FDI Technology Spillovers and Wages

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Abstract

This study distinguishes multinational firm (MNE) technology-spillover from learning effects. Whenever learning takes time, the model predicts that foreign investors deduct the economic value of learning from wages of inexperienced workers and add it to experienced ones to prevent them from moving to local competitors. Hence, the national wage bill is unaffected by the presence of MNEs. In contrast to learning, technology spillover effects occur whenever a worker with MNE experience contributes more to local firms' than to MNEs' productivity. In this case, experienced MNE workers are hired by indigenous firms and the host country obtains a welfare gain from the presence of MNEs. Implications of this model for the empirical findings of the MNE wage premium and the empirical FDI technology spillover literature are also discussed.

JEL Code: F2, J3.

Keywords: FDI, foreign takeover, cross-border M&A, FDI technology spillover.

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1) Introduction

There is a rich empirical literature that investigates technology spillover effects to indigenous firms from foreign direct investment (FDI). A prominent channel of FDI spillover effects is worker turnover: Workers who are exposed to superior foreign technology in an affiliate may transmit part of this technology to indigenous firms when changing workplace.

Fosfuri et al. (2001) and Glass and Saggi (2002)[2] derive from models the conclusion that multinational enterprises (MNEs) pay higher wages, because they want to prevent leakage of superior technology to local competitors through worker turnover. The wage premium measures then the economic value of the host-country benefit from potential technology-spillover effects. This theory is an explanation for the empirical finding from firm data of a wage-cost premium that foreign-owned firms have relative to comparable indigenous firms (e.g. Aitken et al., 1996).

New empirical results with employee-employer matched data require, however, a revision of the theory, which explains the wage premium of foreign-owned firms but not its time profile. The wage premium and the productivity is rising with the years after a foreign takeover (Csengödy et al., 2005, Huttunen, 2006), and the wage premium is dependent on the number of years of experience of a worker in a foreign-owned firm or MNE (Martins, 2005; Balsvik, 2006; Pesola, 2006, Malchow-Møller et al., 2007).

An explanation is given in Malchow-Møller et al. (2007) using a model with competitive labor markets where learning a superior technology from a firm by a worker takes time. For an equilibrium of high-productivity firms hiring both workers with and without previous experience from high-productivity firms to exist, the relative wages of both worker types must

[2] A similar model set-up has been used earlier in Markusen (2001) to discuss intellectual property right protection in developing countries. Markusen and Rutherford (2005) set up a model of technology export through foreign expert consultancy, i.e. international labor mobility, rather than worker mobility within a country.

reflect their relative productivity. This explains why wages rise with the number of years of experience in high-productivity firms. However, firms with high-productivity become multinationals (Helpman et al., 2004). Hence, learning does not originate from MNEs per se but from firms with high productivity in general. This explains why national MNEs have no wage premium different from foreign-owned firms (Heyman et al., 2007).

Still the model of Malchow-Møller et al. (2007) does not fully explain the stylized facts. In some countries such as Norway national low-productivity firms seem to attract frequently workers with experience from high-productivity firms (Balsvik, 2006). In other countries such as Portugal and Hungary workers stick to foreign-owned firms (Csengödy et al., 2005; Martins, 2005). In fact, Malchow-Møller et al. (2007) focus on modelling a steady flow of transiting workers. Since the labor market is competitive, MNEs cannot engage in strategic actions to avoid labor mobility and the subsequent leakage of knowledge. Because of the market form of monopolistic competition on the goods market and the way learning is modelled, MNEs do not loose their competitive edge against direct local competitors, do not loose profits from worker transition, and thus have no incentive to prevent leakage of knowledge.

My model shares the assumption that learning takes time with Malchow-Møller et al. (2007) which results into a similar wage-premium time-profile at least in some circumstances. However, I depart by first separating *learning* from *technology spillover effects* and second assuming strategic interactions in goods and labor market. Learning is a productivity gain of a worker from experience in an MNE that is fully transferable to other firms.[3] A technology spillover is a productivity gain of a national firm from hiring a worker with MNE experience that does not only contain the transferable productivity gain from learning of the transient

[3] I call the non-transferable part in the productivity difference of a worker within an MNE relative to the same worker in a national firm the result of a firm-specific asset.

worker herself but also the productivity fertilization of fellow-workers. For example, a former MNE worker may introduce new work practices to the national firm which do not only increase her own productivity (learning) but the one of the entire team (technology spillover), because knowledge is a public good within a firm. Since this work practice is already established in the MNE among all workers, the same worker who transited would have contributed less to MNE productivity than to the national firm productivity in this case.

The distinction between learning and technology spillover effects is crucial for the host country welfare impact of MNEs. If there is only learning, MNEs are able to internalize the learning effect by paying higher wages than indigenous firms after learning and lower wages before. Hence, the expected life-time income of host-country workers remains unaffected by MNEs. A host-country benefit arises, however, from a technology spillover effect additional to learning such that an MNE-experienced worker contributes more to local firms' productivity than to MNEs'. Then, MNEs will specialize in training workers, discount wages by the value of their human capital production, and workers will move to indigenous firms after training. Since there is a productivity gain to indigenous firms that does not accrue to MNEs, indigenous firms are able to hire the MNE-experienced worker at wages below marginal productivity. Hence, the host countries' welfare gain from technology spillovers consists of an increase of indigenous firms' profits.

The model offers also a simple way to observationally discriminate whether there is only learning *without* a welfare gain from knowledge transmission through MNEs or knowledge spillover *with* such a welfare gain. With pure learning MNEs have a wage premium *above* the average of comparable national firms, and the workforce stays with the MNE. With technology spillovers MNEs have a wage cost *below* the average of comparable national firms (opposite to Fosfuri et al., 2001, and Glass and Saggi, 2002), and there is frequent worker transition to national firms. This may explain why there is frequent worker transition in Norway, but not in Hungary or Portugal.

My results are robust to a large number of extensions. It holds for a model with many sectors, many time periods, in the absence of a perfect capital market, and at different market forms. Only the result on the wage discount disapears in the case when I allow for collective bargaining.

The rest of the paper is organized as follows. Section 2 contains a simple baseline model; section 3 discusses a number of model variations; section 4 relates the model to the empirical literature; and section 5 concludes.

2) A Technology Spillover Model

I begin with a simplified model that highlights the main effects.

2.1) Model Set-up

There are two time periods t=1,2. I consider an economy with 2 sectors i=1,2 in addition to another sector called "rest of the economy". Goods are homogeneous within each sector. There is one production factor labor with potential differences in efficiency across workers. There is also one MNE (M) with particularly efficient technology (e.g. patent holder), fixed cost and constant marginal cost. The MNE exists only in sector 1. In all sectors exists a competitive fringe of symmetric potential indigenous firms. There is free firm entry and exit at any time of all competitive fringe firms which have ex ante identical constant returns to scale technology across all sectors (Murphy et al., 1989).

All workers are initially identical regardless of where they are employed. Moreover, workers are always identical within each firm. In period 1, workers allocate to the MNE or active indigenous firms. Henceforth, I call **MNE-experienced workers** those workers in period 2 who have worked for the MNE in period 1. Then, there are three alternative moves τ of MNE-experienced workers in period 2: (a) τ=N$_1$: MNE-experienced workers move to indigenous firms in sector 1; (b) τ=N$_2$: MNE-experienced workers move to indigenous firms in sector 2; (c) τ=M: no worker turnover. I refer for simplicity to τ also as a regime. MNE-experienced workers can leave the MNE only at an additional marginal cost χ, $\chi \to 0^+$, which is proportional to output of the firm. This cost will be born in equilibrium by the indigenous firm that hires the MNE-experienced worker.[4] All other workers do not have moving cost.

Firms maximize their (operating) profits, $\pi^F(t,\tau)$:

$$\pi^F(t,\tau) = x^F(t,\tau) \cdot \left[P_i(t,\tau) - A^F(t,\tau)^{-1} \cdot w^F(t,\tau)\right] \tag{1}$$

with i=1,2 denoting the sector index, t the time index, F$\in${M,N$_1$,N$_2$} the firm index, $x^F(t,\tau)$ the firm-specific demand in units, $P_i(t,\tau)$ the price in sector i at time t in regime τ, and $w^F(t,\tau)$ the corresponding wage. For example, $w^F(2,F)$ is the wage rate offered by firm type F in period 2 when the MNE-experienced worker is hired by this firm in period 2.

Total factor productivity (TFP), $A^F(t,\tau)$, consists of two components. There is an F-firm specific knowledge asset that supports a **firm-specific productivity component**, $\widetilde{A}^F(t,\tau)$, at time t in regime τ. I assume, when leaving the firm, workers cannot transfer this firm-specific component of productivity. There is also a **worker-specific efficiency component** $\widetilde{A}_F^W(t,\tau)$ in regime τ at time t of a worker initially allocating to firm F. In contrast to the firm-specific

[4] The nature of the cost is not important for the model results in this paper. It is only important that some cost exists - even if negligibly small – to ensure uniqueness of equilibrium. Letting this cost be marginal intends to make these cost relevant for individual decisions, but not for the overall welfare evaluation of a country, as moving cost should not have a significant negative impact on GDP.

component, the worker-specific component of technology is embodied in the worker and thus transferable from firm to firm once the worker changes workplace. The productivity differences across workers are not based on formal training but on learning-by-doing. Hence, they will not be detectable in econometric studies. Formally, I have thus:

$$A^F(t,\tau) = \widetilde{A}^F(t,\tau) \cdot \widetilde{A}_F^W(t,\tau); \qquad \tau \in \{M, N_1, N_2\}; \quad t = 1,2; \tag{2}$$

The multiplication of the two productivity components in equation (2) implies that high-quality workers are relatively more productive in high-tech than in low-tech firms.

I continue the discussion of technology by giving the initial conditions on the two productivity components in each regime, and for each firm- and worker type. I assume that there is a common-practice technology level which I normalize without loss of generality to 1. This common-practice technology level applies both to the productivity component of workers and indigenous firms initially and remains in place, whenever workers are not exposed to MNEs, and local firms are not hiring workers that have MNE experience.

Instead, the MNE firm-component of productivity, M, is above the common-practice level

$$\widetilde{A}^M(t,\tau) = M \text{ , M>1,} \tag{3}$$

for all $\tau \in \{M, N_1, N_2\}$ and t=1,2.

Next, I introduce learning of workers from MNEs into the model.

Definition 1: Learning of workers from MNEs

Workers learn from MNEs if they have been employed at the MNE in the first period, adopt part of the technology, and increase their worker-specific efficiency in the second period by a factor L, i.e.

$$\widetilde{A}_{\tau}^{W}(2,\tau)=L\text{ , L>1,} \tag{4}$$

for all $\tau \in \{M, N_1, N_2\}$.

Condition (4) describes a productivity gain of workers through learning from MNEs over time. It corresponds to the dynamic FDI learning model by Findlay (1978). Importantly, learning occurs only one period after having joined the MNE which is the decisive assumption of this model.

Assumption 1: Learning takes time.

The workers increase their efficiency only one period after they have worked for an MNE.

In contrast, I consider also a technological knowledge-spillover effect through worker turnover of MNE-experienced workers to indigenous firms.

Definition 2: Technological knowledge spillover

A technological knowledge spillover is called an increase of the indigenous-firm-specific productivity when workers with MNE experience join the company.

$$\widetilde{A}^{N_i}(2,N_i)=S_i,\ S_i\geq 1, \tag{5}$$

for i=1,2.

This effect also causes a total factor productivity gain from a worker in period 2 if she was employed at a MNE in the first period. However, this productivity gain is firm-specific and accrues only to indigenous firms. For example, a MNE worker may have observed innovative management practices that can be implemented in indigenous firms and rise the firm-specific productivity component. Since the more efficient management practice is already in place at the MNE but not at the indigenous firm, the MNE-experienced worker increases the productivity of the indigenous firm beyond what she could do for the MNE.

To distinguish learning from technological knowledge spillovers, note that learning results in an equal productivity gain of employing MNE-experienced workers in both MNEs and indigenous firms. Knowledge spillovers, instead, imply productivity gains from hiring MNE-experienced workers that accrue only to indigenous firms, but not to the MNE. For short, knowledge spillovers imply that MNE-experienced workers contribute more to indigenous firm than to MNE productivity. It will become clear later why I call S_i a technology spillover effect and L a learning effect.

To derive empirically relevant results, I employ three additional assumptions.

Assumption 2: Lack of absorptive capacity of workers.

$$L < M \ . \tag{6}$$

Assumption 2 ensures that the superior technology of the MNE is not entirely transferred to its workers.

Assumption 3: Technological proximity condition.

$$1 \leq S_2 \leq S_1 < L \text{ for i=1,2.} \tag{7}$$

The knowledge spillover from an MNE can occur both to domestic firms within the same sector or even in some other sector. However, knowledge spillovers across sectors may become weaker. A value of 1 implies the absence of any knowledge spillover that shall be discussed, as well. The strict inequality implies a lack of willingness of indigenous firms to adopt new technology, because its workers have already been learning L by assumption but the firm asset may still remain below that productivity level, for example, because the management blocks innovation to secure its power within the organization.

Assumption 4: No-leapfrogging condition.

$$L \cdot S_1 < M \qquad (8)$$

This condition ensures that even an indigenous firm equipped with former MNE workers does not have a technology superior to the MNE when operating with newly hired workers without MNE experience.[5]

The technology is summarized in Table 1 where I give total factor productivity by firm type and by the decision of MNE-experienced workers where to work in the second period.

Table 1: Total factor productivity by firm type and choice of worker with MNE experience

	Period1 t=1	Period 2 t=2		
Total factor productivity (TFP) $A^F(t,\tau) = \widetilde{A}^F(t,\tau) \cdot \widetilde{A}^W_F(t,\tau)$		MNE-experienced worker stays with MNE τ=M	MNE-experienced worker moves to indigenous firm in sector 1 $\tau=N_1$	MNE-experienced worker moves to indigenous firm in sector 2 $\tau=N_2$
Multinational firm F=M	M	$M \cdot L$	M	M
Indigenous firm in sector 1 $F=N_1$	1	1	$L \cdot S_1$	1
Indigenous firm in sector 2 $F=N_2$	1	1	1	$L \cdot S_2$

Note: ($M,L>1$; $S_i \geq 1$; $L \cdot S_i < M$; $S_1 \geq S_2$)

I will in the following distinguish two cases: one where there actually exists a technology spillover effect, i.e. $S_i>1$ for i=1,2; and the second case where there is such a technology spillover effect absent, i.e. $S_i=1$.

[5] Of course, Assumption 2 is a subset of Assumption 4. I separate them, since they can be empirically tested independently.

Finally, I turn to the numéraire sector "rest of the economy". There is a CRS technology with total factor productivity 1, perfect competition, and MNEs are absent. There is free inter-sectoral labor mobility of workers without MNE experience. Hence, equation (1) implies together with the zero profit condition due to free entry and exit that the wage for workers with common-practice productivity is 1.

Bertrand competition on goods market i=1,2 yields limit pricing (see Murphy et al., 1989), i.e. the firm with the larger profits will compete the other firm type out of the market. Hence, only one firm type in one sector can have weakly positive profits. For sector 1, this implies formally:

$$Min\{\pi^{M}(t,\tau);\pi^{N_1}(t,\tau)\} < 0 \leq Max\{\pi^{M}(t,\tau);\pi^{N_1}(t,\tau)\} \tag{9}$$

for t=1,2 and $\tau \in \{M, N_1, N_2\}$ at strictly positive output. Since only one firm is active in each sector, output of the active firm equals goods market demand, $x_i(P_i)$, which is assumed to be a function of prices in sector i with $x_i'(P_i)<0$. Since there exist many firms that can obtain workers with productivity 1 at wage 1, and free entry and exit ensure that profits are competed away, there is an upper limit price in the product market of sector 1 such that

$$P_i(t,\tau) \leq 1 \text{ for i=1,2; t=1,2 and } \tau \in \{M, N_1, N_2\}. \tag{10}$$

Since a MNE-experienced worker can always work in the position of one without MNE experience in an indigenous firm at wage 1, there is a lower bound on the wage of workers with MNE experience:

$$w^{\tau}(2,\tau) \geq 1 \text{ for } \tau \in \{M, N_1, N_2\}. \tag{11}$$

There is another important arbitrage condition on wages.

Lemma 1 (**Lazear-condition**)[6]: If there is a perfect capital market with discount factor R, R<1, and both MNEs and indigenous firms offer jobs to the same type of workers in equilibrium[7], then life-time wage income of a worker in an MNE and in an indigenous firm must be equal in equilibrium. Formally:

$$w^{M}(1,\tau)+R\cdot w^{\tau}(2,\tau)=w^{N_i}(1,M)+R\cdot w^{N_i}(2,M)=(1+R) \qquad (12)$$

for all $\tau\in\{M,N_1,N_2\}$ and i=1,2.

Proof: Suppose they were unequal. Then, either all workers would supply their work to the MNE or exclusively to indigenous firms in the first period. Neither case can constitute an equilibrium with MNEs and indigenous firms both active. **qed**.

Lemma 1 implies immediately that workers cannot benefit from the presence of MNEs in terms of their life-time income. I share this feature of the model with Malchow-Møller et al. (2007).

2.2) Subgame Perfect Equilibrium

The above model constitutes a game, where the players are the three firm types M, N_1, N_2, and the MNE-experienced workers. Their strategies are the setting of wages and prices and the labor allocation decision, respectively. Firms set wages before product prices. Wage offers are made simultaneously, and workers have complete information on them.

[6] Condition (12) was first used in Lazear (1979) to show that efficiency wage problems can be solved with a steep wage schedule over lifetime, whenever there exists a mandatory retirement age. Malchow-Møller et al. (2007) have included this condition into their MNE-worker-transition model, too.

[7] Görg et al. (2002) developes a rent-sharing model that explains wage premia of workers in foreign-owned firms, when workers learn slowly over time. By assumption, the return to human capital accumulation is larger in foreign firms. To the extent that workers are able to share in the surplus of the higher return to human capital through bargaining, wages in foreign-owned firms rise above the ones in indigenous firms. Görg et al. (2002) deviate in two crucial assumptions from the present model: there is no worker mobility across sectors and there is a lock-in effect in the sense that workers cannot be instantaneously replaced by untrained ones. Such a model is very suitable to describe conclave economies, where MNEs form a modern sector on their own, while the traditional sector of indigenous firms is technologicaly so remote that workers cannot be substituted across sectors. Görg et al. (2002) apply their model consequently to data of Ghana.

A subgame perfect equilibrium of the game (1)-(12) is defined as a vector of wages, labor allocation in period 2, and product prices over both periods such that neither period 2 profits nor the asset price of any firm can increase by deviating, and no MNE-experienced worker can improve wage income in period 2.[8]

As usual, the model is solved by backward induction. For solving the Nash equilibrium in period 2, it is useful to define the maximum offer $\hat{w}^{\tau}(2,\tau)$ that a firm type τ is willing to make to obtain the MNE-experienced worker in period 2. A firm will offer at most as much a wage such that profits are no less than if the firm did not hire an MNE-experienced worker, i.e. formally:

$$\hat{w}^{\tau}(2,\tau) \equiv \underset{w^{\tau}(2,\tau)}{\arg\inf} \left\{ \pi^{\tau}(2,\tau) \,\middle|\, \pi^{\tau}(2,\tau) = \sup_{l \in \{M, N_1, N_2\}} \{\pi^{\tau}(2,l)\} \right\}. \tag{13}$$

The worker with MNE experience will end up in the firm T that is willing to make the highest offer:

$$T = \underset{\tau \in \{M, N_1, N_2\}}{\arg\sup} \{\hat{w}^{\tau}(2,\tau)\}, \tag{14}$$

Conveniently, (14) is sufficient to constitute a Nash equilibrium of the end game. Analogue to the theory on second-price sealed-bid auctions, the worker with MNE experience will, however, only be paid marginally more than the second highest bid.

The intuition is straight forward: when firm N_1 wants to hire the MNE-experienced worker, it needs to compete the MNE first out of the market according to (9). This requires setting the goods price so low that the MNE would make losses when hiring a worker without MNE experience in period 2, i.e.

[8] Note that only MNE-experienced workers act strategically, while inexperienced workers have no strategic choices. However, workers with MNE experience exist only in period 2.

$$p_1(2, N_1) = (1/M) - \varepsilon, \tag{15}$$

where $\varepsilon, \varepsilon \to 0^+$, is a value that is marginally positive. However, then the maximum bid that firm N_1 is able to make without making losses itself is:

$$\hat{w}^{N_1}(2, N_1) = [(1/M) - \varepsilon - \chi] \cdot (L \cdot S_1) < 1. \tag{16}$$

Because of the inequality in (16) which contradicts (11), the firm N_1 will never be able to hire MNE-experienced workers. Intuitively, the Assumption 4 of no leapfrogging ensures that the MNE has always the highest total factor productivity and can therefore set prices so low that the indigenous firm becomes unprofitable at competitive wages. Instead, the highest bid of the MNE is:

$$\hat{w}^{M}(2, M) = L > 1. \tag{17}$$

The MNE is willing to pay for the learning gain L in productivity when the worker gained MNE experience. The MNE does not compensate the entire marginal productivity of the worker, because hiring a worker without MNE experience will become more profitable in this case. Still, the highest bid stems from firm N_2, whenever there exists some positive technology spillover externality (S_2>1):

$$\hat{w}^{N_2}(2, N_2) = L \cdot S_2 \cdot (1 - \chi), \tag{18}$$

where I recall that the moving cost, χ, are close to zero by assumption. The reason is that a worker with MNE experience contributes more to indigenous firms' than to MNEs' productivity through the technology spillover effect in case it exists (S_2>1). In this case, the firm N_2 will outbid the MNE and pay marginally more than what the MNE would have been prepared to pay: $L + \varepsilon$. If, instead, there is no technology spillover effect (S_2=1), then the MNE wins the bidding competition, because it does not bear moving costs χ, and offers marginally more than the second-highest bid of firm N_2: $L \cdot (1 - \chi)$. In both cases, the wage of the MNE-experienced worker is (about) L. Note that this wage rate is above the one otherwise found in the economy for the same position.

From the Lazear condition (12) follows that the wage that the MNE pays to its workers in the first period must be below the one that prevails otherwise in the economy for the same position. The Lazear condition is graphically displayed in Figure 1.

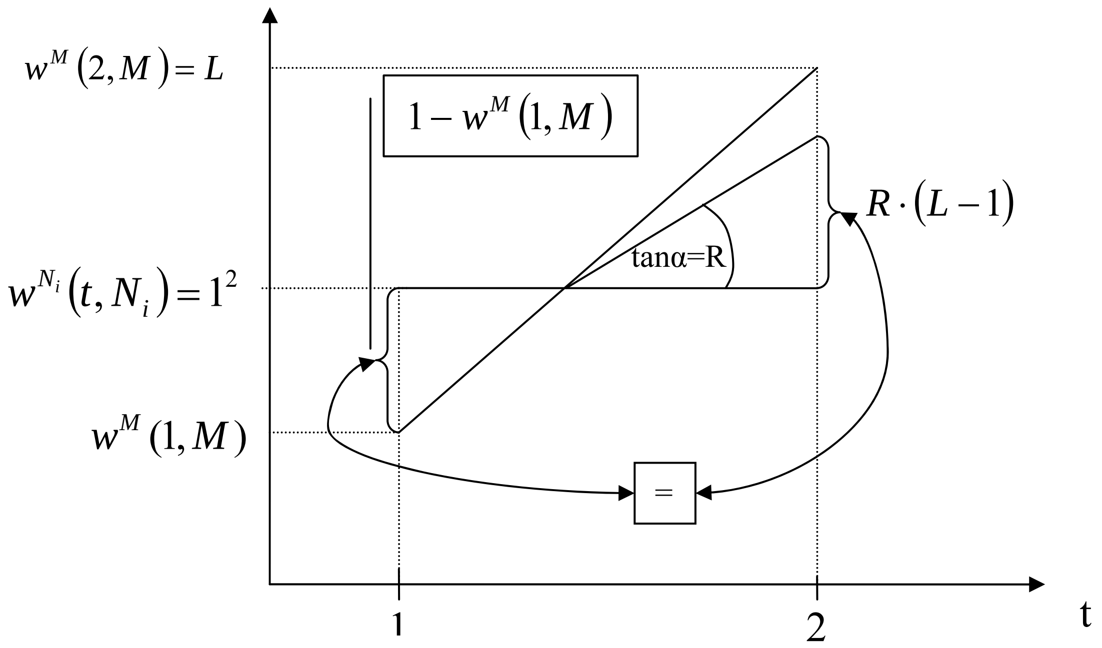
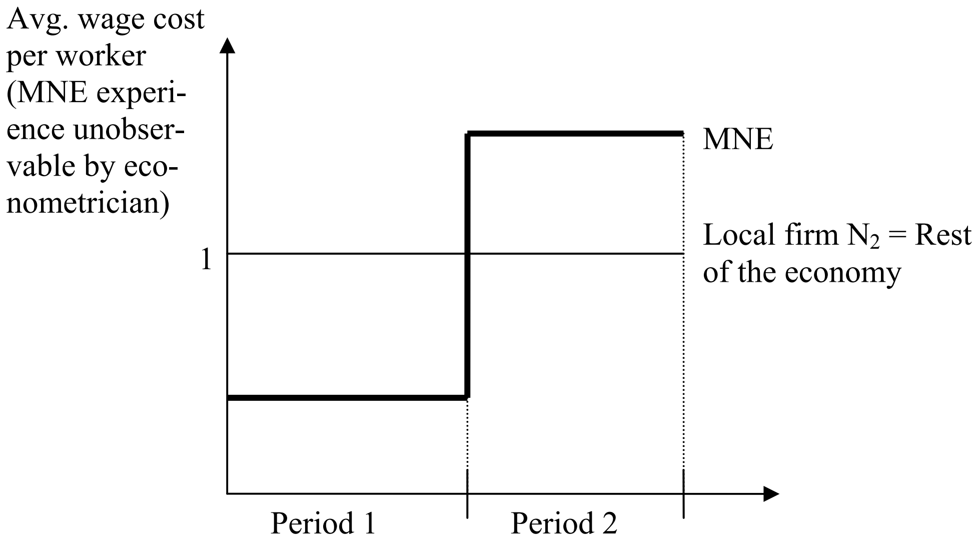


Figure 1: The Lazear-Condition

The Figure 1 depicts wages in periods t=1 and t=2 when employed at an MNE or at an indigenous firm. No matter whether a worker remains at the MNE in period 2, there will be a higher salary of this worker after her work experience at the MNE. However, the MNE is able to fully internalize the learning effect by discounting wages of its workers in period 1 by the expected learning gain.

Typical empirical studies on wage cost premia (e.g. Aitken et al., 1996) do not estimate the wage profile of a worker over time, but the average wage costs of a firm over time. Therefore, I turn in Figure 2 to the average wage cost per worker of a firm. Panel (a) of Figure 2 considers the case when a spillover externality is absent (S_2=1). In this regime, the MNE-experienced workers stay with the MNE and receive a wage above the average of the economy. Hence, the average wage cost per worker of MNEs is above the one of indigenous firms in period 2 but below in period 1. All local firms are never hiring MNE-experienced workers and will thus have also in period 2 the average wage cost per employee that they had already in period 1.

Panel (a) Case of no technology spillovers (S_i=1)



Panel (b) Case of technology spillovers (S_i>1)

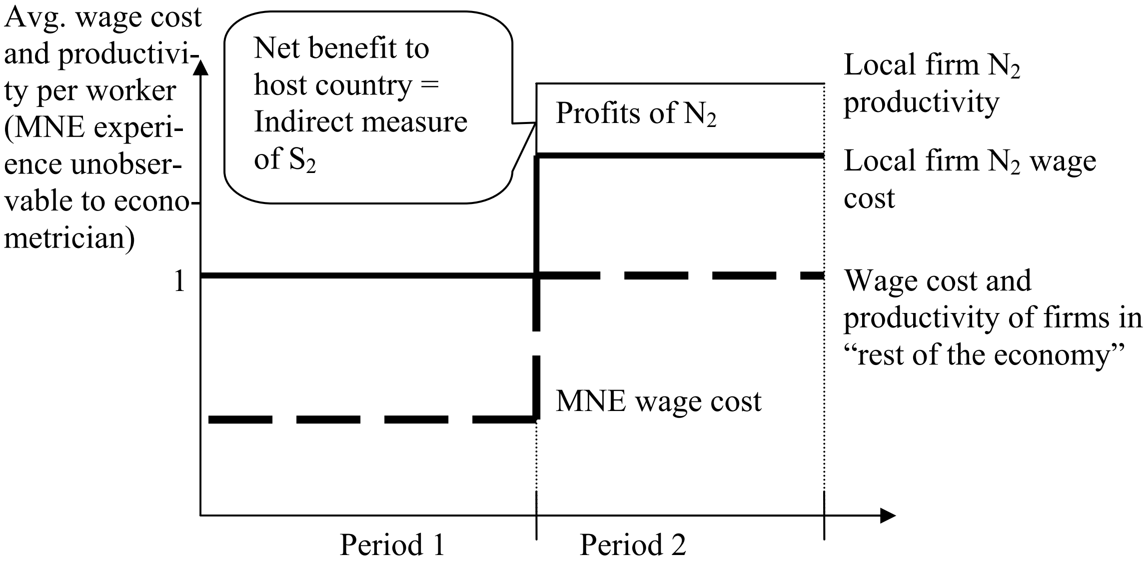


Figure 2: Average wage cost by firm type and technology spillover case

Instead, panel (b) of Figure 2 depicts the case where a technology spillover externality actually exists ($S_2>1$). Then, the MNE wage cost are on average over both periods below the one of indigenous firms. In period 1, there is the discount through the Lazear effect. However, the MNE-experienced worker moves to firm N_2 in period 2 and the MNE hires again a worker without MNE experience. Since there is no third period, the new workers do not benefit anymore from future learning and demand the average wage of the economy.[9] The firm N_2, instead, while having average wage cost in the economy in period 1, hires MNE-experienced workers in period 2 and pays a wage premium for them. However, since this wage is only marginally higher than the second highest bid, firm N_2 makes still a profit, since the productivity gain is larger than the wage premium. The profit is at the same time the channel through which the productivity gain S_2 exerts a positive externality on the host country. I summarize the above findings in proposition 1.

Proposition 1: (i) There exists a unique subgame perfect equilibrium T, $T \in \{M, N_1, N_2\}$, to the game (1)-(12) such that there will be worker turnover, T, from the MNE to firm N_2 if there are technology spillover externalities from the MNE-experienced worker to firm N_2 beyond pure learning ($S_2>1$); there will not be any worker turnover otherwise. Formally:

$$T = \begin{cases} N_2 & if\ S_2 > 1 \\ M & if\ S_2 = 1 \end{cases} \tag{19}$$

(ii) The MNE offers a wage for a workplace in period 1 below the one of indigenous firms if there exists a technology spillover from MNE-experienced workers to firm N_2 ($S_2>1$). Otherwise, MNE wages will be below this benchmark in period 1 and above in period 2.

(iii) There exists a direct net benefit through the MNE to the host country if and only if there exists a technology spillover from MNE-experienced workers to firm N_2 ($S_2>1$). There is no net benefit to the host country from learning alone.

[9] This artefact of a finite time horizon will be remedied in section 3.3.

Proof: See appendix. **q.e.d.**

A comment is due on the welfare effects of potential takeovers. The presence of multinational firms causes productivity of domestic workers to rise. This is not sufficient, however, for constituting a net benefit to the host country, because MNEs are able to internalize the learning effect and the discounted life-time income of workers is not affected by FDI. It is the circumstance that an MNE-experienced worker contributes more to domestic firms' than to MNEs' productivity which is exploited to create a net benefit to the host country. By the well-known second-price sealed-bid auction argument, the MNE-experienced worker is not able to internalize the incremental benefit that she brings to a domestic firm relative to the MNE. But then the MNE has no possibility to cash in this spillover externality.[10] The indigenous firm that hires the MNE-experienced worker increases productivity more than wage cost. The resulting profit of this firm is a net benefit to the host country through the knowledge flow from the MNE to the indigenous firm. Hence, wages are not the appropriate dependent variable to look at in an econometric study if one wants to detect technology spillovers. Instead, profits of indigenous firms are expected to rise if they hire former employees from MNEs.

3) Model Extensions

Next, I discuss assumption perturbations and their impact on the model results. Contrary to Markusen (2001), Fosfuri et al. (2001), and Glass and Saggi (2002), there is no export option to the MNE. In this model, the MNE will never choose to export at the price of additional transport cost to prevent knowledge spillovers, because the MNE is able to fully internalize

[10] This result hinges on the disregard of labor contracts that contain something else than just the wage for a period. More complex labor contracts are typically not observed in emerging market economies where technology spillovers are most likely to occur.

the learning externality. Hence, the model results are not affected by including an exporting option. However, other assumption perturbations change the equilibrium in some respects.

3.1) Additional Sectors

Suppose there exist many sectors such as sector 2. I denote the additional sectors i=3,..,n and assume that (5) holds for sectors i=3,..,n, as well. Moreover, I assume without loss of generality that $S_i \geq S_{i+1} \geq 1$ for all i. Since, equation (18) still holds analogously:

$$\hat{w}^{N_i}(2, N_i) = L \cdot S_i \cdot (1-\chi), \tag{20}$$

The bidding competition for the worker with MNE experience is still won by firm N_2. But the second highest bid stems from firm N_3, and the wage of the worker with MNE experience is:

$$w^{N_2}(2, N_2) = L \cdot S_3 \cdot (1-\chi) + \varepsilon\,. \tag{21}$$

The fact that the MNE experience is not uniquely useful for just one indigenous firm, but for many, allows the worker to partially internalize the technology spillover via the bidding competition. However, this allows in turn the MNE to internalize even (part of) the technology spillover effect by decreasing wages in the first period even further and the net benefit to the host country decreases. In fact, the profit of the firm N_2 in period 2 is:

$$\pi^{N_2}(2, N_2) = x(1) \cdot \left[1 - S_2^{-1} \cdot S_3\right], \tag{22}$$

which is positive if and only if $S_2 \neq S_3$. Hence, there will only be a net benefit of a foreign takeover to the host country if the expected technology spillover effect is very specific to only one indigenous firm which is not directly competing with the MNE. However, then the scope of this effect is likely to be small.

3.2) Imperfect Capital Market

Crucial for the strong result is the Lazear condition (12) which rests mainly on the hardly questionable assumption that learning takes time. However, the condition may break down if the assumption of a perfect capital market (free lending and borrowing) does not hold. To make a strong contrast, I assume complete lack of access of workers to the capital market.

I discuss first the case, when workers are homogeneous in the time preference rate λ. Then, condition (12) will be replaced by:

$$U\left(w^{M}(1,\tau)\right)+\lambda\cdot U\left(w^{\tau}(2,\tau)\right)=U\left(w^{N_i}(1,M)\right)+\lambda\cdot U\left(w^{N_i}(2,M)\right)=(1+\lambda)\cdot U(1) \tag{23}$$

for $\tau\in\{M,N_1,N_2\}$ and i=1,2, where U(.), U'(.)>0, U''(.)<0, is the period utility function of a representative worker. Note that the end game will not change under condition (23) and thus the wage of workers with MNE experience, when staying with the MNE, will be larger in period 2 than prevails in the rest of the economy for a well-defined occupation (i.e. $w^{M}(2,M)>1$). Hence, by the monotonicity of the utility function, it is still true that

$$w^{M}(2,M)>w^{M}(1,M). \tag{24}$$

Workers still do not experience a welfare gain from foreign takeovers, because condition (23) requires the welfare of workers to be balanced when either working for an MNE, or not. The host country benefits only from foreign takeovers, if a technology spillover effect cannot be internalized by workers and some indigenous firm can increase its profits.

Next, I drop the assumption of a homogeneous time preference rate. Let there be m workers in the economy with time preference rates $\lambda_1>\lambda_2>...>\lambda_m$. Moreover, labor supply is exogenous and normalized to 1, and, to make the case interesting, $x(1)>1$, i.e. the MNE will have to hire more than one worker. Integer problems will be evaded by assuming that a worker can partially supply her work to an indigenous firm and partially to an MNE. Additionally, I assume that the MNE cannot observe the time preference rate of its workers. Now, equation (12) is replaced by (25):

$$U\left(w^{M}(1,\tau)\right)+\overline{\lambda}\cdot U\left(w^{\tau}(2,\tau)\right)=U\left(w^{N_i}(1,M)\right)+\overline{\lambda}\cdot U\left(w^{N_i}(2,M)\right)=\left(1+\overline{\lambda}\right)\cdot U(1), \qquad (25)$$

where $\overline{\lambda}$ is defined as the worker with smallest time preference still required to work for the MNE (formally: $\overline{\lambda}=\max\{\lambda_i | i \leq (x(1))\}$). The MNE will offer a wage schedule over time that corresponds to (25). By self-selection, only workers i with time preference $\lambda_i \geq \overline{\lambda}$ will join the MNE. Hence, some workers will actually benefit from joining the MNE, because $U\left(w^{M}(1,\tau)\right)+\lambda_i\cdot U\left(w^{\tau}(2,\tau)\right)>\left(1+\overline{\lambda}\right)\cdot U(1)$ if $\lambda_i > \overline{\lambda}$. This is indeed another source of a net benefit to the host country. Such a gain rests on the MNE being an imperfect substitute to a functioning capital market. Since only the most patient workers would self-select to work for the MNE, the implied interest rate $\overline{\lambda}$ would likely be below the market interest rate R if a perfect capital market existed. Hence, the MNE is able to charge lower wages in period 1 compared to the case of the otherwise identical model with a perfect capital market.

Yet another qualification has to be made: if worker utility $U(1)$ is at the subsistence level or if there is a conclave economy with a highly developed foreign-owned sector, an underdeveloped informal sector, and no labor mobility in between, then my model does not apply. This may be the case for developing countries. Then, the learning and rent-sharing model of Görg et al. (2002) may be more appropriate.

3.3) Infinite Time Horizon

There is an artefact in the previous model that results from the assumption that the game ends after period 2. A worker without MNE experience newly hired by the MNE in period 2 does not enjoy any learning benefits in the future. Hence, the MNE cannot discount the wage in period 2. To avoid this artefact, I assume that firms exist forever, but workers only for 2 periods. The time index t denotes now the two life periods, young and old, of a worker of a generation. The full game is an infinite repetition of these two life periods. Then, MNEs will always hire the young generation, because only young workers benefit from learning in the next period.

Under these assumptions, the game solution changes only in one respect: the MNE can hire in regime $\tau=N_i$, i=1,2, a young worker at the wage $w^M(2,N_i)$ in t=2, which will be below the rate 1 that prevails elsewhere in the market for workers without MNE experience. Intuitively, this lowers the maximum offer that the MNE is willing to pay for a worker with MNE experience during period 2, because the outside option has become cheaper. In fact, I find that

$$\hat{w}^M(2,M) = \frac{1+R}{L^{-1}+R} < L. \tag{26}$$

Still, this is larger than what firm N_1 would be willing to offer which is below one. The equilibrium of this modified game will then be:

$$T = \begin{cases} N_2 & if\ L \cdot S_2 \cdot (1-\chi) \geq \dfrac{1+R}{L^{-1}+R} \\ M & else \end{cases} \tag{27}$$

The term on the right hand side of the inequality in (27) is smaller than L, and MNE-experienced workers will normally move to firm N_2, even when the technology spillover effect is absent (S_2=1). Interestingly, the local firm that hires MNE-experienced workers increases its productivity, but there is still no welfare gain to the host country without technology spillover externality and U-shaped wage profile, because local firms bid up wages of MNE-experienced workers in labor market competition to at least L.

3.4) Cournot Competition

The results so far are obtained from a model that assumes Bertrand competition. Next, I show that my results are also obtained from a simple Cournot oligopoly model. To keep the analysis short, I assume that there is an MNE affiliate M, one indigenous firm N in the same sector and in addition the “rest of the economy”. Moreover, I assume a linear goods market demand function: $p=a-b(x^M+x^N)$ with parameters a, b such that $a > 2-1/M$ and b>0.[11] Otherwise, the assumptions of the benchmark model are sustained.

It is straightforward to find the maximum offer that an MNE affiliate is willing to make for MNE-experienced workers in period 2:[12]

$$\hat{w}^M = \frac{1+2(1/M)}{S_1^{-1}+2(1/M)} \cdot L. \tag{28}$$

The maximum wage offer will be L, if there are no FDI technology spillover externalities (S_1=1) and else larger. Likewise, the maximum offer of the indigenous firm is found to be

$$\hat{w}^N = \frac{2+(1/M)}{2S_1^{-1}+(1/M)} \cdot L. \tag{29}$$

It is easily seen from (28) and (29) that the bidding competition for MNE-experienced workers is won by the indigenous firms if and only if technology spillover externalities exist (S_1>1). Otherwise, the MNE offers the same wage as the indigenous firm but MNE-experienced workers can avoid the marginal moving costs χ and stay with the MNE. Formally, result (19) in Proposition 1 applies also to the case of Cournot competition.

This result is in contrast to Glass and Saggi (2002), although both models are Cournot duopolies. Notably, the deviating assumption of my model – learning takes time – changes not only the first stage of the game but also the last one (period 2). If learning occurs instantaneously, instead, then the MNE looses its outside option to operate with a worker without MNE experience at lower productivity, because all its employees have a higher productivity immediately after joining by assumption. This change of the game is sufficient to exclude the outcome that the indigenous firm wins the bidding competition even without technology spillover externalities in the case of a large technology gap. The Lazear condition

[11] The restriction on a is a sufficient condition to ensure that no natural monopoly emerges. This condition is also a necessary one if S_1=L=1.

[12] Calculations are available from the author upon request.

(12) and the fact that the wage in period 2 is at least $L > 1$ ensures that the U-shaped wage pattern continues to hold.

Turning to the welfare effects, there arises a slight modification compared to the previous models. With Cournot competition, price effects arise from technology spillover effects that affect the consumer surplus. The product price in period 2 is found to be in equilibrium:

$$p = \frac{1}{3}\left[a + (1/M) + \frac{1 + 2(1/M)}{1 + 2S_1(1/M)}\right]. \tag{30}$$

Since the learning effect L does not appear in (30), the host country does not have an increase of its consumer rent from learning alone. A contrasting result emerges, however, from FDI technology spillovers (S_1>1). The larger the technology spillover externality S_1, the more decreases the product price and the larger is the gain of the host country in consumer rent. Indigenous firm profits are also independent from learning effects L:

$$\pi^N = \frac{1}{9b}\left[a + (1/M) - 2 \cdot \frac{1 + 2(1/M)}{1 + 2(1/M)S_1}\right]^2 \tag{31}$$

However, they rise with the extent of technology spillover externalities (S_1>1).

Summing up, in a simple model of Cournot competition my results are mostly qualitatively preserved. The only major deviation to the previous analysis stems from an additional channel besides indigenous-firm profits through which the host country can benefit from technology spillover externalities: product prices will fall and consumer surplus increase.[13]

3.5) Technology Spillovers and Bargaining

In a final robustness check I relate the technology spillover theory to a bargaining model with learning such as Görg et al. (2002). To do this in the simplest possible way, I depart from the baseline set-up by introducing the following timing of the game: in each period, first there is a

[13] This fall in product prices due to technology spillover externalities is additional to the effect that new MNEs increase product market competition and drive down profit mark-ups.

wage offer, then there is a hiring decision subject to job applications (individual contract), after the hiring decision there is a re-negotiation possibility of workers who can opt to strike (collective bargaining for payrise of existing contracts). Given that there is an agreement, there is production and product market interaction. The threat point of collective bargaining for the worker is to loose the job and continue working at a domestic firm for a compensation equal to her marginal productivity (one in the first period and L in the second). The firm will have zero profits in this case.[14] To keep the model simple, I apply a Nash-bargaining equilibrium concept.

Solving this model backward, the bargaining pins down the wages. In period two, the wage negotiated between MNE and MNE-experienced workers will be:

$$w^M(2, M) = L[1 + \beta(M - 1)] \tag{32}$$

given a bargaining power of the trade union of β. The maximum bid for an MNE-experienced worker from national firms of sector 2 is still $w^{N_2}(2, N_2) = L \cdot S_2$, which is larger than the maximum bid of the MNE, $w^M(2, M)$, if S_2 is sufficiently large. Worker mobility from the domestic to the foreign firm can again be seen as an indicator of technology spillover externalities in contrast to pure learning effects.

Contrary to the previous model, however, there is a welfare gain from MNEs even in the absence of technology spillovers, since the MNE workers share the rents of the superior technology with the MNE. Albeit the welfare gain to the host country is larger if technology spillovers exist, of course.

[14] The MNE cannot replace striking workers by new ones, because the latter would have the same incentive to start a strike.

In addition, there is no dip in the wage in the first period contrary to the previous model.[15] To see this, note that the bargaining outcome in the first period is a wage

$$w^{M}(1,M)=1+\beta(M-1)>1, \qquad (32)$$

which is larger than the wage at the outside option that prevails in the rest of the economy for the same job. Since life-time income of workers entering an MNE in the first period is larger than for those remaining in national firms, every worker supplies her work at the prevailing wage to the MNE. However, not all workers are taken, because demand by MNEs is restricted to the amount of workers needed to satisfy monopoly demand on the goods market.

4) Relation to Empirical Literature

This section relates the theoretical findings to the empirical literature. In particular, I discuss the empirical evidence for our deviating assumption – that learning takes time, the implication for empirical studies on the wage premium of MNEs, and empirical studies on technology spillover effects.

4.1) Empirical evidence for the assumption "learning takes time"

In a seminal study, Brown et al. (2006) investigate the total factor productivity of Eastern European and Russian firms before and after privatization to domestic and foreign investors. They find that firms privatized to foreign investors experience a gradual rise in total factor productivity above the level of an appropriate control group over several years after privatization. A similar result is obtained for foreign takeovers in Hungary by Csengödy et al. (2005) and for foreign takeovers in Indonesia by Arnold and Smarzynska Javorcik (2005) applying matching techniques. This supports the view that the local work force needs time to

[15] The absence of a fall of wages for MNE workers before they have gained training to compensate for larger wages after training can also be explained by minimum wage laws (see Malchow-Møller et al., 2007). Those are, however, not binding in Hungary, for example, where no such wage dip is found after foreign takeovers (see Csengödy et al., 2005).

achieve full efficiency when confronted with the technology, organization, and management know-how of foreign investors.

4.2) Implications for studies on MNE wage premia

Aitken et al. (1996) and Görg and Girma (2007), among others, find a significant average wage premium that MNEs seem to pay above comparable domestic firms[16].

Fosfuri et al. (2001) motivate their technology spillover model with this empirical observation. However, this model requires that learning be instantaneous to explain the wage premium which contradicts the empirical evidence on gradual productivity gains after foreign takeovers. If learning takes time, instead, the theory predicts technology spillover effects exist only if MNEs pay lower rather than larger wages than comparable domestic firms. If there is found on average a wage premium in the data, this is a hint for learning rather than technology spillover[17], and no welfare gains are obtained by the host country. Hence, empirical evidence is not consistent with a technology-spillover explanation of the MNE wage premium.

4.3) Implications for empirical technology spillover studies

Aitken et al. (1999) estimate domestic firm productivity in dependence of some measure of the density of MNEs in geographical and technological vicinity and Balsvik (2006) relates productivity advantages of national firms to the share of its employees with MNE experience.[18] This model has shown that a productivity gain is a necessary but not a sufficient condition for a host-country welfare gain through technological spillover effects. MNEs may

[16] Martins (2004) and Heyman et al. (2007) do not find such a premium for Portugal and Sweden, using matching techniques on employee-employer matched data.

[17] While inexperienced MNE workers must have a wage lower than average while experienced ones a larger wage, the wage premium must be larger than the wage dip due to discounting, yielding an MNE-worker wage on average above the one of workers who stay a life-long with a national firm (see also Malchow-Møller et al., 2007).

[18] Surveys on subsequent empirical studies are Görg and Greenaway (2004) and Blomström et al. (2001).

be able to discount the wage to obtain an indirect fee for their education service that eventually boosts local firm productivity.

Alternative indirect measures of direct host-country welfare gains through FDI technology spillover effects are the decrease in goods prices when MNEs enter a host country, or a rise in profits of indigenous firms that hire MNE-experienced workers.

5) Conclusion

This paper has developed a model that deviates from FDI technology spillover models of Fosfuri et al. (2001) and Glass and Saggi (2002) by the assumption that learning of the local workforce from superior MNE technology takes time. It deviates from the worker-transition model of Malchow-Møller et al. (2007) by strategic interaction on goods and.labor market combined with a distinction of learning effects from technology spillover effects. Learning is a productivity gain of a worker from experience in an MNE that is fully transferable to other firms. A technology spillover is a productivity gain of a national firm from hiring a worker with MNE experience that does not only contain the transferable productivity gain from learning of the transient worker herself but also the productivity fertilization of fellow-workers.

The distinction between learning and technology spillover effects is crucial for the host country welfare impact of MNEs. If there is only learning, MNEs are able to internalize the learning effect by paying higher wages than indigenous firms after learning and lower wages before. Hence, the expected life-time income of host-country workers remains unaffected by MNEs. A host-country benefit arises, however, from a technology spillover effect additional to learning such that an MNE-experienced worker contributes more to local firms' productivity than to MNEs'. Then, MNEs will specialize in training workers, discount wages by the value of their human capital production, and workers will move to indigenous firms after training. Since there is a productivity gain to indigenous firms that does not accrue to MNEs, indigenous firms are able to hire the MNE-experienced worker at wages below marginal productivity. Hence, the host countries' welfare gain from technology spillovers consists of an increase of indigenous firms' profits.

Model extensions to capital market imperfections, different market forms (Bertrand and Cournot-competition, collective bargaining), many sectors, and many time periods are discussed. When confronted with the empirical literature, the wage premium that MNEs seem to pay above indigenous firms for an otherwise identical workforce cannot be explained by FDI technology spillover effects consistently.

The generality of the results are constraint by the partial equilibrium feature of the model. Any price effects are disregarded that MNE inflows may cause to the host country. Hence, the analysis is constraint to welfare gains through direct technology spillover effects and disregards other channels through which MNEs may benefit (or harm) the host country.

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Appendix: Proof of Proposition 1.

First, I formally define a subgame perfect equilibrium.

Definition A1: Worker turnover τ=T, $T \in \{M, N_1, N_2\}$, is a subgame perfect equilibrium of the game (1)-(16) iff:

(i) all firms maximize their profits and exit if profits are negative;
(ii) $\pi^l(2,T) = \sup_{j \in \{M,N_1,N_2\}} \{\pi^l(2,j)\}$ for all $l \in \{M, N_1, N_2\}$;

(iii) $w^T(2,T) = \sup_{j \in \{M,N_1,N_2\}} \{w^T(2,j)\}$;

(iv) $\pi^l(1,T) + R \cdot \pi^l(2,T) = \sup_{j \in \{M,N_1,N_2\}} \{\pi^l(1,j) + R \cdot \pi^l(2,j)\}$ for all $l \in \{M, N_1, N_2\}$.

I recall that the equilibrium of the end-game is summarized by (18). Then, I write up the profit functions in the various regimes beginning with τ=M:

$$\pi^M(2,M) = x_1(p_1(2,M)) \cdot \left[p_1(2,M) - (M \cdot L)^{-1} \cdot w^M(2,M)\right], \tag{A1a}$$

$$\pi^{N_1}(2,M) = x_1(p_1(2,M)) \cdot \left[p_1(2,M) - w^{N_1}(2,M)\right] = x_1(p_1(2,M)) \cdot \left[p_1(2,M) - 1\right], \tag{A1b}$$

$$\pi^{N_2}(2,M) = x_2(1) \cdot \left[1 - w^{N_2}(2,M)\right] = x_2(1) \cdot \left[1 - 1^{-2} \cdot 1^2\right] = 0. \tag{A1c}$$

Analoguously, I find the profit function in regime τ=N_1:

$$\pi^M(2,N_1) = x_1(p_1(2,N_1)) \cdot \left[p_1(2,N_1) - (M \cdot 1)^{-1} \cdot 1^2\right], \tag{A1d}$$

$$\pi^{N_1}(2,N_1) = x_1(p_1(2,N_1)) \cdot \left[p_1(2,N_1) - (L \cdot S_1)^{-1} \cdot w^{N_1}(2,N_1)\right], \tag{A1e}$$

$$\pi^{N_2}(2,N_1) = x_2(1) \cdot \left[1 - 1^{-2} \cdot 1^2\right] = 0. \tag{A1f}$$

Finally, the profit functions in regime τ=N_2 are displayed:

$$\pi^M(2,N_2) = x_1(p_1(2,N_2)) \cdot \left[p_1(2,N_2) - (M \cdot 1)^{-1} \cdot 1^2\right], \tag{A1g}$$

$$\pi^{N_1}(2,N_2) = x_1(p_1(2,N_2)) \cdot \left[p_1(2,N_2) - 1\right], \tag{A1h}$$

$$\pi^{N_2}(2,N_2) = x_2(1-\varepsilon) \cdot \left[1 - \varepsilon - (1 \cdot L \cdot S_2)^{-1} \cdot w^{N_2}(2,N_2)\right], \tag{A1i}$$

where I recall that workers without MNE experience earn salary 1 and I inserted (2), (4), and (6)-(9) into (1). I also note that the price in sector 2 must be 1 because of the non-negative profit constraint (i) of Definition 1 together with (14) except in (A1i), when firm N_2 may make positive profits and therefore is willing to undercut the market price that would prevail from the competitive fringe firms by a marginal amount $\varepsilon, \varepsilon \to 0^{+}$.

Next, I determine market prices according to the market entry condition (13) and the profit conditions (A1a)-(A1i). For offering a wage to MNE-experienced workers, the MNE must be active in regime τ=M (i.e. $\pi^{M}(2,M) \geq 0$). Hence, profits of indigenous firms in sector 1 must be negative:

$$\pi^{N_1}(2,N_1) < 0 . \tag{A2}$$

by condition (13). This implies together with condition (i) of Definition 1 and the assumption of binding limit prices that:

$$p_1(2,M) = 1 - \varepsilon . \tag{A3}$$

Likewise in the regime τ=N$_1$, the indigenous firm makes an offer to workers with MNE experience only if its profits are non-negative. Hence, MNE profits must be negative by condition (13):

$$\pi^{M}(2,N_1) = x_1(p_1(2,N_1)) \cdot [p_1(2,N_1) - (1/M)] < 0 . \tag{A4}$$

Then, the indigenous firm will maximize profits by setting the price in this regime at:

$$p_1(2,N_1) = (1/M) - \varepsilon . \tag{A5}$$

Considering regime τ=N$_2$, I note that

$$\pi^{M}(2,N_2) - \pi^{N_1}(2,N_2) = x_1(p_1(2,N_2)) \cdot [1 - (1/M)] > 0 , \tag{A6}$$

where I used (10), (A1g), and (A1h). By condition (13) follows from (A6) that the indigenous firm N$_1$ will not be active and the MNE will maximize profits subject to $\pi^{N_1}(2,N_2) < 0$ (A7)

by setting

$$p_1(2,N_2) = 1 - \varepsilon . \tag{A8}$$

Next, I calculate the maximum offers. First, I note that $\pi^{M}(2,M) \geq \max[0; \pi^{M}(2,N_2)]$ if

$$w^{M}(2,M) \leq L , \tag{A9}$$

where I used (A1a), (A1g), (A5) and (A8).

Second, I note that $\pi^{M}(2,M) \geq \max[0; \pi^{M}(2,N_1)]$ if

$$w^{M}(2,M) \leq (1-\varepsilon)\cdot M \cdot L\,, \tag{A10}$$

where I inserted (A1a), (A1d), (A3) and (A4) into the inequality. Plugging (A9) and (A10) into definition (17) yields:

$$\hat{w}^{M}(2,M) = L\,. \tag{A11}$$

I am turning next to the maximum offer of indigenous firms N_1. First, $\pi^{N_1}(2,N_1) \geq \max[0;\pi^{N_1}(2,M)]$ if

$$w^{N_1}(2,N_1) \leq [(1/M)-\varepsilon-\chi]\cdot(L\cdot S_1) < 1\,, \tag{A12}$$

where I used (A2), (A1e), (A5) and (12). Moreover, $\pi^{N_1}(2,N_1) \geq \max[0;\pi^{N_1}(2,N_2)]$ if and only if (A12) is fulfilled, which follows from (A7) and (A1e). Hence, (A12) implies together with definition (17) that

$$\hat{w}^{N_1}(2,N_1) = [(1/M)-\varepsilon-\chi]\cdot(L\cdot S_1)\,. \tag{A13}$$

Finally, I calculate the maximum offer of firm N_2. Using (A1c) and (A1i), I find that $\pi^{N_2}(2,N_2) \geq \max[0;\pi^{N_2}(2,M)]$ if

$$w^{N_2}(2,N_2) \leq L\cdot S_2\cdot(1-\chi)\,. \tag{A14}$$

And likewise, if $\pi^{N_2}(2,N_2) \geq \max[0;\pi^{N_2}(2,N_1)]$, then condition (A14) emerges again, when applying (A1f) and (A1i). From (A14) and (i) of Definition 1, I obtain the maximum offer of firm N_2 as:

$$\hat{w}^{N_2}(2,N_2) = L\cdot S_2\cdot(1-\chi)\,. \tag{A15}$$

Comparing (A15) with (A11) and (A13), I find

$$\begin{aligned} &\hat{w}^{N_2}(2,N_2) > \hat{w}^{M}(2,M) > \hat{w}^{N_1}(2,N_1) \qquad \textit{iff}\ S_2 > 1 \\ &\hat{w}^{M}(2,M) > \hat{w}^{N_2}(2,N_2) > \hat{w}^{N_1}(2,N_1) \qquad \textit{iff}\ S_2 = 1 \end{aligned} \tag{A16}$$

and thus by (18)

$$T = \begin{cases} N_2 & \textit{iff}\ S_2 > 1 \\ M & \textit{iff}\ S_2 = 1 \end{cases} \tag{A17}$$

Moreover, (i) of Definition 1 implies together with (A16) and (A17) that

$$w^{N_2}(2,N_2) = L + \varepsilon \quad \textit{iff}\ S_2 > 1 \tag{A18}$$

and

$$w^M(2,M) = L\cdot(1-\chi)+\varepsilon \quad iff\ S_2 = 1. \tag{A19}$$

which is just the result of a second-price zealed-bid auction. The end game is now completely characterized.

Turning to the full game, condition (16) is used to solve for first period MNE wages:

$$w^M(1,M) = \begin{cases} 1+R\cdot(1-L\cdot(1-\chi))-R\cdot\varepsilon<1 \quad iff\ S_2>1 \\ 1+R\cdot(1-L)-R\cdot\varepsilon<1 \quad iff\ S_2=1 \end{cases} \tag{A20}$$

after inserting (A18) and (A19). Moreover, the Lazear condition (16) immediately implies together with (1), (4) and (6) that

$$\pi^M(1,M) = \pi^M(1,N_1) = \pi^M(1,N_2). \tag{A21}$$

Next, it is straight forward to see that

$$\pi^{N_i}(1,M) = \pi^{N_i}(1,N_1) = \pi^{N_i}(1,N_2) \qquad i=1,2 \tag{A22}$$

From (A21) and (A22) follows that

$$\underset{\tau\in\{M,N_1,N_2\}}{\arg\max}\left[\pi^k(1,\tau)+R\cdot\pi^k(2,\tau)\right] = \underset{\tau\in\{M,N_1,N_2\}}{\arg\max}\left[\pi^k(2,\tau)\right] \qquad \forall k\in\{M,N_1,N_2\} \tag{A23}$$

which verifies condition (iv) of Definition 1 given that conditions (i), (ii) and (iii) hold. Finally, the welfare results follow directly by noting that the host country welfare consists of three components: consumer rent, wage bill and indigenous firm profits. When taking as yardstick an economy without MNE, prices are 1, wages 1, and domestic firm profits zero in both periods. Lemma 1 guarantees that no gain in the wage bill is possible. The consumer rent remains unaffected up to first order, because goods prices for goods in market 1 differ only by a marginal ε. However, firm rents of firm N_2 rise above zero:

$$\pi^{N_2}(2,N_2) = x_2(1-\varepsilon)\cdot\left[1-\varepsilon-(S_2)^{-1}\right], \tag{A24}$$

which is strictly positive if and only if $S_2>1$. **q.e.d**

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