to firms in order to prevent them from overstating their productivity. Given this incentive structure in equilibrium, we can pin down the optimal employment path and arrive at 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** *We can rewrite the expression for the equilibrium employment path and get*

$$l^{IAS}(\theta) = \left( \hat{l}(\theta)^\alpha + G(\theta)(1 - \alpha)^2 \theta^{-\alpha} g(\theta) b \right)^{\frac{1}{\alpha}}, \quad (32)$$

*which implies that  $l^{IAS}(\theta) > \hat{l}(\theta)$  for  $\theta > 1$  and with  $G(1) = 0$  that  $l^{IAS}(1) = \hat{l}(1)$ .*

What is the intuition behind this result? Let us first look at the least productive firm. For this firm, the incentive to overstate productivity is strongest. Thus, having the least productive firm tell the truth is most valuable as it results into the highest information rent payment. To make up for this high payment, the union sets employment efficiently, i.e. allows for the maximum size of the pie. For firms with higher productivities, the overstating incentive becomes weaker so that the information rent payment can be reduced. Hence, the union can deviate from setting employment efficiently. By constructing contracts with overemployment, the union then can save even more information rent payments (see (28)) which is the reason for the chosen equilibrium employment path.

A property of the equilibrium (which will become important when determining the threshold productivity for exclusion) is the fact that the wage  $w^{IAS}$  falls short of  $w^{IS}$ . Rewriting gives

$$w^{IAS}(\theta) = b + \frac{(\theta l^{IAS}(\theta))^{1-\alpha} - b l^{IAS}(\theta) - \Delta^{IAS}(\theta) - \hat{\pi}^F(\theta)}{l^{IAS}(\theta)}, \quad (33)$$

which is smaller than  $w^{IS}$  due to two reasons. First of all, the union has to pay an information rent, thus the firm accrues a larger part of the production

value, leaving less to the union. Second, employment is inefficient, thus the size of the pie is smaller than under information symmetry. Bluntly speaking, the consequence of the information friction is that the union can only capture a smaller piece of a smaller pie by its wage demands.

So far we have discussed the equilibrium in which the participation constraint is not binding. Suppose now that  $\check{\theta} \in [1, \bar{\theta}]$ . As shown in appendix A.4, the participation constraint becomes binding (i.e. a situation in which the contract offered by the union makes some firms indifferent between accepting the contract and de-locating production) for  $\theta \geq \check{\theta}$ . The equilibrium over this interval  $[\check{\theta}, \bar{\theta}]$  is characterized by<sup>21</sup>

$$\begin{aligned}\lambda^{IAS}(\theta) &= g(\theta)\theta \frac{b - b^F}{(1 - \alpha)b^F}, \\ l^{IAS}(\theta) &= \hat{l}^F(\theta), \\ \Delta^{IAS} &= 0, \\ w^{IAS}(\theta) &= b^F + \frac{K}{\hat{l}^F(\theta)}, \\ \mu^{IAS}(\theta) &= g(\theta) - \frac{d(g(\theta)\theta)}{d\theta} \frac{b - b^F}{(1 - \alpha)b^F}.\end{aligned}$$

In this equilibrium, the understating incentive exactly outweighs the overstating incentive so that the union does not need to pay an information rent to induce truthtelling. Nevertheless, employment remains inefficient. The union forces firms to overemploy, because this incentivizes firms to report their productivity truthfully. Moreover, the contract wage  $w^{IAS}$  is smaller than  $w^{IS}$  (see appendix A.5) because of the inefficient employment which results in a smaller pie. Note that the monotonicity constraint is fulfilled since we have  $d\hat{l}^F/d\theta > 0$ .

### 3.2 Exclusion

Having characterized the equilibrium contract on the condition that all firms will be offered a contract, we can now turn to the exclusion decision. The union offers only (non-null) contracts to those firms whose marginal gain of inclusion, which we denote by  $mg$ , is positive. The marginal gain of including a firm (which has not been included in the contract previously) is

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<sup>21</sup>The equilibrium over the non-binding interval is obviously identical to the one that has been discussed above.

given by (see, e.g. Seierstad and Sydsaeter (1987))

$$mg(\theta) := g(\theta)(l^{IAS}(\theta)(w^{IAS}(\theta) - b)) + \lambda^{IAS}(\theta) \frac{d\Delta^{IAS}(\theta)}{d\theta}. \quad (34)$$

The marginal gain is made up of two effects. First, the direct gain is the production value minus the payment to the specific firm such that it participates and tells the truth (which is  $w^{IAS}$ ) exceeds the opportunity costs of working. Second, there is an indirect effect because including a firm of some specific productivity  $\theta$  also (by the incentive compatibility constraint) increases the payment that has to be made for all other firms under the contract. This argument leads to the following proposition:

**Proposition 4** *With unionization and information asymmetry, the per-employee marginal value of including a firm is smaller under asymmetric information than under symmetric information. Moreover, the per-employee marginal value of including a firm is decreasing in  $\theta$ .*

**Proof 4** *Concerning the first part of the proposition, note that  $w^{IS}$  is larger than  $w^{IAS}$ . Moreover, the effect of including a firm on the incentive compatibility constraint is negative, because  $\lambda^{IAS} \frac{d\Delta^{IAS}}{d\theta} \leq 0$ . For the second part of the proposition, note that  $\frac{K - \hat{\delta}(\theta)}{l(\theta)}$ , which is the per-employee marginal gain of a firm under information symmetry, is decreasing in  $\theta$ . Because the marginal gain under information asymmetry is smaller than that under information symmetry, it must be true that the marginal gain under asymmetric information is indeed decreasing in  $\theta$ .*

The intuition for this proposition is that with asymmetric information, the union has to compensate the firm not only for giving up the opportunity of producing abroad but also for telling the truth. This implies that the marginal gain of including a firm is smaller compared to the information symmetry case. In addition, due to the dominating overstating incentive, including more productive firms into the contract makes the self-selection constraint more severe so that we have  $dmg(\theta)/d\theta < 0$ .

Proposition 4 is important because it sheds light on the effect of unionization on the de-location choice of firms which is summarized in the following corollary:

**Corollary 1** *First, if  $g(1)(l^{IAS}(1)(w^{IAS}(1) - b)) < 0$ , the union excludes all firms from the contract. Then, the product is exclusively produced abroad.*

Second, for parameter vectors for which there is production at home, the productivity of the marginal firm that is just included  $\theta^{IAS}$  (which is determined by  $g(\theta^{IAS})(l^{IAS}(\theta^{IAS})(w^{IAS}(\theta^{IAS})-b))+\lambda^{IAS}(\theta^{IAS})\frac{d\Delta^{IAS}(\theta^{IAS})}{d\theta^{IAS}}=0$ ) is smaller than  $\hat{\theta}$ .

Thus in our stylized economy, unionization only affects the extensive production margin if information concerning firm's revenues (productivity in our case) is private to the firm. With symmetric information, the union would want to include any firm into the contract with positive quasi-rents (that can be captured). But these are positive for all firms that would choose to produce at home under competitive labor markets. Hence, the union has no effect along the extensive margin. Under information asymmetry, however, parts of the quasi-rents are protected from being captured by the union. Including firms is then less valuable. As a result, the union offers null-contracts to a larger fraction of firms, thus making de-location more likely.

Due to the overstating incentives, the union excludes high productivity firms because this narrows the overstating possibility of low productivity firms and hence saves on information rent payments. To put it differently, the union balances two effects when deciding about excluding high productive firms. On the one hand, these firms create the largest production value and therefore the largest pie. On the other hand, high productive firms have a better outside option (and thus a strong incentive to overstate their productivities) such that it is very costly for the union to keep them at home. If the firm's productivity exceeds a certain threshold, the latter effect dominates and the union forces the firm to de-locate production. From a welfare perspective this forced de-location, however, is inefficient because production at home would have occurred under competitive labor markets.

## 4 A numerical example

What are the quantitative effects of the analysis provided so far? In other words, 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 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 hence have

$$G(\theta) = 1 - \frac{1 - \theta^{-c}}{1 - (\bar{\theta})^{-c}}, \quad (35)$$

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 (7) and the assumption that employment is Zipf distributed, we conclude that productivity is Pareto distributed<sup>22</sup> (as in (35)) with shape parameter  $c = \frac{1-\alpha}{\alpha}$  and  $\bar{\theta} = 10^{6\frac{\alpha}{1-\alpha}}$ .<sup>23</sup>

The parameter  $\alpha$  (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 mark-up (over unit costs that the firm sets). This mark-up is given by  $(1 - \alpha)^{-1}$ . There is some variation in the literature

<sup>22</sup>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.

<sup>23</sup>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.



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 reason for this choice is a.) that it is reasonably close to what is assumed in the macroeconomic literature and b.) 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. (2010) 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.<sup>24</sup> Eq. (10) and the assumptions concerning  $K$  and  $\alpha$  then specify the value  $b^F$ . The opportunity costs of working at home  $b$  are just 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.

## 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 (i.e.  $G(\theta^{IAS})$ ) and on industry employment (denoted by  $L^{IAS}$ ) compared to the outcomes of both under competitive labor markets (i.e.  $G(\hat{\theta})$  and  $\hat{L}$ , respectively). The magnitude of the effects are based on the calculations of  $G(\theta^{IAS}) - G(\hat{\theta})$  and  $L^{IAS} - \hat{L}$  given the respective specification.

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 as high a value as 46 pp in the case in which unionization shuts down the

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<sup>24</sup>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	$10^6 \frac{\alpha}{1-\alpha}=78.76$
$\alpha$ (Value of the inverse price elasticity)	0.26	0.26
$b^F$ (Opportunity costs of working – abroad)	0.24	0.24
$K$	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

Specification 1				
$b$	$G(\hat{\theta})$	$\hat{L}$	$G(\theta^{IAS})$	$L^{IAS}$
1.1 $b^F$	0.9	83.68	0.87	108.41
1.3 $b^F$	0.65	34.44	0.34	33.81
1.5 $b^F$	0.46	17.95	0	0

  

Specification 2				
	$G(\hat{\theta})$	$\hat{L}$	$G(\theta^{IAS})$	$L^{IAS}$
1.1 $b^F$	0.77	92.37	0.72	118.54
1.3 $b^F$	0.48	35.18	0.2	32.51
1.5 $b^F$	0.32	18.09	0	0

Table 2: Calibration results

industry. These magnitudes are in the same ballpark range between these two specification. We can thus conclude that the results are robust against changes in the (form of) the productivity distribution function. The important point here is that shutting down the industry will occur (at least in our specifications) even for relatively modest differences between the opportunity costs of working at home and abroad (in our case of only 50%).

The second important point is that the effects of unionization on industry level employment are relatively modest (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 (and hence de-industrialization) has 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 private information regarding their productivities. The union gains the right to construct a wage-employment contract, but has to ensure the self-selection of firms into 'their' contracts, or equivalently, 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 include this type of firm into the 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 under- and overstate its productivity both to get a more favorable contract from the union.

We show that in equilibrium the overstating incentive dominates. Hence, 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 since 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 are forced to de-locate production although they would have produced at home under information symmetry or perfectly competitive labor markets. Hence, 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 small differences in labor

(opportunity) costs between home and abroad, up to 50% of firms are forced to de-locate. The effect on average employment, however, is relatively modest and even positive. Thus, a de-location process that is enforced through unionization must not necessarily go hand-in-hand with a decrease in employment.

## A Appendix

### A.1 Data and estimation

For establishing the relation between unionization and FDI, we employ a very parsimonious empirical strategy. Using the information on FDI and unionization on 34 OECD countries over a period of 32 years, we estimate a time and country fixed effects regression of the form

$$FDI_{it} = \beta_0 + \beta_i + \beta_t + \beta_1 UD_{it} + u_{it}, \quad (\text{A.1})$$

where  $FDI_{it}$  denotes FDI per employee in country  $i$  in year  $t$  and  $UD_{it}$  denotes union density (i.e. number of union members per employee) in country  $i$  and year  $t$ . We allow for specific country heterogeneity and for year heterogeneity by including fixed year and country effects. Both of these effects could be correlated with the explanatory variable, i.e. the country specific rule of law, which may affect FDI, could be correlated with union density. By using a fixed effects regression we control for these correlations.

Data on unionization are retrieved from OECD (2014), data for out-bound FDI come from UNCTAD (2014) (at current prices and exchange rates in US Dollar). Some summary statistics on this data is given in table 3. Using this data, the regression results are given in table 4 where we

Variable	n	Mean	Std. Dev.	Min	Max
FDI (stock)	1060	23316.64	54315.91	0	523326.7
Union Density	914	35.27982	20.97511	5.797465	96.35514

Table 3: Summary statistics

suppressed the coefficients for the fixed effects (both of which are available from the authors upon request).

$UD_{it}$	752.461 (2.09)
$\alpha_0$	-37279.87 (-2.07)
Country Fixed E	yes
Year Fixed E	yes

Table 4: Fixed effect regression (robust standarderrors, t-values in brackets)

Obviously, our results suffer from endogeneity issues as well as the lack

of not being structural estimation of the theoretical model. Nevertheless, it gives an important hint in which way FDI (or the de-location of industry structures) and unionization are related.

## A.2 Information symmetry and right-to-manage

In the following, we derive the effect of unionization (under information symmetry) on the intensive and extensive margin of firm behavior if the firm has the right to manage employment. Obviously, we employ the same notation as in the main body of the text. For convenience, we repeat here the firm's home labor demand and union's utility

$$w = \alpha \theta^{1-\alpha} l^{-\alpha}, \quad (\text{A.2})$$

$$V^{union} = l(w - b). \quad (\text{A.3})$$

With the union constructing the contract ex-ante, the objective is

$$\mathbb{E}(V^{union}) = \int_1^{\bar{\theta}} l(w - b) d\theta, \quad (\text{A.4})$$

and the union sets a wage for every firm with productivity  $\theta$ .

First, we analyze the wage setting behavior of the union taking only the intensive margin into account. Based on this, we consider its effect on the extensive (i.e. the de-location) margin. Note that the firm's equilibrium profit under right-to-manage is given by

$$\pi = (1 - \alpha) \theta^{1-\alpha} l^{-\alpha} \quad (\text{A.5})$$

or equivalently

$$\pi = w^{-\frac{1-\alpha}{\alpha}} (\theta \alpha)^{\frac{1-\alpha}{\alpha}} (1 - \alpha). \quad (\text{A.6})$$

The equilibrium foreign profit of the firm is given by  $\hat{\pi}^F$ .

The union sets the wage (unilaterally) in order to maximize its utility, taking the employment reaction of the firm into account implying that  $\pi(w)$  must exceed  $\hat{\pi}^F$  since otherwise the firm would de-locate. Moreover, the union cannot set wages that are lower than  $b$ , because otherwise no worker would find it worthwhile to provide labor supply. The objective of the union

then reads

$$\mathcal{L} = \int_1^{\bar{\theta}} (g(\theta)l(w-b) + \eta_1(\pi(w) - \hat{\pi}^F)) d\theta + \eta_2(w-b), \quad (\text{A.7})$$

where  $\eta_1$  is the shadow value of the firms' participation constraint and  $\eta_2$  is the one associated with the workers' participation constraint. The first-order condition that governs optimal wage setting is

$$g(\theta) \left( \frac{dl}{dw}(w-b) + l \right) + \eta_1 \frac{d\pi(w)}{dw} + \eta_2 = 0, \quad (\text{A.8})$$

with complementary slackness given by

$$\eta_1(\pi(w) - \hat{\pi}^F) = 0, \quad (\text{A.9})$$

$$\eta_2(w-b) = 0. \quad (\text{A.10})$$

Suppose first of all that the constraints on the extensive margin and the participation constraints are not binding. Then we get the wage

$$\begin{aligned} \frac{dl}{dw}(w-b) + l &= 0, \\ \Leftrightarrow w + l \frac{dw}{dl} &= b, \\ \Leftrightarrow w^{RTM} &= (1 + \frac{l}{w} \frac{dw}{dl})^{-1} b, \end{aligned} \quad (\text{A.11})$$

where the wage is a mark-up over the outside option  $b$ . In our specification, this mark-up is given by  $(1-\alpha)$ .

There exists some productivity  $\hat{\theta}$  for which the firms' participation constraint starts to bind, i.e.  $\eta_1 > 0$ . The wage then is given by

$$w^{RTM} = (\hat{\pi}^F)^{-\frac{\alpha}{1-\alpha}} (\theta\alpha)(1-\alpha)^{\frac{\alpha}{1-\alpha}}. \quad (\text{A.12})$$

Employment in the right-to-manage case is given by

$$l^{RTM} = \left( \frac{w^{RTM}}{\alpha\theta^{1-\alpha}} \right)^{-1/\alpha} = \left( \frac{b}{(1-\alpha)\alpha\theta^{1-\alpha}} \right)^{-1/\alpha} < \hat{l} \quad (\text{A.13})$$

implying underemployment in those firms that produce at home (compared to the situation of competitive labor markets).

With the wage given by (A.12) we get that

$$\begin{aligned}
w^{RTM} - b &= (\hat{\pi}^F)^{-\frac{\alpha}{1-\alpha}} (\theta\alpha)(1-\alpha)^{\frac{\alpha}{1-\alpha}} - b, \\
\Leftrightarrow w^{RTM} - b &= (\theta\alpha)(1-\alpha)^{\frac{\alpha}{1-\alpha}} \left( (\hat{\pi}^F)^{-\frac{\alpha}{1-\alpha}} - b(\theta\alpha)^{-1}(1-\alpha)^{-\frac{\alpha}{1-\alpha}} \right), \\
\Leftrightarrow w^{RTM} - b &= (\theta\alpha)(1-\alpha)^{\frac{\alpha}{1-\alpha}} \left( (\hat{\pi}^F)^{-\frac{\alpha}{1-\alpha}} - (\hat{\pi})^{-\frac{\alpha}{1-\alpha}} \right).
\end{aligned} \tag{A.14}$$

Thus, for all  $\theta \in [\hat{\theta}, \hat{\theta}]$ , the 'limit' wage will exceed the opportunity costs  $b$  and the participation constraint of workers does not bind.

For productivities that exceed  $\hat{\theta}$ , both the firms and the workers participation constraints bind. This results in a contradiction which implies that all those firms de-locate (or alternatively are forced to de-locate since no worker will want to work there for a wage smaller than  $b$ ).

In this framework in which home and foreign workers are perfect substitutes, unionization affects the intensive margin, i.e. employment of home firms is lower than under competitive labor. However, the extensive margin ( $\theta = \hat{\theta}$ ) is the same as under competitive labor markets and is thus not affected by unionization.

### A.3 Incentive compatibility

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

$$\Delta(\theta, \theta') := \pi(\theta, \theta') - \hat{\pi}^F(\theta) = (\theta l(\theta'))^{1-\alpha} - w(\theta') l(\theta') - \hat{\pi}^F(\theta). \tag{A.15}$$

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 (see section 2.2.2). The quasi-rent can be written as

$$\Delta(\theta, \theta') := \pi(\theta, \theta') - \hat{\pi}^F(\theta) = (\theta \hat{l}(\theta'))^{1-\alpha} - (\theta' \hat{l}(\theta'))^{1-\alpha} + \hat{\pi}^F(\theta') - \hat{\pi}^F(\theta). \tag{A.16}$$

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 firms 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 for this case a more attractive contract.

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

$$\frac{d\Delta(\theta, \theta')}{d\theta'} = (1-\alpha)(\theta l(\theta'))^{-\alpha} \theta \frac{dl(\theta')}{d\theta'} - w(\theta') \frac{dl(\theta')}{d\theta'} - \frac{dw(\theta')}{d\theta'} l(\theta') = 0, \quad (\text{A.17})$$

which gives  $\theta'$  as a function of  $\theta$  where this relation  $\theta'(\theta)$  is shaped by the form of the contract. Let us consider contracts only such that telling the truth is optimal. Thus, we only consider contracts such that  $\theta'(\theta) = \theta$ . Eq. (A.17) restricts then the form of the wage-employment contract. Differentiating this with respect to  $\theta$  (under truthtelling), we find that

$$soc + (1-\alpha)^2(\theta l(\theta'))^{-\alpha} \frac{dl(\theta')}{d\theta'} = 0, \quad (\text{A.18})$$

where *soc* denotes the second-order condition for the problem. With the optimal  $\theta'$  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

$$\frac{d\Delta}{d\theta} = (1-\alpha)(\theta l)^{-\alpha} l - (1-\alpha)(\theta \hat{l}^F)^{-\alpha} \hat{l}^F, \quad (\text{A.19})$$

where we used the first-order condition (A.17).  $\Delta$  paths that obey this 'slope' 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.4 Equilibrium derivation under information asymmetry

As stated in section 3, finding the equilibrium under countervailing incentives is tricky, because without knowing the equilibrium path of the quasi-rent (which is in standard problems unambiguously determined by the incentive compatibility constraint), it is ad-hoc unclear where (and if) the participation constraint is binding.<sup>25</sup> In finding the equilibrium, we rely on an approach suggested by Maggi and Rodriguez-Clare (1995). The idea here is very simple.

First, assume that the participation constraint was binding over the complete support of  $\theta$ . In our case, this implies that

$$\Delta = 0 \Rightarrow \frac{d\Delta}{d\theta} = 0 \Rightarrow \bar{l}^{IAS} = \hat{l}^F. \quad (\text{A.20})$$

Over any binding interval, equilibrium contract employment is identical to (equilibrium) employment when the firm de-locates production. Using this the resulting 'intertypal' shadow value (over a binding interval) is given by

$$\bar{\lambda}^{IAS}(\theta) = -g(\theta) \frac{b^F - b}{(1 - \alpha)\theta^{-1}b^F} = g(\theta)\theta \frac{b - b^F}{(1 - \alpha)b^F} > 0, \quad (\text{A.21})$$

where we used the fact that over the binding interval it is true that  $(1 - \alpha)(\theta\hat{l}^F)^{-\alpha}\theta = b^F$  (by the optimality condition under de-location). Note that in general along an optimal employment path it must be true that (rewriting (28))

$$l^{IAS} = \left( \frac{g(\theta)(1 - \alpha)\theta^{1-\alpha} + \lambda^{IAS}(1 - \alpha)^2\theta^{-\alpha}}{g(\theta)b} \right)^{\frac{1}{\alpha}}, \quad (\text{A.22})$$

which implies that equilibrium employment is increasing in  $\lambda^{IAS}$ .

This and the fact that  $\frac{d^2\Delta}{d\theta dl} > 0$  have important implications for the evolution of information rents for different  $\lambda^{IAS}$  paths.

1. All  $\lambda^{IAS}$  paths which are characterized by  $\lambda^{IAS} > \bar{\lambda}^{IAS}$  imply that employment is larger than  $\bar{l}^{IAS}(=\hat{l}^F)$  and vice versa.
2. Along the  $\bar{\lambda}^{IAS}$  path, the information rent path is flat (i.e.  $d\Delta/d\theta = 0$ ). With larger employment than associated with  $\bar{\lambda}^{IAS}$  path,  $d\Delta/d\theta$  increases, i.e. is positive:  $d\Delta/d\theta > 0$ .

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<sup>25</sup>In standard problems without countervailing incentives, this constraint is only binding at one corner of the support of  $\theta$ .

3.  $\lambda^{IAS}$  paths above (below)  $\bar{\lambda}^{IAS}$  imply that the information rent  $\Delta$  is increasing (decreasing), i.e.  $d\Delta/d\theta > (<)0$ .

Second, in order to derive the equilibrium  $\lambda^{IAS}$  path (i.e. the path that does not contradict the first-order conditions for an optimum), we first of all consider the hypothetical situation in which the participation constraint was not binding except for the lowest productivity type. We focus on a situation in which  $d\Delta/d\theta > 0$ . From (29), we solve for the associated  $\lambda^{IAS}$  path which is given by

$$\begin{aligned}\lambda^{IAS}(\bar{\theta}) - \lambda^{IAS}(\theta) &= 1 - G(\theta), \\ \Leftrightarrow^1 \lambda^{IAS}(\theta) &= G(\theta) - 1 (< 0).\end{aligned}\tag{A.23}$$

$G(\cdot)$  denotes the distribution function associated with the density function  $g(\theta)$ . Modification <sup>1</sup> follows from the assumption that the participation constraint is not binding at  $\bar{\theta}$ . This  $\lambda^{IAS}$  path is strictly smaller than  $\bar{\lambda}^{IAS}$  which implies that it is associated with lower employment than  $\bar{l}^{IAS}$ . This, however, implies  $d\Delta/d\theta < 0$  which contradicts the assumed information rent path. This path hence cannot be (part of) the equilibrium path.

Alternatively, consider the hypothetical situation in which the participation constraint was not binding except for the highest productivity type. We focus on a situation in which  $d\Delta/d\theta < 0$ . From (29), we solve for the associated  $\lambda^{IAS}$  path which is given by

$$\begin{aligned}\lambda^{IAS}(\theta) - \lambda^{IAS}(1) &= G(\theta) - G(1), \\ \Leftrightarrow^2 \lambda^{IAS}(\theta) &= G(\theta) (> 0),\end{aligned}\tag{A.24}$$

where <sup>2</sup> follows from the assumption that the participation constraint is not binding at  $\theta = 1$ . With  $\lambda^{IAS}(1) < \bar{\lambda}^{IAS}$ ,  $\lambda^{IAS}$  will be smaller than  $\bar{\lambda}^{IAS}$  at least for an interval. This again implies smaller associated employment than  $\bar{l}^{IAS}$  and hence  $d\Delta/d\theta < 0$ . Thus, this can be (part of) the equilibrium path.

Having derived possible values for the  $\lambda^{IAS}$  path (namely either  $G(\theta)$  or  $\bar{\lambda}^{IAS}$ ), we have to determine the form of the path (i.e. over which productivity interval which value will be followed). To get some more structure, let us impose the following assumption:

**Assumption A.1** *Over the support of  $\theta$  we focus on situations in which*

$$\frac{d\bar{\lambda}^{IAS}}{d\theta} = \frac{d(g(\theta)\theta)}{d\theta} \frac{b-b^F}{(1-\alpha)b^F} \leq (\geq) g(\theta) = \frac{d\lambda^{IAS}}{d\theta}.$$

Using this assumption we can prove that

**Lemma A.1** *The intercept between  $\bar{\lambda}^{IAS}(\theta)$  and  $\lambda^{IAS}(\theta)$  exists and is unique or does not exist over the support of  $\theta$ . Denoting this intercept by  $\check{\theta}$  a necessary condition for  $\check{\theta} > 1$  is that  $\frac{d(g(\theta)\theta)}{d\theta} \frac{b-b^F}{(1-\alpha)b^F} \leq g(\theta)$ . Moreover, with  $\check{\theta} \in [1, \bar{\theta}]$ , we have that  $\bar{\lambda}^{IAS}(\theta) > (<) \lambda^{IAS}(\theta)$  if  $\theta < (>) \check{\theta}$ .*

**Proof A.1** *At  $\theta = 1$ , we have  $\bar{\lambda}^{IAS}(1) > \lambda^{IAS}(1) = 0$ . Combining this with assumption A.1 proves the lemma.*

Using assumption A.1 we eventually can derive possible equilibrium paths for  $\lambda^{IAS}$ .  $G(\theta)$  is the equilibrium path if it is strictly smaller than  $\bar{\lambda}^{IAS}$ . With (interior) continuity of  $\lambda^{IAS}$  this is the only path that is in accordance with the first-order as well as with the transversality conditions. With an intercept, i.e.  $G(\check{\theta}) = \bar{\lambda}^{IAS}(\check{\theta})$ , the only equilibrium path which does not contradict first-order and transversality conditions is that it is  $G(\theta)$  for low productivities and  $\bar{\lambda}^{IAS}$  for larger ones.

Formally, we then have the path of  $\lambda$  (which determines the equilibrium paths of  $l$  and  $\Delta$ ) as given by

$$\lambda^{IAS}(\theta) = G(\theta) \quad \check{\theta} \notin [1, \bar{\theta}], \quad (\text{A.25})$$

$$\lambda^{IAS}(\theta) = \begin{cases} G(\theta) & \theta \in [1, \check{\theta}) \\ g(\theta)\theta \frac{b-b^F}{(1-\alpha)b^F} & \theta \in [\check{\theta}, \bar{\theta}]. \end{cases} \quad (\text{A.26})$$

#### A.5 $w^{IAS}$ over the binding interval and $w^{IS}$

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

$$\begin{aligned} w^{IAS} &= \frac{b^F \hat{l}^F + K}{\hat{l}^F}, \\ \Leftrightarrow w^{IAS} &= \frac{b^F \hat{l}^F + K - (\theta \hat{l}^F)^\alpha}{\hat{l}^F} + \frac{(\theta \hat{l}^F)^\alpha}{\hat{l}^F}, \\ \Leftrightarrow w^{IAS} &= \frac{\hat{\pi} - \hat{\pi}^F}{\hat{l}^F} + \frac{(\theta \hat{l}^F)^\alpha}{\hat{l}^F} - \frac{\hat{\pi}}{\hat{l}^F}, \\ \Leftrightarrow w^{IAS} &= \frac{\hat{\pi} - \hat{\pi}^F}{\hat{l}^F} + \frac{(\theta \hat{l}^F)^\alpha}{\hat{l}^F} - \frac{\hat{\pi}}{\hat{l}^F} + w^{IS} - \frac{\hat{\pi} - \hat{\pi}^F}{\hat{l}} - b, \\ \Leftrightarrow w^{IAS} &= w^{IS} + \frac{\hat{\pi} - \hat{\pi}^F}{\hat{l}^F} - \frac{\hat{\pi} - \hat{\pi}^F}{\hat{l}} + \frac{(\theta \hat{l}^F)^\alpha - b \hat{l}^F - \hat{\pi}}{\hat{l}^F}, \end{aligned} \quad (\text{A.27})$$

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

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