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**Working Paper**

## Multinational firms and heterogeneous labor

Kiel Working Paper, No. 1454

**Provided in Cooperation with:**

Kiel Institute for the World Economy – Leibniz Center for Research on Global Economic Challenges

*Suggested Citation:* Larch, Mario; Lechthaler, Wolfgang (2008) : Multinational firms and heterogeneous labor, Kiel Working Paper, No. 1454, Kiel Institute for the World Economy (IfW), Kiel

This Version is available at:

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## **Working Papers**

**Kiel Institute  
for the World Economy**



### **Multinational Firms and Heterogeneous Labor**

by Mario Larch and  
Wolfgang Lechthaler

**No. 1454** | October 2008

**Web:** [www.ifw-kiel.de](http://www.ifw-kiel.de)

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## **Multinational Firms and Heterogeneous Labor**

Mario Larch and Wolfgang Lechthaler

Abstract:

In the presence of increasing specialization of workers it becomes more and more difficult for firms to find the most suitable workers. In such an environment a multinational corporation has an advantage because it can exchange workers between plants in different countries. In this way it can draw on a larger labor market pool, reducing the mismatch of its workforce. This paper analyzes the consequences of this advantage for production, employment and, most prominently, wages.

We are able to disentangle the effects of worker heterogeneity and firm heterogeneity on wages and show that the latter is important to explain why multinationals typically pay higher wages. Keywords: Monetary Persistence, Labor Market, Hiring and Firing Costs.

Keywords: Heterogeneous labor; Multinational firms; Intra-wage distribution; Heterogeneous firms

JEL classification: F23, F12, J41

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# 1 Introduction

The impact of globalization on labor-market outcomes, specifically on wages and employment levels, continues to be an important concern of scholars and policy makers alike (e.g., see the volumes of Abowd and Freeman, 1991; and Feenstra, 2000). The empirical literature on the effects of multinational enterprises (MNEs) on wages and productivity is quite big. Typically, it is found that MNEs are more productive and pay higher wages.

There are basically two possible explanations for this: a) MNEs employ the same workers as national firms but have a better, more efficient production technology or b) MNEs use the same technology but get the better workers. We refer to the first explanation as firm heterogeneity and to the second one as worker heterogeneity. Recently, the literature on MNEs focussed on productivity differences. However, the effects of worker heterogeneity in the presence of foreign owned plants have been neglected so far.

This paper tries to close this gap. Introducing heterogeneous workers leads to a new, theoretically not investigated advantage for a MNE: A MNE may exchange workers between its plants in different countries. Hence a MNE can draw on a bigger pool of workers than a typical national firm. In this way it can pick the best-fitting workers from various countries and move them to the production site where they are most productive. As a consequence, mismatch of its workforce is reduced. Empirically, the importance of MNEs for the international migration of high-skilled workers was established by Miller and Cheng (1976), Salt (1992) and Tzeng (1995). However, theoretically the international exchange of skilled workers by MNEs was not investigated so far.

To model the heterogeneity among workers we use the approach of Amiti and Pissarides (2005) and adapt it to a market with both, national and multinational firms. All firms and workers are lined up along a "skills-circle" and the output of a firm depends on the distance of its own location on the circle to the location of its workers. The farther the distance, the higher the mismatch and the lower production. Firms compete for the workers by posting a wage per efficiency unit and workers

choose the firm offering her the highest effective wage. We assume that there are two countries. The MNE having branches in both countries can move workers from one branch to the other and thus reduce its mismatch.

We analyze the consequences of this advantage for production, prices, employment and most notably, the wage structure.<sup>1</sup> We find that the MNE, using the same production technology as a national firm, offers *lower* wages. Thus worker heterogeneity does not explain why MNEs pay higher wages. However, we also show that only a small degree of firm heterogeneity (i.e. lower marginal costs for MNEs) is sufficient to explain the stylized fact that MNEs pay higher wages than comparable national firms. Hence, we are able to disentangle the effect of firm heterogeneity and worker heterogeneity on wages, which has not been done thus far.

After reviewing the relevant literature in Section 2, we begin by formulating a benchmark model where there are no costs associated with the acquisition of foreign workers in Section 3. The main results are presented in Section 4. We proceed by assuming recruitment costs, depending on the distance of the plants, and movement costs, depending on the number of workers hired abroad in Section 5. Both extended versions of the model include the national firms and the MNE of the benchmark model as special cases. Conclusions are drawn in Section 6.

## 2 Literature

The empirical results concerning the effect of foreign ownership are quite conclusive, establishing the fact that MNEs pay higher wages on average in their foreign subsidiaries than domestically-owned firms. This result was obtained with firm-level data (Aitken, Harrison, and Lipsey, 1996; Dobbelaere, 2004; Doms and Jensen, 1998; Feliciano and Lipsey, 2006; Girma, Greenaway, and Wakelin, 2001; Globerman, Ries, and Vertinsky, 1994; Howenstine and Zeile, 1994; Lipsey and Sjöholm, 2004; Muendler and Becker, 2006), as well as with matched employer-employee data

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<sup>1</sup>To get clear-cut results, we abstract from other differences between national firms and MNEs, as for example scale economies, internalization advantages, the economization on transport costs, or productivity advantages. For an overview see Markusen, (2002), Barba Navaretti, Venables, Barry, Ekholm, Falzoni, Haaland, Midelfart, and Turrini (2004), and Helpman (2006).

(Becker and Muendler, 2007; Heyman, Sjöholm, and Tingvall, 2004; Martins, 2004).

While all the empirical contributions show that foreign owned firms pay higher wages, it is less clear why they pay higher wages. One reason investigated and empirical inferred is the higher average quality of workers in foreign-owned firms. Other studies focus on productivity advantages in foreign-owned firms (see Lipsey (2002) for a survey).

Hence, given these empirical facts, one may ask whether wage differences are due to 1) productivity differences of workers, or due to 2) firm heterogeneity resulting from other characteristics distinguishing foreign-owned firms from domestically-owned firms and leading to lower marginal costs.

There are only a few theoretical papers that consider heterogenous workers in the presence of heterogenous firms. Hamilton, Thisse and Zenou (2000) investigate the effect of worker heterogeneity on the equilibrium wage with heterogeneous firms in a closed economy. They find that the structure of information is critical for wage determination. When firms can observe the workers' skills, wages result from a bargaining process based on the alternative jobs a worker can take. Under asymmetric information, all workers within the same labor pool are given the same gross wage set noncooperatively by oligopolistic firms. As a consequence, in the latter case wages rise as job matches improve, whereas in the former case wages increase with the degree of job mismatch. Davidson, Matusz and Shevchenko (2008) model heterogenous workers and heterogenous firms in an open economy and show that exporting firms are bigger and offer higher wages. Further, they show that in export-oriented (import-competing) markets openness can generate within-firm productivity losses (gains) for the weakest firms. Thus, these models are similar in spirit but do not consider MNEs, which is at the heart of our analysis.

Zhao (1998) studies the impact of foreign direct investment (FDI) on wages and employment in the presence of trade unions. In his framework, FDI always reduces the negotiated wage and reduces union employment and the competitive wage if the union cares more about employment than wages or is equally concerned about employment and wages. These effects are weaker, if labor-management bargaining is firm-specific and unionization is industry-wide. Zhao (1998) therefore analyzes

imperfect labor markets in the presence of FDI, but sticks to the assumptions of homogenous labor and identical firms.

Yeaple (2005) assumes heterogeneous workers and homogeneous firms that may export. However, in his framework firms choose from competing technologies, which leads together with international trade costs and the availability of workers of heterogeneous skill to firm heterogeneity. The model predicts that exporting firms are larger, employ more advanced technologies, pay higher wages, and appear to be more productive than firms that do not export.

Malchow-Møller, Markusen, and Schjerning (2006) develop a heterogeneous-firm model à la Melitz (2003) in which ex-ante identical workers learn from their employers in proportion to the firm's productivity. They allow foreign-owned firms which have, on average, higher productivity in equilibrium due to entry costs, and therefore have higher wage growth and, with some exceptions, pay higher average wages. In their empirical study they find, that controlling for firm size, these effects are much smaller.

The papers by Yeaple (2005) and Malchow-Møller, Markusen, and Schjerning (2006) both introduce firm heterogeneity in their models, leading the exporting firms/MNEs to be the more productive ones. This then leads exporting firms/MNEs to pay higher wages, making it hard to disentangle the effects of firm heterogeneity and worker heterogeneity.

In contrast, we want to study how worker heterogeneity effects equilibrium wages paid by MNEs as compared to national firms, abstracting from all other differences between national firms and the MNEs. We introduce MNEs that have plants in both countries, but produce with the same technology as firms that operate only in a single market. Specifically, we do not assume that MNEs can take advantage of economies of scale resulting from fixed costs. Rather both plants have to incur the same amount of fixed costs as local national firms. However, MNEs can search workers in the labor markets of both countries via their plant in the other country, whereas national firms are restricted to their home labor market. Using workers from both countries leads to international labor migration of workers. This high-skilled labor migration by MNEs was found to be an important channel for international

migration of high-skilled workers (see for example Miller and Cheng, 1976; Salt, 1992; Tzeng, 1995), but not accounted for in theoretical works.

### **3 A Model of Multinational Firms and Heterogeneous Labor**

The main goal of our model is to analyze how a major advantage of the MNE affects production, wages and the wage distribution at the firm level. The advantage we are talking about is the fact that the MNE having a plant in more than one country can exchange workers between the plants. In contrast, national firms having a plant in one single country, can only hire workers from that country. Additional acquisition of workers from abroad is assumed to be prohibitively costly for a national firm. For the MNE, which has plants in more than one country, the situation is different. If the branch in country  $A$  wants to recruit workers from country  $B$ , it can draw on the expertise of the plant in country  $B$ .

In order to create an incentive for a firm to employ workers from abroad, we have to allow for heterogeneity among workers. With heterogeneous workers, moving workers between plants opens the possibility to transfer the best-fitting workers from various countries to the production site where they are most productive. As a result, the mismatch between workers and the firm they are employed in is reduced. To model the heterogeneity of workers we use the approach of Amiti and Pissarides (2005).

The kind of heterogeneity that we model is not a heterogeneity between skilled workers and unskilled workers. In our model all workers have the same "level" of skills but the heterogeneity stems from the fact that they are "specialized" in a certain skill, denoted by the worker's position on a skills circle. The firms are also located on this skills circle, their position indicating the kind of skills that they need for production. The quality of a match is then given by the distance between the worker and the firm. The higher this distance, the bigger the discrepancy between the skill-needs of the firm and the skills the workers can offer and, thus, the lower the productivity of the worker.



The circumference of the circle is  $2H$ . As in Amiti and Pissarides (2005), we assume that workers are uniformly distributed along the circle, while firms are free to choose their position. Since, for a given labor force, the circumference of the circle tells us how far away from each other the workers are located,  $H$  can also be interpreted as a measure of heterogeneity. The higher  $H$  is, the higher is the heterogeneity. For  $H = 0$  all workers are homogeneous.

In our model there are two countries, home and abroad. Both countries have a large number of national firms, which only serve their home market. They are monopolistic competitors with free entry to the market, so that their profits are driven down to zero. In both countries, workers are distributed along a circle, as described above. Furthermore, we assume that both countries are identical, which also applies to the skills circle, meaning that a worker in country  $A$  at a certain position has exactly the same skills as a worker from country  $B$  who sits at the same position of the skills circle in her country.

For simplicity we assume that there is only one MNE having a plant in each country.<sup>2</sup> It produces in both countries and sells the output where it is produced. However, the MNE has one big advantage over the national firms: It can recruit workers in both countries and move them from one country to the other in order to use them in production there. Due to the heterogeneity on the labor market this allows the MNE to achieve better match-quality than the national firms which cannot recruit workers from abroad.<sup>3</sup>

For the benchmark model we assume that the MNE can move workers freely from one country to the other, without any costs or restrictions, and that it has the same knowledge about the labor market as a national firm. Both these assumptions are extreme and not very realistic but they serve well to work out the effects of high-skilled labor movement between plants of the MNE. Later on we will extend the

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<sup>2</sup>The main focus of our analysis is the comparison of one MNE with one national firm. Increasing the number of MNEs would not affect the behavior of individual firms. Hence, the number of MNEs is of no relevance to our results, while allowing for a larger number of MNEs would complicate matters considerably, mainly due to the problem of how the firms should be aligned along the circle.

<sup>3</sup>As in Amiti and Pissarides (2005) it is assumed that workers do not move on their own from one country to the other. Only when they are actively recruited by a firm from abroad will they move.

model by introducing costs for moving workers from one country to the other and costs for recruiting workers.

### 3.1 National Firms

#### 3.1.1 Profit Maximization

Every national firm  $i$  faces the downward sloping demand curve:

$$x_i = p_i^{-\sigma}, \quad (1)$$

where  $\sigma$  is the price-elasticity of demand.<sup>4</sup> The inverted production function is described by:

$$L_i^E(w_i) = \alpha + \beta x_i(w_i). \quad (2)$$

The parameters  $\alpha$  and  $\beta$  denote fixed and marginal costs measured in labor units, respectively.  $L_i^E$  is effective labor input<sup>5</sup> which depends positively on  $w_i$ , the wage posted by firm  $i$ . The profit function of a firm is given by:

$$\pi_i = p_i x_i(w_i) - w_i L_i^E(w_i). \quad (3)$$

The firm maximizes profits under the constraints (1) and (2). The first order condition (FOC) is found by substituting out price and quantity in the profit function (by using the production function (2) and demand (1)) and taking the derivative with respect to the wage:

$$\frac{\partial \pi_i}{\partial w_i} = \frac{\sigma - 1}{\sigma \beta} \left( \frac{L_i^E - \alpha}{\beta} \right)^{-1/\sigma} \frac{\partial L_i^E}{\partial w_i} - L_i^E - w_i \frac{\partial L_i^E}{\partial w_i} = 0. \quad (4)$$

The derivative  $\partial L_i^E / \partial w_i$  will be determined in the section describing the labor market.

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<sup>4</sup>This demand equation could be derived from a utility function such as  $U = \sum_i (\sigma / (\sigma - 1)) x_i^{(\sigma-1)/\sigma} + Y$ , where  $Y$  is a good from another industry. For an application to trade and MNEs, see Ludema (2002).

<sup>5</sup>Described in more detail further below.

### 3.1.2 Skill Differentiation and Supply of Labor

The time structure is as follows. First, the MNE chooses the location of both its branches. Next, the national firms choose their strategy, knowing how much space on the skills-circle the MNE will occupy but not knowing where its branches will be located. Furthermore, we assume that the number of national firms is big enough so that the probability of being a neighbor to the MNE is close to zero.<sup>6</sup> These assumptions allow us to model the national firms in exactly the same way as in Amiti and Pissarides (2005), i.e. in a third step Cournot-Nash competition leads to symmetric locations of the national firms along that part of the circle which is not occupied by the MNE.<sup>7</sup>

Given this symmetric structure it is clear that the distance between any two *national* firms is  $(2H - 2H_m)/N$ , where  $N$  is the number of national firms and  $H_m$  is the part of the circle which is occupied by one plant of the MNE. The worst case of mismatch of workers is half this distance, which we shall define as  $m$ .

Now we are in a position to analyze the wage-posting of national firms. The actual wage of a worker is the product of two things: The wage per efficiency unit  $w_i$  posted by the firm, which is equal for all workers employed by that firm, and the productivity of the worker. The productivity of a worker for a specific firm is  $1 - d_i$ , where  $d_i$  is the distance between the firm and the worker on the skills circle. Thus, the wage that the worker receives, is given by  $w_i(1 - d_i)$ .

A worker always prefers to work for the employer which is offering her the highest wage. Hence, a worker located at some distance  $d_i$  from firm  $i$  will choose to work for this firm whenever:

$$w_i(1 - d_i) \geq w_n(1 - (2m - d_i)), \quad (5)$$

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<sup>6</sup>This is in line with Amiti and Pissarides (2005) who also assume a very large number of firms.

<sup>7</sup>If we did not use these assumptions, the national firm neighboring the MNE would behave different than the other national firms, which implies that the neighbor to this neighbor would behave different as well, and so on. This would result in a huge degree of heterogeneity among national firms without buying any further insights. Cosnita (2005) considers these interaction effects in a setting where two out of three or four firms merge to a two-plant firm in a homogenous good Cournot competition environment. It is shown that a lot of different location patterns are subgame perfect Nash equilibria.

i.e. when the wage she is earning in firm  $i$  is larger than the wage offered by the neighboring firm. The neighboring firm is  $2m$  away from firm  $i$  and so the distance of the worker to this firm is  $(2m - d_i)$ , which implies a productivity of  $(1 - (2m - d_i))$ . Firm  $i$  gets all the workers for which the above equation is fulfilled and thus we can determine the maximum distance of a worker by rearranging it to:<sup>8</sup>

$$d_i = \frac{w_i - w_n(1 - 2m)}{w_i + w_n}, \quad (6)$$

which is valid in both directions. Since workers are assumed to be uniformly distributed along the circle this brings the firm a total of  $L_s d_i / H$  workers with average mismatch  $d_i / 2$  and average productivity  $1 - d_i / 2$ . The total number of effective units of labor supplied to the firm is therefore:

$$L_i^E = \frac{d_i}{H} \left(1 - \frac{d_i}{2}\right) L_s = \frac{L_s}{2H} \frac{(w_i - w_n + 2mw_n)(w_i + 3w_n - 2mw_n)}{(w_i + w_n)^2}. \quad (7)$$

Symmetry among national firms implies  $w_i = w_n$ . From the equation above we can derive the effect of wage changes on effective labor supply:<sup>9</sup>

$$\frac{\partial L_i^E}{\partial w_n} = \frac{L_s(1 - 2m + m^2)}{2Hw_n}. \quad (8)$$

## 3.2 Multinational Firms

As motivated above, in the presence of a heterogenous workforce the MNE has an incentive to exchange workers between the plants. Therefore, part of the workers recruited in country  $A$  will actually be employed in  $B$  and vice versa. In this section we assume, that the MNE underlies no restrictions whatsoever, concerning the movement of workers. Therefore, it can locate the plant in one country independently of the other country's plant, with the only restriction that their shares on the skills circle shall not overlap. Then the plant in country  $A$  will recruit workers

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<sup>8</sup>The reader should be careful to not confuse the variables  $m$  and  $d_i$ . While  $m$  denotes half the distance between two national firms and is predetermined by the market,  $d_i$  is the distance of a specific worker to the firm, which can be influenced by the posted wage.

<sup>9</sup>For a derivation see Appendix A.

up to a distance  $d_m$  from the home country and up to a distance  $d_m^*$  from abroad.<sup>10</sup> Likewise for the other plant and thus the movement of workers can be illustrated as in Figure 1. In fact, from the point of view of the workers it is as if the MNE has *two* plants not only one in each country, because it is recruiting from two spots on the skills circle. However, workers in one interval are only recruited for migration and production in the other country.

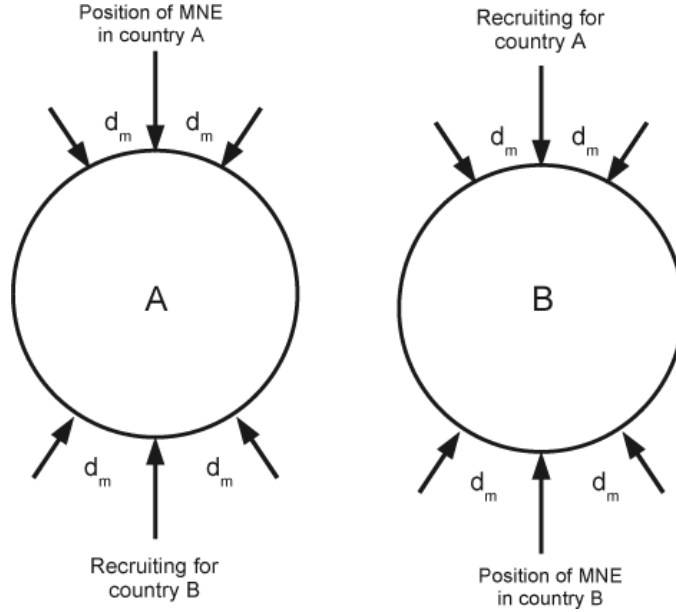


Figure 1: Recruiting of the Multinational Firm on the Skills Circle

In the figure we show the very extreme case where both plants of the MNE are situated at the exact opposite of each other on the skills circle. This is only to illustrate that the recruiting underlies no restrictions in the benchmark and therefore the MNE can choose its position wherever it likes. In the extended model with recruitment and movement costs, this will no longer be the case and the plants are located next to each other.

### 3.2.1 Profit Maximization

In this section we illustrate the situation of one plant of the MNE. The decisions of the other plant are analogous. The MNE faces the same demand function as the

<sup>10</sup>Due to symmetry and lack of movement costs, the two distances will be equal to each other in the benchmark model, i.e.  $d_m = d_m^*$ .

national firms given in Equation (1). However, as every plant of the MNE employs workers from both countries, the production function changes to:

$$x_m = \frac{L_m^E + L_m^{E*} - \alpha}{\beta}, \quad (9)$$

where  $L_m^E$  denotes the labor input originating from the same country as the plant is located in, while  $L_m^{E*}$  are the workers coming from the foreign country. In a similar manner the profit function modifies to:

$$\pi_m = p_m x_m - w_m L_m^E - w_m^* L_m^{E*}. \quad (10)$$

The plant of the MNE has to choose two wages, one for the workers of the home country and one for the workers of the foreign country, it also has two FOC's:

$$\begin{aligned} \frac{\partial \pi_m}{\partial w_m} &= \frac{\sigma - 1}{\sigma \beta} \left( \frac{L_m^E + L_m^{E*} - \alpha}{\beta} \right)^{-1/\sigma} \frac{\partial L_m^E}{\partial w_m} - L_m^E - w_m \frac{\partial L_m^E}{\partial w_m} = 0. \\ \frac{\partial \pi_m}{\partial w_m^*} &= \frac{\sigma - 1}{\sigma \beta} \left( \frac{L_m^E + L_m^{E*} - \alpha}{\beta} \right)^{-1/\sigma} \frac{\partial L_m^{E*}}{\partial w_m^*} - L_m^{E*} - w_m^* \frac{\partial L_m^{E*}}{\partial w_m^*} = 0. \end{aligned} \quad (11)$$

### 3.2.2 Supply of Labor

The problem of the MNE considering wage-posting is very similar to the decision of a national firm described in Equation (6). The main difference is that the distance between the MNE and its neighboring firms is no longer given by  $2m$  but by  $m + m_m$  where  $m_m$  is the worst mismatch for the MNE.<sup>11</sup> Then a worker with distance  $d_m$  to the MNE will decide to work for the MNE whenever:

$$w_m(1 - d_m) \geq w_n(1 - (m + m_m - d_m)), \quad (12)$$

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<sup>11</sup>Or put differently, the maximal distance of a national firm to one of its employees is  $m$ , while the maximal distance of the MNE to one of its employees is  $m_m$ . Thus, the distance between the MNE and its neighboring national firm is  $m + m_m$ .

which implies that the distance of the worker farthest away but still choosing the MNE is:<sup>12</sup>

$$d_m = \frac{w_m - w_n(1 - m - m_m)}{w_m + w_n}. \quad (13)$$

The effective labor-supply of the MNE is given by:

$$L_m^E = \frac{d_m}{H} \left(1 - \frac{d_m}{2}\right) L_s = \frac{L_s}{2H} \frac{(w_m - w_n + (m + m_m)w_n)(w_m + 3w_n - (m + m_m)w_n)}{(w_m + w_n)^2}. \quad (14)$$

From this equation we can derive the derivative of labor supply with respect to the wage:

$$\frac{\partial L_m^E}{\partial w_m} = \frac{L_s}{H} \frac{w_n^2(4 - 4(m + m_m) + (m + m_m)^2)}{(w_m + w_n)^3}. \quad (15)$$

This equation corresponds to Equation (8) for national firms, which is less complex due to  $w_i = w_n$  implied by symmetry, while it is not generally true that  $w_m = w_n$ .

### 3.3 The Equilibrium

So far we have described the decisions of the single firms. Now we investigate the equilibrium on the labor market, the number of national firms and the resulting mismatch.

To determine the equilibrium, we begin by setting labor supply equal to labor demand which both depend on mismatch. Labor supply was already derived further above, given by Equation (7). Labor demand can be found by using the zero-profit condition. First we set profits equal to zero for national firms and deduce the price a national firm will charge. From this we can derive quantities produced. Labor demand is then given by the amount of labor needed to produce this quantity:

$$L_i^D = \frac{\alpha\sigma}{\sigma - (\sigma - 1)(1 - m)^2}. \quad (16)$$

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<sup>12</sup>Of course in equilibrium the worst mismatch is equal to the farthest distance, or  $m_m = d_m$ .

Effective labor demand is upwards sloping in  $m$ , while labor supply is downwards sloping. Together the two determine equilibrium mismatch.

Given equilibrium mismatch, we can derive the optimal wage of a national firm and effective labor supply from Equations (4), (7) and (8). Finally, production and price follow from Equations (1) and (2). Combining Equations (4) and (8) as described in Appendix B, the equilibrium for the national firms is fully determined by the five equations:

$$x_i = p_i^{-\sigma}. \quad (17)$$

$$L_i^E = \frac{\alpha\sigma}{\sigma - (\sigma - 1)(1 - m)^2}. \quad (18)$$

$$L_i^E = \alpha + \beta x_i. \quad (19)$$

$$L_i^E = \frac{m}{H} \left(1 - \frac{m}{2}\right) L_s. \quad (20)$$

$$\frac{L_s(1 - 2m + m^2)}{2Hw_n} = \frac{L_i^E}{\frac{\sigma-1}{\sigma\beta} \left(\frac{L_i^E - \alpha}{\beta}\right)^{-1/\sigma} - w_n}. \quad (21)$$

The five equations are product demand, labor demand, the production technology, labor supply and finally the first order condition for profit maximization of national firms. Note, that the five equations above do not determine the number of national firms in the market. The number of national firms is found by using the definition of mismatch:

$$m = \frac{H - H_m}{N}, \quad (22)$$

where  $H_m$  is the labor recruited in one country by the MNE for both, domestic and foreign production.

In a similar manner as for the national firms, it is now possible to derive the wages  $w_m$  and  $w_m^*$  and the corresponding labor supply from the corresponding FOCs. Using the production function and the demand equation, the MNE's production quantity and the charged price can be determined.

We have eight endogenous variables for a single plant of the MNE ( $x_m, p_m, L_m^E, L_m^{E*},$



$d_m, d_m^*, w_m$  and  $w_m^*$ ) and the eight equations determining the equilibrium are:

$$x_m = p_m^{-\sigma}. \quad (23)$$

$$L_m^E + L_m^{E*} = \alpha + \beta x_m. \quad (24)$$

$$L_m^E = \frac{d_m}{H} \left(1 - \frac{d_m}{2}\right) L_s. \quad (25)$$

$$L_m^{E*} = \frac{d_m^*}{H^*} \left(1 - \frac{d_m^*}{2}\right) L_s^*. \quad (26)$$

$$d_m = \frac{w_m - w_n(1 - m - m_m)}{w_m + w_n}. \quad (27)$$

$$d_m^* = \frac{w_m^* - w_n^*(1 - m^* - m_m^*)}{w_m^* + w_n^*}. \quad (28)$$

$$\frac{L_s w_n^2 (4 - 4(m + m_m) + (m + m_m)^2)}{H (w_m + w_n)^3} = \frac{L_m^E}{\frac{\sigma-1}{\sigma\beta} \left(\frac{L_m^E + L_m^{E*}}{\beta} - \alpha\right)^{-1/\sigma} - w_m}. \quad (29)$$

$$\frac{L_s^* w_n^{*2} (4 - 4(m^* + m_m^*) + (m^* + m_m^*)^2)}{H^* (w_m^* + w_n^*)^3} = \frac{L_m^{E*}}{\frac{\sigma-1}{\sigma\beta} \left(\frac{L_m^E + L_m^{E*}}{\beta} - \alpha\right)^{-1/\sigma} - w_m^*}. \quad (30)$$

## 4 Main Results

### 4.1 Homogeneous Firms

This section compares output, prices, employment and wages of national firms and the MNE if they use the same production technology. The results are stated in propositions if we derive them analytically and in form of results if we rely on numerical simulations. Table 1 summarizes results for the most important variables in our benchmark case.<sup>13</sup>

**Proposition 1 *Production:*** *Every plant of the MNE produces more than a national firm.*

*Proof:* See Appendix C.

<sup>13</sup>In line with Amiti and Pissardies (2005) we use the following parameter values:  $H = 1$ ,  $\alpha = 1/4$ ,  $\beta = 3/4$ ,  $L_s = L_s^* = 100$ . The only deviation from Amiti and Pissarides is  $\sigma = 6$ , which is more in line with the empirical literature (see for an overview of different approaches to estimate  $\sigma$  Anderson and van Wincoop (2004), pages 715-716.). Further below we show what happens when we allow for different values of  $\sigma$ .

	National Firms	MNE	Ratio
Output	1.4327404	1.5992759	1.1162356
Price	0.8084418	0.7937604	0.9818399
Employment	2.6668914	2.9094954	1.0909688
Wage per Efficiency Unit	0.8744725	0.8691337	0.9938949
Average Wage	0.8686422	0.8659728	0.9969269
St. Dev. of Wages	0.0033661	0.0018250	0.5421542

Table 1: Base Case.

The intuition is as follows. Given the advantage of being able to move workers from one country to the other, the MNE can produce the same amount of output in every plant as a national firm with fewer workers from *one* country. This improves the quality of the workforce (measured by mismatch) and thereby reduces marginal costs. It becomes efficient for the MNE to produce more than a national firm in every plant.

**Proposition 2 *Price:*** *The MNE charges a lower price for the produced good than a national firm.*

Given the demand equation and the fact that the MNE produces more, it immediately follows that the MNE charges a lower price.

**Result 1 *Employment:*** *Every plant of the MNE employs more workers than a national firm.*

Even though every employed worker is more efficient due to a better match, the output increase in every plant of the MNE is large enough to raise labor employment above the level of a national firm. In the numerical example (see Table 1), output is nearly 12% higher in a plant of the MNE than in a national firm, whereas the number of employed workers in the MNE plant exceeds labor employment of a national firm by about 9%. This is due to the increased efficiency of the employed workers. Hence output raises more than labor employment increases.

In order to get some feeling for the relationship of mismatch and employment levels, note that for symmetric countries employment levels are given by  $2m_m L_s/H$  for a plant of the MNE and by  $m L_s/H$  for a national firm. Hence, employment level differences only depend upon the relative magnitudes of  $m_m$  and  $m$ .

One plant of the MNE and the national firm would employ the same number of people, if  $m_m = m/2$ . If mismatch of the MNE in every country is lower/higher than half the magnitude of the mismatch in a national firm, than the employment level of the MNE will be lower/higher than for a national firm. Given our numerical examples using plausible parameter values, a mismatch lower than half seems huge. Hence, it is most likely that every plant of the MNE will employ more workers than a national firm.

**Proposition 3 *Wage per Efficiency Unit:*** *The MNE offers a lower wage per efficiency unit than a national firm.*

*Proof:* See Appendix D.

If the MNE posts the same wage as the national firms, it will attract twice as many workers. It gets the same number of workers as the national firms of country  $A$ . But at the same time it gets the same number from country  $B$  and moves them to country  $A$ . Thus, if it is efficient for the MNE to use more than twice as many workers as a national firm, it will post a higher wage than the national firms. Otherwise, its wage will be lower.

In Proposition 1 we stated that every plant of the MNE produces more than a national firm. However, the output does not double. Hence, in order to recruit only the needed amount of workers, the MNE will post a lower wage in every country than a national firm.

**Proposition 4 *Average Wage:*** *The average wage and mismatch is lower for the MNE than for a national firm.*

*Proof:* See Appendix E.

As the MNE offers a lower wage per efficiency unit, also mismatch is lower in equilibrium. However, there are two counteracting effects on the average wage. Of course, a wage decrease directly decreases the average wage. But at the same time a lower wage per efficiency units leads to a smaller share on the skills circle. This implies, that average productivity goes up. A higher average productivity raises the average

wage. However, this second effect can never dominate the direct effect of a decrease of the wage per efficiency unit. Thus, for the average wage of the MNE the same is true as for the wage per efficiency unit: The average wage of the MNE is lower.

**Proposition 5 *Standard Deviation of Wages:*** *The intra-firm wage dispersion is lower for a plant of the MNE than for a national firm.*

Given our assumptions that productivity is based on mismatch and that workers are uniformly distributed along the skills circle, wages in our model are also uniformly distributed. The standard deviation of a uniformly distributed variable is defined as:

$$dev = \frac{b - a}{\sqrt{12}} \quad (31)$$

where  $a$  and  $b$  are the minimum and the maximum of the distribution, respectively. The boundaries of the wage distribution are  $w_m$  (resp.  $w_n$ ) and  $w_m(1 - d_m)$  (resp.  $w_n(1 - m)$ ) and thus the standard deviation of wages in a national firm and the MNE are given by:

$$dev[w_n] = \frac{w_n m}{\sqrt{12}}, \quad dev[w_m] = \frac{w_m m_m}{\sqrt{12}}. \quad (32)$$

As already stated above, the MNE offers a lower wage and has a lower mismatch than a national firm, both factors tending to decrease wage dispersion. Hence, the advantage of the MNE to realize a more homogeneous workforce through migration leads to less dispersion of wages.

**Result 2 *Increasing Labor Heterogeneity:*** *An increase in labor heterogeneity aggravates the differences between the MNE and a national firm for all variables except the intra-firm wage distribution.*

Table 2 summarizes the effects of an increase in labor heterogeneity, showing the ratios of the values for the MNE and a national firm. Increasing labor heterogeneity means, that with the same wage per efficiency unit, less suitable workers are attracted. Hence, the advantage of the MNE to draw from two labor market pools becomes more important. This leads to a greater difference in the output level, the

	H=0.5	H=1.0	H=1.5
Output	1.0622862	1.1162356	1.1640010
Price	0.9899800	0.9818399	0.9750071
Employment	1.0494173	1.0909688	1.1267517
Wage per Efficiency Unit	0.9966447	0.9938949	0.9915686
Average Wage	0.9983164	0.9969269	0.9957436
St. Dev. of Wages	0.5229481	0.5421542	0.5586258

*Note:* Numbers give ratios of MNE to NE values.

Table 2: Base Case: Variation of Skill Differentiation  $H$ .

prices, employment levels, wages per efficiency unit and average wages. However, concerning the intra-firm wage distribution, national firms and the plants of the MNE become more equal. In both firms the standard deviation of wages rises, but in the MNE plants more so.

**Result 3 *Increasing Demand Elasticity:*** *An increase in the demand elasticity aggravates the differences between the MNE and a national firm for all variables except the intra-firm wage distribution.*

	$\sigma=3$	$\sigma=4$	$\sigma=5$	$\sigma=6$	$\sigma=7$	$\sigma=8$	$\sigma=9$	$\sigma=10$
Output	1.0329322	1.0566603	1.0848619	1.1162356	1.1495914	1.1839215	1.2184220	1.2524838
Price	0.9892576	0.9863162	0.9838414	0.9818399	0.9802818	0.9791171	0.9782884	0.9777387
Employment	1.0198002	1.0393064	1.0634503	1.0909688	1.1206979	1.1516452	1.1830125	1.2141886
Wage per Efficiency Unit	0.9964018	0.9954102	0.9945735	0.9938949	0.9933651	0.9929679	0.9926844	0.9924953
Average Wage	0.9981943	0.9976941	0.9972710	0.9969269	0.9966575	0.9964549	0.9963095	0.9962119
St. Dev. of Wages	0.5080654	0.5172681	0.5288398	0.5421542	0.5566311	0.5717734	0.5871790	0.6025382

*Note:* Numbers give ratios of MNE to NE values.

Table 3: Base Case: Variation of demand elasticity  $\sigma$ .

Table 3 reports the effects of an increase in the demand elasticity on the most important variables. As argued above in the explanation for the wage, higher wages lead to more attracted workers. This, in fact leads to more output of the MNE. In order to be able to sell the output, prices have to fall. The less price sensible consumers are, the more the MNE will sell, because it can still obtain comparable high prices for higher sales volumes.

Hence, if the elasticity of demand increases, the MNE will lower wages relatively more, in order to reduce hired workers and output, and maintain a comparable high price. This is the profit-maximizing strategy for the MNE.

Again, the standard deviation of wages develops in exactly the opposite direction. With increasing demand elasticity, fewer but more suitable workers will be hired, leading to a narrower distribution of wages within a plant of the MNE.

## 4.2 Heterogeneous Firms

In order to disentangle the effect of worker and firm heterogeneity, we assumed until now that both, national firms and MNEs, produce with the same technology. However, recently firm heterogeneity was reconsidered in international trade as one important channel in order to explain endogenous selection of different organizational forms. For an overview see Helpman (2006) and Bernard, Jensen, Redding, and Schott (2007).

In the already huge and still growing literature on firm heterogeneity, Helpman, Melitz, and Yeaple (2004) as well as Grossman, Helpman and Szeidl (2006) focus on the firms' choice between exports and (various forms of) FDI. Firms are heterogeneous with respect to their productivity as in Melitz (2003), and the decision to export or to go multinational therefore also depends on the productivity of the firms. Specifically, the most productive firms engage in FDI, whereas slightly less productive firms decide to serve the foreign market via exports. The least productive but still active firms sell their products only locally.

Without productivity differences, we find that the MNEs pay lower wages. Introducing firm productivity differences by assuming that the marginal costs for the national firms  $\beta_n$  are higher than the marginal costs  $\beta_m$  for the MNE, we find a similar result.

	$\beta_n/\beta_m=1$	$\beta_n/\beta_m=0.92$	$\beta_n/\beta_m=0.83$	$\beta_n/\beta_m=0.75$	$\beta_n/\beta_m=0.67$
Output	1.1162356	1.7873157	2.9258471	4.8764854	8.2254523
Price	0.9818399	0.9077504	0.8361639	0.7679192	0.7038391
Employment	1.0909688	1.5154202	2.1679774	3.1682275	4.6794608
Wage per Efficiency Unit	0.9938949	0.9967362	1.0011364	1.0079569	1.0184399
Average Wage	0.9969269	0.9983572	1.0005720	1.0040052	1.0092818
St. Dev. of Wages	0.5421542	0.7552371	1.0852205	1.5967184	2.3828748

*Note:* Numbers give ratios of MNE to NE values.

Table 4: Base Case: Productivity Differences between national firms and MNEs.

**Result 4 *Productivity Differences:*** *Productivity advantages of the MNE aggravate the differences between the MNE and a national firm for output, employment and prices. To the contrary, the differences between wages become smaller until the MNE even pays higher wages.*

Table 4 summarizes the results for various levels of productivity differences between

national and multinational firms. Specifically, we maintain the assumption that  $\beta_n = 3/4$  and vary  $\beta_m$ . The first column reproduces the case of identical productivities. As the productivity of the MNE relative to the national firm increases, implying a fall in marginal costs, relative output increases and prices fall. The firm is now able to produce more output with a given amount of labor. In order to sell it on the market, prices have to fall.

The employment level of every plant of the MNE compared to a national firm rises, which is the net-effect of three forces: (i) the level effect due to the increased output, leading to a higher employment level, (ii) the increasing mismatch, leading to lower efficiency of workers, and therefore an increasing amount of workers, (iii) the higher productivity level, leading to a lower employment level. The first two effects outweigh the last one, leading to a positive net-effect on employment.

Wages per efficiency unit also increase with increasing productivity. The reason is that in order to produce a higher quantity, more workers have to be hired. This can only be achieved by paying higher wages, which attracts more workers to the MNE. Observe, that eventually the productivity advantage of the MNE becomes large enough so that he pays higher wages. The behavior for average wages is similar, but less strong, as an increasing workforce leads to a lower average efficiency of workers. The intra-firm wage distribution also rises with increased productivity, which is again a direct result of the increasing heterogeneity of workers employed.

To sum up, adding productivity differences in our model leads to predictions that cope very well with empirical findings concerning, wages, output and employment.

## 5 Extensions

So far we have assumed that the MNE can move workers without any restrictions from one country to the other. However, as was for example stressed by Franko (1973), transferring its employees abroad can induce large costs. Besides a premium of 10 to 20 percent of base salary, there are numerous allowances for housing, costs of living, school, and moving (see for example Reynolds, 1972; Tzeng, 1995). At the same time, recruiting from a foreign country is likely to be more expensive than

hiring at home, even if the MNE can draw on the knowledge of the plant in that country. Therefore we will extend the benchmark model by introducing two different kinds of costs. Both extended models will include the MNE and the national firms of the previous sections as special cases. Specifically, if the costs introduced in this section are zero, then we are back to the case of the MNE in the benchmark model, while for national firms the costs are infinite. Thus, in our model MNE and national firms are equivalent with the only difference being the costs they face with respect to hiring workers from the other country.

## 5.1 Recruitment Costs

In this section we discuss a concept that we call recruitment costs. In our model one plant of the MNE is recruiting workers for the plant of the other country. However, since both plants are not located at exactly the same position, it is likely that screening those workers is costly. Moreover, the farther the distance of the plants on the skills circle (i.e. the more heterogeneous their skill-needs), the more expensive the screening process will be. In the benchmark model it played no roll at all where the two plants of the MNE situated themselves (as long as their shares of the circle did not overlap). Now we assume that the MNE has to pay an extra-cost which depends positively on the distance between the two plants, because it is more difficult to recruit workers that are far away on the circle.

### 5.1.1 The Model

With recruitment costs we have to distinguish two different cases. If recruitment costs are positive but small this will imply that the first order conditions of the benchmark model are still valid, but the MNE will now locate both plants as neighbors of each other to minimize the costs (see the left sketch of Figure 2). The distance between the two plants will be  $2d_m$ .

More interesting is the case where the recruitment costs are so high that it is optimal for the MNE to lower the distance between the two plants even below  $2d_m$ . Then the plant will still recruit workers up to a distance  $d_m$  from that side where it is



facing a national firm. But on the other side of the circle, where its neighbor in the labor market is its own affiliate, the distance will be smaller. Let us call this distance  $d_i$  with  $d_i < d_m$ . This case is illustrated in the right sketch of Figure 2. The distance between the two plants now reduces to  $2d_i$  and we no longer need to care about the wage to attract workers, because if it is large enough to attract workers with distance  $d_m$  it is certainly large enough for workers with distance  $d_i$ .

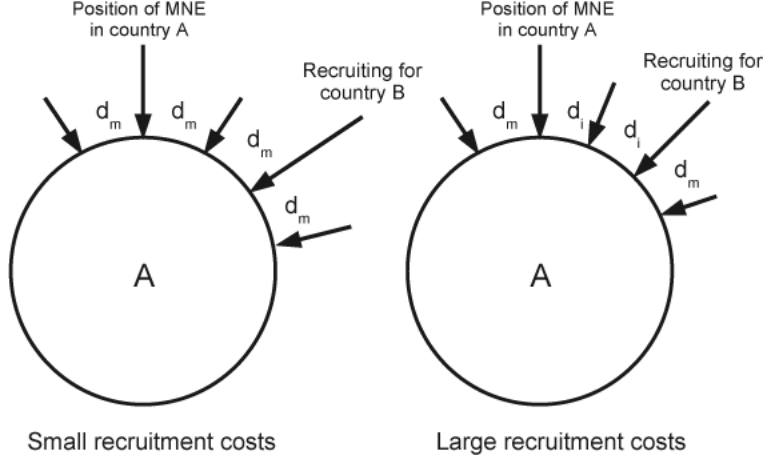


Figure 2: The Model with Large and Small Recruitment Costs

Effective labor supply changes to:

$$L_m^E = \frac{d_m}{2H} \left(1 - \frac{d_m}{2}\right) L_s + \frac{d_i}{2H} \left(1 - \frac{d_i}{2}\right) L_s, \quad (33)$$

which is very similar to Equation (14) of the benchmark but differs with respect to two points. The obvious one is the inclusion of  $d_i$ . The second one is the division by two of both expressions, which is due to the fact that  $d_m$  and  $d_i$  are only relevant on one side of the plant. Note that, due to symmetry, the average productivity of workers,  $1 - d_m/2$ , on the side neighboring the national firm does not differ from the one in the benchmark.

Assuming that the costs of recruitment of one plant are  $c(d_i)$  with  $c'(d_i) > 0$ , the profit function of the MNE modifies to:

$$\pi_m = p_m x_m - w_m L_m^E - w_m^* L_m^{E*} - c(d_i). \quad (34)$$

Since the MNE has an additional control over which it has to decide we need a second first order condition governing the choice of  $d_i$ .<sup>14</sup> It is found by taking the derivative of the profit function with respect to  $d_i$  and setting it equal to zero:

$$\begin{aligned} \frac{\partial \pi_m}{\partial d_i} &= \frac{\sigma - 1}{\sigma \beta} \left( \frac{L_m^E + L_m^{E*} - \alpha}{\beta} \right)^{-1/\sigma} \left( \frac{\partial L_m^E}{\partial d_i} + \frac{\partial L_m^{E*}}{\partial d_i} \right) - w_m \left( \frac{\partial L_m^E}{\partial d_i} + \frac{\partial L_m^{E*}}{\partial d_i} \right) \\ &\quad - c'(d_i) = 0. \end{aligned} \tag{35}$$

The first term is the marginal revenue of an increase in  $d_i$ , while the second and third term are the marginal costs, the additional wage payments and the additional recruitment costs. Note that the FOC is including the influence of  $d_i$  on both, the labor supply from the home country and from the foreign country, because it is using workers from both countries.

Finally, the impact of  $d_i$  on effective labor supply is found from the definition of labor supply (Equation (33)):

$$\frac{\partial L_m^E}{\partial d_i} = \frac{L_s}{2H} (1 - d_i). \tag{36}$$

For an overview of all the equations of this extended version see Appendix F.

### 5.1.2 Results

For the simulations we have normalized the recruitment costs to the largest value for which it is still true that  $d_i = d_m$ . The second column in Table 5 labelled "Costs=1" gives the results for this case. We then increase the recruitment costs compared to this situation. The fourth column, for example, shows what happens, when the recruitment costs are doubled. From the table it is clear that the basic picture is still the same: The MNE produces more, employs more workers but offers a lower wage.

**Result 5 *Recruitment Costs:*** *Recruitment costs mitigate the difference between the MNE and a national firm.*

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<sup>14</sup>The FOC for  $d_m$  is the same as in the benchmark with the only difference that it has to be divided by two.

	Costs=1	Costs=1.5	Costs=2	Costs=3	Costs=5	Costs=10	Costs=100
Output	1.0368515	1.0245649	1.0184219	1.0122798	1.0073671	1.0036832	1.0003683
Price	0.9939867	0.9959635	0.9969622	0.9979679	0.9987774	0.9993875	0.9999386
Employment	1.0265424	1.0169416	1.0124205	1.0080885	1.0047604	1.0023453	1.0002314
Wage per Efficiency Unit	0.9934650	0.9956146	0.9967001	0.9977929	0.9986723	0.9993348	0.9999334
Average Wage	0.9967106	0.9985388	0.9991854	0.9996474	0.9998811	0.9999756	1.0000007
St. Dev. of Wages	0.5099170	0.5812370	0.6626155	0.7633567	0.8536028	0.9254139	0.9924321
$d_i/d_m$	1.0000000	0.5086421	0.3409143	0.2053773	0.1143876	0.0542688	0.0051877

*Note:* Numbers give ratios of MNE to NE values.

Table 5: Recruitment Costs.

Looking at employment, the effects of increases in recruitment costs might seem not too big. While in the benchmark the MNE employs approximately 2.7% more workers than a national firm, it still employs 1.2% more workers when costs are doubled. Looking at wages the effects become even smaller, they are below half a percentage point. However, behind these numbers hides a huge structural change, which is illustrated by the seventh row, showing the relation between  $d_i$  and  $d_m$ . While, by definition, both are the same in the benchmark case, an increase of costs by 50% is sufficient to lower the ratio to just one half. This change is caused by a simultaneous increase in  $d_m$  and decrease in  $d_i$ . The plants of the MNE move closer together, which implies that in between the two plants fewer workers can be recruited. Therefore, the MNE tries to take bigger advantage from its possibility to move workers by increasing  $d_m$ .

Comparing the different columns in Table 5, we see that the MNE becomes more and more like a national firm, the higher the recruitment costs are. The distance  $d_i$  between the two plants converges towards zero, while all the other values converge towards the values of a national firm. This reflects the fact that in our model the only difference between the MNE and a national firm is the possibility to move workers between the plants in different countries.

## 5.2 Movement Costs

### 5.2.1 The Model

Next we want to relax the assumption that it is costless to migrate workers from one country to the other. Therefore, we introduce movement costs, which depend

positively on the number of workers moved by the MNE. Since, given a fixed number of workers on the labor market, the number of workers that migrate depends solely on the distance  $d_m^*$ , we can write the profit function as:

$$\pi_m = p_m x_m - w_m L_m^E - w_m^* L_m^{E*} - c(d_m^*), \quad (37)$$

where  $c(d_m^*)$  are the movement costs, with  $c'(d_m^*) > 0$ .

Effective labor supply is the same as in the benchmark model. The same is true for the FOC for choosing  $d_m$ . However, while in the benchmark the FOC for  $d_m^*$  was the same as the one for  $d_m$ , here we have to take account of the movement costs and thus the FOC changes to:

$$\frac{\partial \pi}{\partial d_m^*} = \frac{\sigma - 1}{\sigma \beta} \left( \frac{L_m^E + L_m^{E*} - \alpha}{\beta} \right)^{-1/\sigma} \frac{\partial L_m^{E*}}{\partial d_m^*} - w_m^* \frac{\partial L_m^{E*}}{\partial d_m^*} - L_m^{E*} \frac{\partial w_m^*}{\partial d_m^*} - c'(d_m^*) = 0. \quad (38)$$

Again the first term is the marginal revenue of increasing the distance, while the remaining terms make up the marginal costs. The second and third terms illustrate the additional wage payments, while the last term reflects the marginal movement costs. The effect of  $d_m^*$  on labor supply is found by taking the derivative of Equation (14):

$$\frac{\partial L_m^{E*}}{\partial d_m^*} = \frac{L_s^*}{H^*} (1 - d_m^*). \quad (39)$$

For a summary of all equations see Appendix G.

### 5.2.2 Results

For the simulations we have normalized the movement costs to relative shares of the total wage bill of the MNE in the benchmark model. Thus the value 0.1 in the table means that the MNE has to pay 10% of the wage bill as movement costs if it migrates the same number of workers as in the case of zero movement costs. Of course it can (and will) reduce the costs by migrating less workers.

	Costs=0	Costs=0.01	Costs=0.05	Costs=0.1	Costs=1
Output	1.1162356	1.0296119	1.0074942	1.0038769	1.0004002
Price	0.9818399	0.9951482	0.9987564	0.9993553	0.9999333
Employment	1.0909688	1.7589476	1.9383392	1.9680456	1.9966959
$w_m/w_n$	0.9938949	0.9983738	0.9995835	0.9997841	0.9999777
$w_m^*/w_n^*$	0.9938949	0.9885507	0.9871456	0.9869142	0.9866912
Average Wage	0.9969269	0.9984898	0.9995633	0.9997693	0.9999757
St. Dev. Of Wages	0.5421542	0.8160748	0.9510610	0.9745035	0.9973508
$d_m^*/d_m$	1.0000000	0.1626143	0.0376340	0.0191991	0.0019558

*Note:* Numbers give ratios of MNE to NE values.

Table 6: Movement Costs.

**Result 6 *Movement Costs:*** *Movement costs mitigate the difference between the MNE and a national firm.*

Table 6 summarizes the results. Again, the most dramatic effects can be found in the last row showing the ratio of MNE's shares on the skills circle in both countries ( $d_m^*/d_m$ ). Relatively low costs of 1% of the wage bill is sufficient to reduce the share abroad,  $d_m^*$ , (and thereby the number of workers moved) to 16% of the share in the home country,  $d_m$ . A further increase to 5% reduces the ratio to 3.8%.<sup>15</sup> Again, we can see that the MNE converges towards a national firm, if the costs of moving a worker become larger and larger.

## 6 Conclusions

Workers are heterogeneous. Hence, finding the right employees is not an easy task. This is well known and investigated in labor economics. However, the role of foreign owned firms is largely disregarded in this respect. This is even more astonishing given the important role MNEs play as employers.

Hence, we investigate how MNEs affect the labor market if they face a heterogeneous labor mass. The main advantage of the MNE is, that it can search for the suitable workers in the home and foreign market, as it is present with a plant in both countries. We show, that this implies that the MNE, compared to national firms, has lower mismatch, higher productivity, lower prices, higher output, and higher

<sup>15</sup>These effects might appear large but it should be taken into account that 5% of the wage bill is also quite a lot. Our model is a static one-period model. If the wage is interpreted as present value of all future wage-payments, then of course the same interpretation applies to the movement costs and thus 5% of the wage bill is a large amount.

employment.

Concerning the wage, we have found that the MNE pays lower wages, but that the within wage distribution is narrower. However, this result depends crucially on our assumption of homogeneous firms. If we assume that MNEs have just slightly lower marginal costs (as confirmed by the recent empirical literature), then the MNE actually pays higher wages.

Our model therefore can cope with the stylized and recent empirical findings, that MNEs pay higher wages, are larger, and employ more people. Further, labor migration through internal movements can be explained, which was found to be especially relevant for the high-skilled sector. Note, that so far most of the heterogeneous firm models assume immobile, homogeneous workers, where firms end up paying the same wages.

There are various interesting lines for future research. Including unemployment would be one possible extension, which was ruled out in our framework by the full employment assumption. Further, endogenizing the number of MNEs and allowing for heterogeneity among national firms in the given model framework would be worthwhile to investigate. This extension would allow to study the effects of firm regime changes on wages, production and employment.

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# Appendix

## A Derivation of Equation (8)

$$\frac{\partial L_{Si}^E}{\partial w_i} = \frac{L_S A}{2H(w_i + w_n)^4},$$

with  $A = (2w_i + 3w_n - 2mw_n - w_n + 2mw_n)(w_i + w_n)^2 - 2(w_i + w_n)(w_i^2 + 3w_n w_i - 2mw_n w_i - w_n w_i - 3w_n^2 + 2mw_n^2 + 2mw_n w_i + 6mw_n^2 - 4m^2 w_n^2)$ . Evaluating at  $w_i = w_n$  leads to:

$$\begin{aligned} \left. \frac{\partial L_{Si}^E}{\partial w_n} \right|_{w_i=w_n} &= \frac{L_S(4w_n 4w_n^2 - 4w_n(8mw_n^2 - 4m^2 w_n^2))}{2H(2w_n)^4} \\ &= \frac{L_S(4w_n - w_n(8m - 4m^2))}{2H(2w_n)^2} \\ &= \frac{L_S(1 - 2m + m^2)}{2Hw_n}. \end{aligned}$$

## B Derivation of Equation (21)

Reformulate the demand equation as:

$$p_i = x_i^{-1/\sigma}.$$

Reformulate production function as:

$$x_i = \frac{L_i^E - \alpha}{\beta}.$$

Now we can write profits as a function of labor and wage:

$$\begin{aligned} \pi_i &= x_i^{-1/\sigma} x_i - w_i L_i^E. \\ \pi_i &= \left( \frac{L_i^E - \alpha}{\beta} \right)^{\frac{\sigma-1}{\sigma}} - w_i L_i^E. \end{aligned}$$

The FOC can then be written as:

$$\frac{\partial \pi_i}{\partial w_n} = \frac{\sigma - 1}{\sigma \beta} \left( \frac{L_i^E - \alpha}{\beta} \right)^{-1/\sigma} \frac{\partial L_i^E}{\partial w_i} - L_i^E - w_i \frac{\partial L_i^E}{\partial w_i} = 0.$$

Using the fact that in the symmetric equilibrium  $w_i = w_n$  and  $\frac{\partial L_i^E}{\partial w_n} = \frac{L_s(1-2m+m^2)}{2Hw_n}$ , we can reformulate as follows:

$$\frac{L_s(1 - 2m + m^2)}{2Hw_n} = \frac{L_i^E}{\frac{\sigma-1}{\sigma\beta} \left( \frac{L_i^E - \alpha}{\beta} \right)^{-1/\sigma} - w_n}.$$

## C Proof of Proposition 1

To see whether a plant of the MNE produces more than a national firm we need to look at the FOC given in Equation (11). We rearrange in such a way that we see the marginal return of an increase in the wage on the left-hand side and the marginal costs on the right-hand side:

$$\frac{\sigma - 1}{\sigma \beta} \left( \frac{L_m^E + L_m^{E*} - \alpha}{\beta} \right)^{-1/\sigma} \frac{\partial L_m^E}{\partial w_m} = L_m^E + w_m \frac{\partial L_m^E}{\partial w_m}. \quad (\text{A1})$$

Putting the last term on the right-hand side to the left and single out  $\partial L_m^E / \partial w_m$ , we see that in order to obtain a positive solution for  $L_m^E$ , the following condition has to hold:

$$\frac{\sigma - 1}{\sigma \beta} \left( \frac{L_m^E + L_m^{E*} - \alpha}{\beta} \right)^{-1/\sigma} > w_m. \quad (\text{A2})$$

Let us assume for the moment that every plant of the MNE produces the same amount as a national firm. We shall show that in such a case marginal returns exceed marginal costs. Therefore, it cannot be optimal for the MNE to produce the same in every plant as a national firm, but instead it will produce more.

If every plant of the MNE produces the same quantity as a national firm, then the effective labor supply would have to be the same:  $L_i^E = L_m^E + L_m^{E*}$ . Using symmetry,

we can write  $L_m^E = L_m^{E*} = L_i^E/2$ . The FOC of the MNE can now be written as:

$$\frac{\sigma - 1}{\sigma\beta} \left( \frac{L_i^E - \alpha}{\beta} \right)^{-1/\sigma} \frac{\partial L_m^E}{\partial w_m} = \frac{L_i^E}{2} + w_m \frac{\partial L_m^E}{\partial w_m}.$$

Comparing with the FOC of a national firm given in Equation (4), it is immediately clear that marginal costs (on the right hand side) are directly lowered. The reason is the lower demand for labor in every country. However, we also need to check indirect effects via  $\partial L_m^E/\partial w_m$ . To do so take the ratio of  $\partial L_i^E/\partial w_n$  and  $\partial L_m^E/\partial w_m$ :

$$\frac{\partial L_i^E/\partial w_n}{\partial L_m^E/\partial w_m} = \frac{(1 - 2m + m^2)(w_n + w_m)^3}{2w_n^3(4 - 4(m + m_m) + (m + m_m)^2)} < 1. \quad (\text{A3})$$

If  $w_m = w_n$  and  $m = m_m$  this expression is equal to one. However, since the MNE needs to recruit less labor from a single country,  $w_m < w_n$  and  $m_m < m$ . Hence the ratio will be smaller than one, as the derivatives with respect to  $w_m$  and  $m_m$  are positive:

$$\begin{aligned} \frac{\partial \left( \frac{\partial L_i^E/\partial w_n}{\partial L_m^E/\partial w_m} \right)}{\partial w_m} &= \frac{3(1 - 2m + m^2)(w_n + w_m)^2}{2w_n^3(4 - 4(m + m_m) + (m + m_m)^2)} \\ &= \frac{3(m - 1)^2(w_n + w_m)^2}{2w_n^3(m + m_m - 2)^2} > 0. \end{aligned}$$

$$\frac{\partial \left( \frac{\partial L_i^E/\partial w_n}{\partial L_m^E/\partial w_m} \right)}{\partial m_m} = \frac{(m - 1)^2(w_n + w_m)^3}{2w_n^3} \left( \frac{2(2 - m - m_m)}{(m + m_m - 2)^4} \right) > 0,$$

where  $2 - m - m_m$  is positive, as  $m < 1$  and  $m_m < 1$ .

Equation (A3) implies that the labor supply of the MNE reacts stronger to changes in the wage or put formally:  $\partial L_m^E/\partial w_m > \partial L_i^E/\partial w_n$ . Coming back to the FOC in Equation (A1) we see that this implies that the marginal return for the MNE is increased. At the same time marginal costs are increased but given the relation in (A2) this effect weights less than the increase in marginal returns.

Putting all this together, we see that marginal returns exceed marginal costs if every plant of the MNE produces the same amount as a national firm. Therefore, it cannot be optimal. Rather, it pays off for the MNE to produce more than a national firm

in every plant.

## D Proof of Proposition 3

In Proposition 1 we found that the MNE produces more than a national firm. To see whether the MNE offers a higher wage, assume for the moment that both wages are equal:  $w_n = w_m$ . Following a similar line of argument as above, we look at the FOC of the MNE. If marginal returns exceed marginal costs then the MNE will offer a higher wage than a national firm and vice versa.

If the MNE pays the same wage per efficiency unit as a national firm, it will get the same share of the skills circle. But the MNE gets workers from both countries and thus production will be considerably higher. Since the price goes down with quantity produced, marginal returns go down as well, which can be seen by inspection of  $\left(\frac{L_m^E + L_m^{E*} - \alpha}{\beta}\right)^{-1/\sigma}$ .

The indirect effect via the influence of the wage on labor supply described in the section above is also at work here. However, the ratio given in Equation (A3) is equal to one if we assume  $w_n = w_m$  and  $m = m_m$ .

Hence, with the same marginal costs, marginal revenues are lower for the MNE, because it recruits double the amount of workers in every plant for the same wage posted as a national firm. Hence, the MNE can raise profits by lowering wages, which proves that in equilibrium  $w_m < w_n$ .

## E Proof of Proposition 4

The relation between the wage of the MNE and the wage of national firms can be derived from Equation (12):

$$w_m(1 - d_m) = w_n(1 - (m + m_m - d_m)).$$

In equilibrium the worst mismatch for the MNE is equal to  $m_m$ , and for the national firm the worst mismatch is given by  $m$ . Hence, we can simplify to:

$$\frac{w_m}{w_n} = \frac{(1-m)}{(1-m_m)}.$$

As we know from Proposition 3 that the MNE charges a lower wage per efficiency unit, i.e.  $w_m < w_n$ , it immediately follows that  $m > m_m$ . Hence, in equilibrium mismatch of workers is lower for the MNE than for a national firm.

Average wages are given by:

$$\bar{w}_m = w_m \left(1 - \frac{m_m}{2}\right), \quad \bar{w}_n = w_n \left(1 - \frac{m}{2}\right).$$

Using the fact that  $w_m = w_n \frac{(1-m)}{(1-m_m)}$ , we can write the ratio of average wages as:

$$\frac{\bar{w}_m}{\bar{w}_n} = \frac{(2-m_m)(1-m)}{(1-m_m)(2-m)} = \frac{2-2m-m_m+mm_m}{2-2m_m-m+mm_m} < 1,$$

since  $m > m_m$ . Hence, the average wage of the MNE is lower than that for a national firm.

## F Main Equations for the Model with Recruitment Costs

$$x_m = p_m^{-\sigma}. \quad (\text{A4})$$

$$L_m^E + L_m^{E*} = \alpha + \beta x_m. \quad (\text{A5})$$

$$L_m^E = \frac{d_m}{2H} \left(1 - \frac{d_m}{2}\right) L_s + \frac{d_i}{2H} \left(1 - \frac{d_i}{2}\right) L_s. \quad (\text{A6})$$

$$L_m^{E*} = \frac{d_m^*}{2H^*} \left(1 - \frac{d_m^*}{2}\right) L_s^* + \frac{d_i}{2H} \left(1 - \frac{d_i}{2}\right) L_s. \quad (\text{A7})$$

$$d_m = \frac{w_m - w_n(1 - m - m_m)}{w_m + w_n}. \quad (\text{A8})$$

$$d_m^* = \frac{w_m^* - w_n^*(1 - m^* - m_m^*)}{w_m^* + w_n^*}. \quad (\text{A9})$$

$$\frac{L_m^E}{\frac{\sigma-1}{\sigma\beta} \left(\frac{L_m^E + L_m^{E*} - \alpha}{\beta}\right)^{-1/\sigma} - w_m} = \frac{L_s w_n^2 (4 - 4(m + m_m) + (m + m_m)^2)}{2H (w_m + w_n)^3}. \quad (\text{A10})$$

$$\frac{L_m^{E*}}{\frac{\sigma-1}{\sigma\beta} \left(\frac{L_m^E + L_m^{E*} - \alpha}{\beta}\right)^{-1/\sigma} - w_m^*} = \frac{L_s^* w_n^{*2} (4 - 4(m^* + m_m^*) + (m^* + m_m^*)^2)}{2H^* (w_m^* + w_n^*)^3}. \quad (\text{A11})$$

$$\begin{aligned} \frac{\partial \pi_m}{\partial d_i} &= \frac{\sigma-1}{\sigma\beta} \left(\frac{L_m^E + L_m^{E*} - \alpha}{\beta}\right)^{-1/\sigma} \left(\frac{\partial L_m^E}{\partial d_i} + \frac{\partial L_m^{E*}}{\partial d_i}\right) \\ &\quad - w_m \left(\frac{\partial L_m^E}{\partial d_i} + \frac{\partial L_m^{E*}}{\partial d_i}\right) - c'(d_i) = 0. \end{aligned} \quad (\text{A12})$$

$$\frac{\partial L_m^E}{\partial d_i} = \frac{L_s}{2H} (1 - d_i). \quad (\text{A13})$$

$$\frac{\partial L_m^{E*}}{\partial d_i} = \frac{L_s^*}{2H^*} (1 - d_i). \quad (\text{A14})$$

## G Main Equations for the Model with Movement Costs

$$x_m = p_m^{-\sigma}. \quad (\text{A15})$$

$$L_m^E + L_m^{E*} = \alpha + \beta x_m. \quad (\text{A16})$$

$$L_m^E = \frac{d_m}{H} \left(1 - \frac{d_m}{2}\right) L_s. \quad (\text{A17})$$

$$L_m^{E*} = \frac{d_m^*}{H^*} \left(1 - \frac{d_m^*}{2}\right) L_s^*. \quad (\text{A18})$$

$$d_m = \frac{w_m - w_n(1 - m - m_m)}{w_m + w_n}. \quad (\text{A19})$$

$$d_m^* = \frac{w_m^* - w_n^*(1 - m^* - m_m^*)}{w_m^* + w_n^*}. \quad (\text{A20})$$

$$\frac{L_s w_n^2 (4 - 4(m + m_m) + (m + m_m)^2)}{H (w_m + w_n)^3} = \frac{L_m^E}{\frac{\sigma-1}{\sigma\beta} \left(\frac{L_m^E + L_m^{E*} - \alpha}{\beta}\right)^{-1/\sigma} - w_m}. \quad (\text{A21})$$

$$\frac{\sigma-1}{\sigma\beta} \left(\frac{L_m^E + L_m^{E*} - \alpha}{\beta}\right)^{-1/\sigma} \frac{\partial L_m^{E*}}{\partial d_m^*} - w_m^* \frac{\partial L_m^{E*}}{\partial d_m^*} - L_m^{E*} \frac{\partial w_m^*}{\partial d_m^*} = c'(d_m^*). \quad (\text{A22})$$

$$\frac{\partial L_m^{E*}}{\partial d_m^*} = \frac{L_s^*}{H^*} (1 - d_m^*). \quad (\text{A23})$$