Foreign Employees as Channel for Technology Transfer: Evidence From MNC’s Subsidiaries in Mexico*

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Abstract
This paper studies the role of foreign employees as a channel for technology transfer in multinational companies (MNCs). We build a simple model of MNC choice between foreign and domestic management as a function of industry characteristics and of institutional quality. We find that foreign employees are a channel for technology transfer within high-tech MNCs. Further, the reliance of MNCs on foreign employees is U-shaped in terms of institutional quality. Our model implies that we should observe the same pattern between technology transfer and institutional quality. We use a unique dataset that links information on technology transfer and the presence of foreign employees in subsidiaries in Mexico with data on judicial efficiency across Mexican states. The evidence is consistent with the implications of the model and difficult to reconcile with alternative hypotheses.

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1 Introduction

The presence of foreign employees in multinational companies (MNCs) has become an increasingly popular area of study (Belderbos and Heijltjes (2005), Urata et.al (2006)). One stream of literature focuses on the role played by foreign employees. Along these lines, Markusen and Trofimenko (2009) find that plants with foreign experts have experienced increases in the wages of domestic workers and in value added per worker. Another stream of literature focuses on their determinants. For example, Ando et.al (2008) find that the presence of foreign employees in affiliates of Japanese MNCs increases with export orientation. Tan and Mahoney (2006) empirically analyze the choice between hiring expatriates and local CEOs using data from Japanese MNCs. The management literature argues that MNCs need to balance the use of expatriates and local staff in response to the local business environment.\footnote{Egelhoff (1984) and Gupta and Govindarajan (1991) show that expatriates are a means of controlling and processing information. At the same time, the impact of expatriates may be reduced because of local factors. See, for example, Black et al. (1999) and Ricks (1999), who show that administrating the development and mobility of expatriate managers has been a major challenge for most MNCs. Lam and Yeung (2010) find that the impact of staff localization on performance is inverse-U-shaped and that this relationship depends on environmental uncertainty.}

This paper studies the role of foreign employees as a channel for technology transfer in MNCs as a function of industry characteristics and of local institutions. To this end, we model the MNC decision of whether to use foreign or domestic management. In the model, the MNC faces the following trade-off. On the one hand, foreign employees are more efficient at transferring technology than domestic managers. On the other hand, they are less efficient at managing local inputs. Further, the cost of the local input is higher for foreign employees than for domestic managers, and this depends on the institutional environment. We test the implications of the model using data from subsidiaries in Mexico and find that foreign employees are key catalysts for technology transfer in high-tech industry MNCs. At the same time, institutions may impose barriers which limit or disincetive the employment of foreign employees. We find that when institutions prevent MNCs from hiring foreign employees, technology transfer decreases accordingly. This result is consistent with the hypothesis that foreign employees act as a channel for technology transfer.

We rely on a unique combination of data sources, which allows us to link foreign employees, technology transfer and local institutions for both foreign owned and domestic manufacturing plants in Mexico. To measure the role of foreign employees as drivers for technology transfer in MNCs, we rely on a plant-level innovation survey from Mexico. This includes both information regarding the acquisition of technology from abroad and the employment of foreign employees for
the year 2000. To study how institutions may impact the costs of hiring foreign employees, we use data on lawyers' perception concerning the level of judicial efficiency - in terms of protecting financial contracts - present in each Mexican state, as collected by ITAM/GMA (1999).

To guide our empirical analysis, we build a model in which we assume that foreign employees are more efficient at dealing with technology transfer but less efficient at dealing with local inputs (for example, labor or inputs sourced from local suppliers). In the model, we derive the amount of technology transfer and local input employed by the MNC under foreign and domestic management. We then compare the profit of the MNC under a foreign manager and a domestic manager, taking into account (1) how the benefit of foreign employees in terms of technology transfer varies with industry characteristics. In particular we assume that foreign employees are beneficial for technologically oriented MNCs. We also take into account (2) how the disadvantage of relying on a foreign employee depends on local institutions. In particular, we assume that the cost of local inputs is higher for a foreign employee than for a domestic one. Further, the cost disadvantage of the foreign employee decreases as institutions improve.

The model produces a set of testable implications as follows. First, MNCs that belong to high-tech industries and choose a foreign employee will experience a higher level of technological transfer since they rely more heavily on technology inputs. Second, the impact of institutions on the employment of foreign employees follows a U-shaped pattern. In particular, the MNC will find it optimal to rely on a foreign employee either in very poor or in very good institutional environments. In very poor institutional environments, the cost of local inputs is prohibitive and the MNC relies exclusively on technology transfer, for which the foreign employee is more efficient. As institutions improve, MNC demand for local inputs increases, and thus, domestic management is more attractive. However, with further institutional improvements, the cost disadvantage of the foreign employee disappears, making foreign employees beneficial again. Because foreign employees are assumed to be more efficient for technological transfers, the model implies that we should observe a similar U-shaped pattern between institutional quality and the level of technology transfer.

Our empirical analysis is consistent with the main implications of the model. Importantly, the fact that we observe a similar pattern between foreign employees and judicial efficiency and between technology transfer and judicial efficiency provides further support for the hypothesis that foreign employees are a channel for technology transfer in MNCs. This pattern is also
hard to reconcile with alternative hypotheses or selection mechanisms, which we discuss in the subsequent analysis. Finally, the mechanism we describe in the paper analyzes technology transfer from the headquarters and therefore should not apply to domestic firms. Reassuringly, we find that foreign employees in domestically owned plants are not associated with technology transfer, which provides further evidence supporting the mechanism described in the paper.

By showing that the role that foreign employees play in fostering technology transfer is specific to high-tech MNCs, this paper contributes to the literature on MNC activities. In particular, the key to the success of MNCs in other countries is the successful transfer of their core knowledge capital, in which they have advantages. This point has long been recognized in the research on foreign direct investment (FDI) (e.g., Markussen, 1984). Studies find that MNCs are more productive, pay higher wages, and are more export oriented than domestic firms (Markussen (2004), Harrison and Rodriguez-Clare (2010) and Yeaple (2013)). Our findings suggest that foreign employees may be a mechanism that contributes to MNC success. Further, focusing on foreign employees suggests a new channel (the staffing of MNCs) through which institutions act as barriers to technological flows between countries. This is related to the emerging international trade literature on the contracting problems of MNCs. Horstmann and Markussen (1996) argue that local agents may extract information rents due to their superior knowledge of the local environment, influencing the entry mode of MNCs. Branstetter, Fisman and Foley (2006) show that legal reforms on intellectual property rights in countries where subsidiaries locate induce MNCs to transfer more technology. Nunn (2007) shows that judicial quality affects the production of more relation-specific contract-intensive products, which leads to differences in comparative advantages based on judicial quality.

The rest of the paper is organized as follows. Section 2 presents the model and three testable implications. Section 3 presents the data and summary statistics. Section 4 presents the empirical results. Section 5 presents robustness checks. Section 6 concludes. Section 7 includes a data appendix.

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2See Aitken and Harrison (1999) and Todo and Miyamoto (2006) for studies of the impact of MNCs in the local economy.

3Similarly, Cheng Chen (2011) analyzes information asymmetries on the boundaries of the firm as applied to MNCs.

4Kesternich and Schnitzer (2009) analyze both theoretically and empirically and find that as political risk increases the foreign ownership share decreases but leverage increases.

5For surveys of this literature, see Helpman (2006) and Antràs and Rossi-Hansberg (2010). Antràs, Desai and Foley (2009), Manova, Wei and Zhang (2014), and Bilir, Chor and Manova (2013) analyze the consequences of financial market imperfection on FDI, while we focus on judicial efficiency in general transactions.
2 Model

Section 2.1 describes the basic setup of the model. Section 2.2 presents the results for the relation between technology transfer and expatriates. Section 2.3 discusses the impact of institutional quality on MNC choice of foreign employees and technology transfer. We include testable implications that we bring to the data in the empirical section.

2.1 Basic setup

Consider an MNC that employs headquarter (H) and domestic inputs (D) to produce a final good (Y) such that

\[ Y_{ij} = \alpha_i(\eta_j \ln H) + (1 - \alpha_i) \ln D, \]

where \( i = \{e, d\} \) denotes expatriate and domestic manager, respectively and \( j = \{l, h\} \) denotes low-tech and high-tech industries. We employ a linear-log model, where both headquarter and local inputs exhibit positive but decreasing marginal products, and assume that the expatriate is more efficient at managing the headquarter input and that the local manager is better at dealing with the domestic input. That is, \( \alpha_e > \alpha_d \). This reflects the fact that expatriates have previous experience with the multinational’s technology, while domestic managers lack this. We also assume that \( \eta_l = 0 \) and \( \eta_h > 0 \), which reflects the assumption that low-tech MNCs subsidiaries are not technologically oriented. The cost of the headquarter input is \( r \) and is taken as given by the MNC. We assume that hiring an expatriate or a domestic manager does not influence this cost because the firm is a multinational.

The cost of the domestic input, on the other hand, is higher when hiring an expatriate than a domestic manager. Furthermore, this cost difference depends on the legal quality of the state where the MNC operates. In particular, we assume that the cost of a domestic input equals \( w(1 + \frac{c}{\lambda}) \), where \( w \) denotes a constant unit cost and where we assume that \( c_e = c \) (with \( c > 1 \)) and \( c_d = 1 \). That is, ceteris paribus, the expatriate faces a higher cost of obtaining the domestic input. Finally, \( \lambda \) is a measure of legal quality such that \( \lambda \in (0, \lambda_{max}) \). That is, we assume that legal quality influences the cost of the domestic input for both an expatriate and a domestic manager. Furthermore, when legal quality is very poor (as \( \lambda \) approaches zero), the cost of the domestic

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6In the model we use the word expatriate to denote foreign management. In the empirical analysis we use foreign employees, since this is what we observe in our data.
7A case study of German plants in Mexico by Carrillo and González (1999) support this interpretation. In particular, in their study, German employees are said to be used for the “introduction of a new product or process” (translation from Spanish).
8We take this extreme assumption for exposition purposes but it suffices to assume that \( \eta_l < \eta_h \) for the main implications to hold.
input becomes prohibitive for both domestic and expatriate managers. On the other extreme, as legal quality increases, the difference in the cost of the domestic input between the domestic and expatriate managers converges to zero.

2.2 Technology transfer and expatriates

The MNC chooses \( H, D \) and a manager (expatriate or domestic) to maximize profits.\(^9\) The profit function is

\[
\pi_{ij} = \alpha_i (\eta_j \ln H) + (1 - \alpha_i) \ln D - rH - w(1 + \frac{c_i}{\lambda_i})D.
\]

The optimal inputs demand are \( H^*_ij = \frac{\alpha_i \eta_j}{r} \) and \( D^*_i = \frac{1 - \alpha_i}{w(1 + \frac{c_i}{\lambda_i})} \). It follows from our assumptions that \( H^*_ij > H^*_dj \) for \( j = h \). That is, the MNC uses more headquarter input when relying on an expatriate because the latter is more efficient at dealing with it \( (\alpha_e > \alpha_d) \). Further, this holds true only for MNCs that belong to the high-tech industry. Given these assumption we derive Testable Implication 1 as follows:

Testable Implication 1: There is a positive correlation between foreign employees and technology transfer in high-tech industries.

2.3 MNC managerial choice and institutions

Hiring an expatriate manager provides the MNC with an advantage in terms of the use of the headquarter input insofar the MNC is technologically oriented, while the domestic manager provides an advantage in terms of the use of the domestic input. For the rest of the model we only consider MNCs belonging to high-tech industries, since only MNCs in these industries face a trade-off when choosing between an expatriate and a domestic manager. To avoid extra notation we assume that \( \eta_h = 1.\(^{10}\)

Notice that \( D^*_e < D^*_d \). The reason why the MNC uses less domestic inputs when relying on an expatriate is twofold: The expatriate is less efficient at dealing with the domestic input, and the domestic input is more costly, particularly in poor institutional environments. Therefore, institutions have an impact on the trade-off MNCs face when choosing to rely on an expatriate or a domestic manager. In particular, the MNC chooses the manager comparing the profit generated

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\(^9\) We normalize the price of the final good to one.

\(^{10}\) Therefore we do not keep track of the subscript \( j \).
under an expatriate and under a domestic manager. Using the optimal quantities of domestic and headquarter inputs, and simplifying, we obtain

$$\pi_{ix} = \alpha_i \ln \frac{\alpha_i}{w} + (1 - \alpha_i) \ln \frac{1 - \alpha_i}{w(1 + \frac{1}{\lambda})} - 1$$

We solve the managerial choice of the MNC for a generic state with judicial efficiency equal to $\lambda$. The MNC will hire an expatriate if $\pi_e - \pi_d > 0$ and a domestic manager if $\pi_e - \pi_d < 0$ where

$$\pi_e - \pi_d = \alpha_e \ln \frac{\alpha_e}{r} - \alpha_d \ln \frac{\alpha_d}{r} + (1 - \alpha_e) \ln \frac{1 - \alpha_e}{w(1 + \frac{1}{\lambda})} - (1 - \alpha_d) \ln \frac{1 - \alpha_d}{w(1 + \frac{1}{\lambda})}$$

Institutional quality influences the MNC managerial choice, as $\lambda$ has a direct impact on the cost of the domestic input for both domestic and expatriate managers and an indirect impact on the relative disadvantage of the expatriate. We can write the derivative of profit with respect to institutional quality, $\frac{\delta \pi_i}{\delta \lambda}$ for $i \in \{e, d\}$, as a function of three components with an economic interpretation: the weight of the domestic input in production, $(1 - \alpha_i)$, the inverse of institutional quality, $\frac{1}{\lambda}$, and the elasticity of the domestic input demand with respect to institutional quality, $\epsilon_{D_i, \lambda}$. In particular,

$$\frac{\delta \pi_i}{\delta \lambda} = (1 - \alpha_i) \frac{1}{\lambda} \epsilon_{D_i, \lambda}$$

We are interested in knowing how the difference in profit evolves as $\lambda$ increases. Note that when $\lambda$ approaches zero, the domestic input demand by the MNC tends to zero because the input becomes too costly. In this case, the MNC prefers to hire an expatriate. What happens when institutional quality increases? Mathematically, we are interested in the sign of $\frac{\delta (\pi_e - \pi_d)}{\delta \lambda}$.

$$\frac{\delta (\pi_e - \pi_d)}{\delta \lambda} = (1 - \alpha_e) \frac{1}{\lambda} \epsilon_{D_e, \lambda} - (1 - \alpha_d) \frac{1}{\lambda} \epsilon_{D_d, \lambda}$$

where $\epsilon_{D_i, \lambda} = \frac{1}{\lambda + c}$ and $\epsilon_{D_d, \lambda} = \frac{1}{\lambda + 1}$.

Note that $(1 - \alpha_e) \frac{1}{\lambda} > (1 - \alpha_d) \frac{1}{\lambda}$ (since $\alpha_e > \alpha_d$) and that $\epsilon_{D_e, \lambda} > \epsilon_{D_d, \lambda}$ (since $c > 1$).\(^\text{11}\) This means that when institutional quality improves, two forces move in opposite directions. On the one hand, improvements in institutions will benefit more an MNC that uses a domestic manager because under a domestic manager, the domestic input demand is higher and it has a bigger weight on production. On the other hand, the elasticity of the domestic input demand is higher for an expatriate than for a domestic manager because the expatriate’s relative cost disadvantage in obtaining the domestic input decreases as institutions improve.

Theoretically, therefore, the difference in profit can be positive or negative depending on the sign of the following expression, which we obtain rearranging the previous equation as follows:

$$\frac{\epsilon_{D_d, \lambda}}{\epsilon_{D_e, \lambda}} \frac{\alpha_e - \alpha_d}{1 - \alpha_e}$$

or in a more reduced way $R(\lambda, c) - \alpha$ where $R(\lambda, c) \equiv \frac{\epsilon_{D_d, \lambda}}{\epsilon_{D_e, \lambda}} = \frac{\lambda + c}{\lambda + 1}$ and $\alpha \equiv \frac{1 - \alpha_e}{1 - \alpha_d}$

\(^\text{11}\)If we assume $c = 1$, the expatriate does not have a relative disadvantage in buying the domestic input that depends on institutional quality. In that case, the elasticities of the domestic input demand would be the same for both the domestic and the expatriate manager. As a consequence, improvements in institutions would unambiguously push the MNC to switch management from foreign to domestic, as $\frac{\delta (\pi_e - \pi_d)}{\delta \lambda} < 0$. 

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where \( \alpha \epsilon (0,1) \) and \( R(\lambda, c) > 0 \).

Therefore,
\[
\frac{\delta (\pi_e - \pi_d)}{\delta \lambda} < 0 \quad \text{when} \quad R(\lambda, c) > \alpha \quad (1)
\]
\[
\frac{\delta (\pi_e - \pi_d)}{\delta \lambda} = 0 \quad \text{when} \quad R(\lambda, c) = \alpha \quad (2)
\]
\[
\frac{\delta (\pi_e - \pi_d)}{\delta \lambda} > 0 \quad \text{when} \quad R(\lambda, c) < \alpha \quad (3)
\]

Because \( \alpha \) does not change with institutional quality, all we need to check is how \( R(\lambda, c) \) changes with \( \lambda \). In particular, \( \frac{(\lambda, c)}{\delta \lambda} = \frac{c^2(\lambda+1) - c(\lambda+c)}{\lambda(\lambda+1)^2} < 0 \) since we assume that \( c > 1 \).

This implies that institutional quality improvements can have non-linear effects on the managerial choice of MNC and, therefore, on the use of domestic and headquarter inputs. Recall that when \( \lambda \) tends to zero, the MNC always prefers to hire an expatriate manager. That is, when institutional quality is extremely poor, the cost of the domestic input is prohibitive for both the domestic and expatriate managers, and the expatriate advantage in terms of the headquarter input dominates. We can distinguish three cases based on conditions (1)-(3):

1. \( \pi_e - \pi_d > 0 \) for all values of \( \lambda \) and the MNC chooses an expatriate regardless of \( \lambda \). In this case the expatriate advantage in terms of the headquarter input is large enough to outweigh its disadvantage in terms of domestic input even when improvements in institutional quality lead to an increase in the domestic input demand that increases the advantage of having a domestic manager.

2. Condition (1) holds for all values of \( \lambda \), and there exists \( \lambda^l \) such that the MNC chooses an expatriate when \( \lambda < \lambda^l \) and a domestic manager when \( \lambda > \lambda^l \). In this case, as institutions improve, the MNC increases its demand for domestic inputs, which eventually makes the domestic manager more attractive, as it is more productive at transforming this input into output and the domestic manager obtains the input at a lower cost.

3. Condition (3) holds for some value \( \lambda^c \) such that \( \lambda^c < \lambda^{max} \), and there exists \( \lambda^l \) and \( \lambda^u \) such that the MNC chooses an expatriate when \( \lambda < \lambda^l \), a domestic manager when \( \lambda^u > \lambda > \lambda^l \) and an expatriate manager when \( \lambda > \lambda^u \), where \( \lambda^{max} > \lambda^u > \lambda^c \). When \( \lambda < \lambda^u \) the same logic as in case 2 applies. Yet, as institutional quality further increases, the domestic input demand increases faster for the expatriate, as the cost of the input converges to the cost for the domestic manager, undoing part of the advantage of the domestic manager. This results from the fact that the elasticity of the domestic input demand is higher for the expatriate.
than for the domestic manager because institutional improvements decrease the cost of the input for the expatriate relatively more than for the domestic manager. When this effect prevails, condition (3) holds, and eventually, the expatriate benefits relatively more from the institutional improvement. The impact of institutional quality on the relative elasticities of the domestic input demand of the expatriate and of the domestic manager means that the advantage of the domestic manager decreases as institutions improve, even if the domestic manager is still more efficient at dealing with the domestic input. In such a case, the expatriate advantage in headquarter input may again outweigh the domestic manager advantage and lead the MNC to hire an expatriate in very good institutional environments.

Based on this discussion, we posit Testable Implication 2:

*Testable Implication 2: MNC hiring of foreign employees is U-shaped in judicial efficiency.*

Testable Implication 1 and 2 together imply Testable Implication 3 as follows:

*Testable Implication 3: Technology transfer in MNC is U-shaped in judicial efficiency.*

## 3 Data

To test our three testable implications we rely on three sources of data, which we describe in detail next. First, the source of information is the *Encuesta Sobre Investigación y Desarrollo de Tecnología* (ESIDET) [Survey on research and development of technology]. This is a confidential survey carried out by the Instituto Nacional de Estadística y Geografía (INEGI) [National institute of statistics and geography] of Mexico for the Consejo Nacional de Ciencia y Tecnología (CONACYT) [National council of science and technology]. It has surveys for three sectors: production, education, and government. We use the data for the manufacturing plants that are part of the production sector. The survey contains information on several aspects of innovative activities: expenditures, human resources and collaborating firms and institutions.

We use the 2002 survey.\(^{12}\) The survey for the production sector addresses plants with more

\(^{12}\)The survey was carried out in 1994, 1996 and 1998. There was no survey in 2000. Starting from 2002, the
than 50 employees. The survey uses the Economic Census of 1999 to draw a sample. Among the 11728 plants in the Economic Census of 1999, the plants with more than 500 employees are included in the sample with certainty. Plants with at most 500 employees are sampled with probability depending on whether they have employees (a) between 50 and 100, (b) 101 and 250 and (c) 251 and 500.

Each survey elicits information for the previous two years, but for this paper, we focus on the cross-sectional variation and report the result for 2000. The key variable is technology transfer, which is defined in the survey as expenses for international technology transfer [egresos por transferencia de tecnología (internacional) in Spanish] and includes the cost for purchase or licence of patents and other non-patented inventions and revelation of know-how. One limitation of the data is that we are not able to distinguish between technology transfers from parents and those from other firms. However, we think that the variable mainly consists of technology transfers from the headquarters, as Branstetter, Fisman and Foley (2006) suggest that the mean of royalties paid by affiliates to their headquarters is 0.7 percent (after the patent reform for all the countries), which is actually larger than the mean of the variable in our sample (0.3 percent).

Second, regarding judicial efficiency, we use the data on lawyers’ perception of judicial efficiency, in terms of the protection of financial contracts, for each Mexican state collected by ITAM/GMA (1999) as a measure of average local efficiency. The ITAM/GMA study collected the data focusing on the legal enforcement of financial contracts, which fits our model. The measure captures the mean score along several dimensions such as the quality of judges, the adequacy of judicial resources and the efficiency of enforcement of rulings, among others, and mainly reflects variations on λ. The mean and the standard deviation of the measure are 2.78 and 0.56.

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respectively.

Table 1 presents summary statistics. We report the mean and the standard deviation of the mean of each variable by whether plants have foreign employees. Plants with foreign employees have larger volumes of total sales and employment. The summary statistics for domestic sales and exports show that plants with foreign employees are more export-oriented. Also, plants with at least one foreign employee have a statistically significant greater likelihood of spending a positive amount in technology transfer from abroad. The amount of the expenditure and the ratio of the expenditure on total sales are higher for plants with at least one foreign employee than for plants with no foreign employee although the difference is not statistically significant. 162 out of our sample of 302 foreign plants report having no foreign employees.

Table 1: Summary statistics of plant variables in 2000 (ESIDET)

<table>
<thead>
<tr>
<th></th>
<th>Plants with no foreign employees</th>
<th>Plants with foreign employees</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log(Total Sales)</td>
<td>12.83***</td>
<td>13.43***</td>
<td>13.11</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
<td>(0.12)</td>
<td>(0.08)</td>
</tr>
<tr>
<td>Log(Domestic Sales)</td>
<td>11.66</td>
<td>12.04</td>
<td>11.84</td>
</tr>
<tr>
<td></td>
<td>(0.26)</td>
<td>(0.29)</td>
<td>(0.19)</td>
</tr>
<tr>
<td>Exporter Dummy</td>
<td>0.80**</td>
<td>0.90**</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Exports/Total Sales</td>
<td>0.29*</td>
<td>0.36*</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Domestic Employees</td>
<td>1083.42*</td>
<td>1563.20*</td>
<td>1305.83</td>
</tr>
<tr>
<td></td>
<td>(156.90)</td>
<td>(241.87)</td>
<td>(140.63)</td>
</tr>
<tr>
<td>Foreign Employees Share (%)</td>
<td>0.00***</td>
<td>1.06***</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.11)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>Dummy (1 if Transfer &gt; 0)</td>
<td>0.11***</td>
<td>0.25***</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td>(0.04)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Total Transfer</td>
<td>2627.68</td>
<td>5252.75</td>
<td>3844.60</td>
</tr>
<tr>
<td></td>
<td>(1038.18)</td>
<td>(1646.18)</td>
<td>(946.08)</td>
</tr>
<tr>
<td>Total transfer/Sales (%)</td>
<td>0.29</td>
<td>0.43</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>(0.09)</td>
<td>(0.10)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>Number</td>
<td>162</td>
<td>140</td>
<td>302</td>
</tr>
</tbody>
</table>

Notes: The table reports summary statistics of basic plant variables. The first column shows statistics for plants without foreign employees, while the second shows statistics for plants with foreign employees, and the third column pools all plants together. Standard deviation of the means are in parentheses. Expenditure on technology transfer is in nominal thousand pesos (A dollar was 9.5 pesos at the beginning of 2000). Significance of the test of the equality of the mean of the two groups: * 10 percent, ** 5 percent, *** 1 percent.
4 Empirical Results

We proceed in the following way. In section 4.1 we investigate Testable Implication 1. In section 4.2, we investigate whether Mexican states with higher levels of judicial efficiency have more/less foreign employees, which is an examination of Testable Implication 2. In section 4.3 we explore Testable Implication 3 by investigating the relation between the judicial efficiency and technology transfer. Finally, in section 4.4 we present and discuss the results for domestic plants.

4.1 Plant-level correlates of foreign employees

In this section, we examine Testable Implication 1, i.e., whether Mexican subsidiaries of MNCs hiring foreign employees that belong to high-tech industries spend more in technology purchases from abroad.

In particular, we analyze the correlation between foreign employees and technology transfer with the following regression for the main specifications.

\[
(Tech\ Transfer/Sales)_{ijs} = \beta_1 D(Foreign\ Expatriates_{ijs}) + \beta_2 D(Foreign\ Expatriates_{ijs}) \times R&D\ Intensity_j + \beta_3 Exporter\ Dummy_{ijs} + \beta_4 \log(Employees_{ij}) + \mu_j + \delta_s + \epsilon_{ijs}
\]

where \((Tech\ Transfer/Sales)_{ijs}\) is the expenditure on technology transfer from abroad over sales in plant \(i\) in industry \(j\) at state \(s\); \(D(Foreign\ Expatriates_{ijs})\) is a dummy variable indicating whether plant \(i\) in industry \(j\) in state \(s\) has foreign employees; \(\mu_j\) is an industry fixed effect and \(\delta_s\) is a state fixed effect. We include an exporter dummy and the log of the number of employees to control for size and export orientation.\(^{17}\) The main coefficient of interest is \(\beta_2\), which according to Testable Implication 1 should be positive.

To capture the technological orientation of the MNC we use U.S R&D intensity since the U.S. is a typical headquarter country.\(^{18}\) The measure of \(R&D\ Intensity_j\) deserves detailed explanation. We draw this information from a standard source, the U.S. Federal Trade Commission (FTC) Line

\(^{17}\)We did not use total sales as an independent variable because it appears in the left-hand-side variable.

\(^{18}\)Over the second half of the 1990s and the first half of the 2000s, over 60 percent of FDI toward Mexico originates in the U.S. See, for example, Cuevas et al. 2005.
of Business Survey from 1974 to 1977. The Line of Business Survey required firms to separately report R&D expenditures by industry, thus providing the most reliable industry-level information on R&D expenditures. The measure has been used in leading studies in international trade, such as Antràs (2003) and Kugler and Verhoogen (2012), for example. We made the concordance between FTC industry classification and Mexican industry classification by verbal industry descriptions.

Table 2: Regression of the technology transfer on foreign employees. ESIDET 2000.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
<td>Technology Transfer: Intensity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign Employees Dummy</td>
<td>0.262*</td>
<td>0.260</td>
<td>0.219</td>
<td>0.048</td>
<td>0.067</td>
<td>0.113</td>
<td>0.108</td>
</tr>
<tr>
<td></td>
<td>(0.152)</td>
<td>(0.189)</td>
<td>(0.174)</td>
<td>(0.194)</td>
<td>(0.231)</td>
<td>(0.186)</td>
<td>(0.241)</td>
</tr>
<tr>
<td>US Industry R&amp;D</td>
<td>0.695</td>
<td>-1.440</td>
<td>-1.164</td>
<td>3.776**</td>
<td>3.386*</td>
<td>3.333**</td>
<td>3.247*</td>
</tr>
<tr>
<td></td>
<td>(1.604)</td>
<td>(1.436)</td>
<td>(1.714)</td>
<td>(1.475)</td>
<td>(1.711)</td>
<td>(1.362)</td>
<td>(1.812)</td>
</tr>
<tr>
<td>Foreign Employees Dummy*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US Industry R&amp;D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry Controls</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Industry Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State Effects</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.195</td>
<td>0.249</td>
<td>0.074</td>
<td>0.037</td>
<td>0.078</td>
<td>0.209</td>
<td>0.252</td>
</tr>
<tr>
<td>N</td>
<td>302</td>
<td>302</td>
<td>302</td>
<td>302</td>
<td>302</td>
<td>302</td>
<td>302</td>
</tr>
</tbody>
</table>

Notes: The table reports coefficients on the dummy variable indicating whether plants have foreign employees, industry-level U.S. R&D intensity and their interactions from plant-level regressions of the expenditure on technology transfer from abroad on the combinations of the dummy variable indicating whether a plant has foreign employees, its interaction term with the U.S. industry-level R&D intensity, the log of the number of workers, exporter dummy, industry fixed effects and state fixed effects. The technology transfer measure is the expenditure divided by total sales. Robust standard errors are in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 2 shows the results. Columns (1) to (3) include preliminary specifications, while Columns (4) to (7) test for our Testable Implication 1. We next discuss these results in detail. Column (1) of Table 2 shows that foreign employees are positively correlated with technology transfer. Yet, this correlation looses significance when including state fixed effect in Column (2). Column (3) shows that U.S. Industry R&D is positively (but not significantly) correlated with technology transfer. Columns (4)-(7) show that, consistent with Testable Implication 1, there is a positive and significant correlation between foreign employees and technology transfer in high-tech industries. In particular, the coefficient on the interaction term between foreign employees dummy and
US industry-level R&D intensity is statistically significant and positive across specifications in Columns (4) to (7). This result is robust to the inclusion of industry controls, or industry fixed effects and to state fixed effects. This suggests that foreign employees are a channel for technology transfer in high tech MNCs, which is the main hypothesis of the paper.

4.2 Regional determinants of foreign employees

This section empirically examines Testable Implication 2, which predicts that the impact of local judicial efficiency on the use of foreign employees is U-shaped. More concretely, Testable Implication 2 states that at a low level of judicial efficiency, the dependence on foreign employees is decreasing in judicial efficiency, while at a high level of judicial efficiency, the dependence on foreign employees is increasing in judicial efficiency.

We run a regression of the following form:

\[ D(\text{ForeignEmployees}_{ijs}) = \beta_1 \text{JudicialEfficiency}_{s} + \beta_2 (\text{JudicialEfficiency}_{s})^2 + (\gamma X_{ijs}) + \mu_j + \epsilon_{ijs} \]

\text{JudicialEfficiency}_{s} is the measure of the judicial efficiency at state s. We include an exporter dummy and the log of the total number of employees in some specifications to control for export orientation and the size of the subsidiaries. We also control for state-level GDP per capita and its square term, population density, the ratio of skilled workers, the capital city dummy, and the state border dummies. We do so to separate the effect of judicial efficiency from the effect of state-level variables. We cluster standard errors at the state level as the judicial efficiency measure varies at that level.

Our theory predicts that the effect of judicial efficiency has a U-shaped effect on the reliance of foreign employees. In terms of the coefficients, this implies that \( \beta_1 \) should be negative and \( \beta_2 \) should be positive. Furthermore, the relative magnitude of \( \beta_1 \) and \( \beta_2 \) should be such that the implied level of judicial efficiency in which the dependence on foreign employees is minimized should happen within the range of judicial efficiency in our data. Therefore, \(-\beta_1/(2\beta_2)\) should range between 1 and 5.

Table 3 shows the results of the estimation using a Probit model. The table reports the marginal effects. For all the specifications, \( \beta_1 \) is negative, while \( \beta_2 \) is positive, which suggests that
the results are not sensitive to the inclusion of industry fixed effects and other regional controls.

Table 3: Regression of the effect of judicial efficiency on the use of foreign employees. ESIDET 2000.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judicial Efficiency</td>
<td>1.738***</td>
<td>1.704***</td>
<td>1.873***</td>
<td>0.986*</td>
</tr>
<tr>
<td>(Judicial Efficiency)^2</td>
<td>0.291***</td>
<td>0.275***</td>
<td>0.307***</td>
<td>0.186*</td>
</tr>
<tr>
<td>Firm Control</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State Control</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry Effects</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>N</td>
<td>302</td>
<td>282</td>
<td>282</td>
<td>282</td>
</tr>
</tbody>
</table>

Notes: The table reports the marginal effects of judicial efficiency and its square term from plant-level probit regressions of the foreign employee dummy on judicial efficiency and its square term, exporter dummy, the log of the number of workers, state-level per capita GDP and its square term, the distance to the border, the dummy variable indicating the capital metropolitan area, skilled worker ratio, population density, and industry fixed effects. Some firms are dropped when we include industry fixed effects due to collinearity, leading the changes in the sample size between columns. Standard errors are clustered at the state level and reported in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

The results in Table 3 suggest that the relation between judicial efficiency and foreign employees is U-shaped in the range of judicial efficiency. The magnitude of the coefficients implies that $-\beta_1/(2\beta_2)$ range between 1 and 5 for all the columns. Furthermore, this is robust to the inclusion of state controls, in addition to firm controls and industry fixed effects as Column (4) of Table 3 shows.

4.3 Regional determinants of technology transfer

Testable Implication 3 states that at a low level of judicial efficiency, technology transfer is decreasing in judicial efficiency and that a high level of judicial efficiency technology transfer is increasing in judicial efficiency. We run a regression of the same form as before but using the intensity of technology transfer as the dependent variable.

$$(TechTransfer/Sales)_{ij} = \beta_1 JudicialEfficiency_{ij} + \beta_2 (JudicialEfficiency_{ij})^2 + (\gamma X_{ij}) + \mu_j + \epsilon_{ij}$$
Table 4: Regression of the effect of judicial efficiency on technology transfer.
ESIDET 2000.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
<td>Technology Transfer: Intensity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judicial Efficiency</td>
<td>-1.173**</td>
<td>-2.287***</td>
<td>-2.267***</td>
<td>-1.433***</td>
</tr>
<tr>
<td>(Judicial Efficiency)</td>
<td>(0.767)</td>
<td>(0.580)</td>
<td>(0.634)</td>
<td>(0.461)</td>
</tr>
<tr>
<td>(Judicial Efficiency)^2</td>
<td>0.215</td>
<td>0.377***</td>
<td>0.372***</td>
<td>0.303***</td>
</tr>
<tr>
<td>(Judicial Efficiency)^2</td>
<td>(0.130)</td>
<td>(0.096)</td>
<td>(0.104)</td>
<td>(0.069)</td>
</tr>
<tr>
<td>Firm Control</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State Control</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry Effects</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>r^2</td>
<td>0.005</td>
<td>0.193</td>
<td>0.204</td>
<td>0.227</td>
</tr>
<tr>
<td>N</td>
<td>302</td>
<td>302</td>
<td>302</td>
<td>302</td>
</tr>
</tbody>
</table>

Notes: The table reports coefficients on judicial efficiency and its square term of linear regressions of the technology transfer intensity on judicial efficiency and its square term, exporter dummy, the log of the number of workers, state-level per capita GDP and its square term, the distance to the border, the dummy variable indicating the capital metropolitan area, skilled worker ratio, population density, and industry fixed effects. The technology transfer intensity measure is the expenditure divided by total sales. Robust standard errors are in parentheses. Standard errors are clustered at the state level and reported in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 4 shows the results. Only when we control for neither state controls nor industry fixed effects results are not significant (Column (1)). For specifications in Columns (2), (3) and (4) results are significant and consistent with our hypothesis ($\beta_1$ is negative, while $\beta_2$ is positive). Thanks to controlling for industry and state characteristics, therefore, we are able to capture the U-shaped relation between technology transfer and judicial efficiency that our theory predicts. The results suggest that, consistent with our theory, judicial efficiency reduces the amount of technology transfer in the low judicial efficiency regime, while the opposite is true in the high judicial efficiency regime.

The reason for which the theory predicts a U-shaped pattern between judicial efficiency and technology transfer follows directly from hypotheses 1 and 2 of the model; namely, (1) foreign employees are positively associated with technology transfer in the MNC because they are more efficient at transferring technology and (2) MNCs are more likely to rely on foreign employees in either very good or very bad institutional environments. This is indeed confirmed by findings in Tables 3 and 4. The fact that we observe this U-shaped pattern in the data very strongly suggests
that foreign employees represent an important channel for technology transfer. Empirically, there could be other reasons that judicial efficiency impacts technological transfer. These alternative reasons would have a monotonic impact on technology transfer, as we discuss in detail in the selection issues section of the robustness checks. Either these additional channels are nonexistent, or they are less strong than the role of foreign employees as a channel for technology transfer. In sum, the U-shaped relationship between technology transfer and judicial efficiency is consistent with the role that foreign employees play as a channel for technology transfer and is difficult to explain with alternative hypotheses.

4.4 Domestically-owned plants

In this section, we revisit the predictions on the correlates of foreign employees but for domestically-owned plants. Domestically-owned plants allow us to further investigate the role of foreign employees. By analyzing the correlation between foreign employees and technology transfer in domestically owned plants, we are able to determine whether foreign employees are a channel for technology transfer only in MNCs. If the strength of foreign employees comes from their specific experiences with the MNCs, we should not observe that domestically-owned plants make more technology purchases when hiring foreign employees.

We also analyze the impact of judicial efficiency on the hiring of foreign employees in domestically owned plants. This evidence allows us to rule out omitted variables concerns. In particular, it could be that correlates of judicial efficiency related to the attractiveness of the Mexican state for foreign employees (such as the quality of infrastructure, administration or schooling, among others) may be driving the results. For instance, if one of these factors makes the state more attractive for both foreign employees and for technology transfer, our findings could be spurious. By analyzing whether the presence of foreign employees in different states follows a different pattern for domestically-owned plants than for foreign owned plants, we are able to provide support for our main interpretation of the findings. Finally, we also show results for the impact of judicial efficiency on technology transfer in domestically-owned plants. This analysis allows us to further address the possibility that institutions impact technology transfer in a U-shaped pattern not because foreign employees are a channel for technology transfer but for some other reason.

Table 5 and Table 6 show the analysis of Tables 2, 3 and 4 using the sample of domestically owned plants. Table 5 shows that the effect of foreign employees on technology transfer intensity...
Table 5: Regression of the technology transfer on foreign employees. Domestically owned plants from ESIDET 2000.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Employees Dummy</td>
<td>0.004</td>
<td>-0.002</td>
<td>-0.011</td>
<td>-0.023</td>
<td>-0.028</td>
<td>-0.009</td>
<td>-0.016</td>
</tr>
<tr>
<td>US Industry R&amp;D</td>
<td>0.201</td>
<td>0.254</td>
<td>0.182</td>
<td>(0.294)</td>
<td>(0.519)</td>
<td>(0.087)</td>
<td>(0.401)</td>
</tr>
</tbody>
</table>

| Industry Controls | No | No | Yes | Yes | No | No | No |
| Industry Effects | Yes | Yes | No | No | Yes | Yes | Yes |
| State Effects | No | Yes | No | Yes | No | Yes | Yes |
| \(R^2\) | 0.020 | 0.044 | 0.007 | 0.033 | 0.027 | 0.051 | 0.052 |
| N | 1071 | 1071 | 1071 | 1071 | 1071 | 1071 | 1071 |

Notes: The table reports coefficients on the dummy variable indicating whether plants have foreign employees, industry-level U.S. R&D intensity and their interactions from plant-level regressions of the expenditure on technology transfer from abroad on the combinations of the dummy variable indicating whether a plant has foreign employees, its interaction term with the U.S. industry-level R&D intensity, the log of the number of workers, exporter dummy, industry fixed effects and state fixed effects. The technology transfer measure is the expenditure divided by total sales. The difference from Table 2 is that this table reports the results for domestically-owned samples while Table 2 reports the results for foreign-owned plants. Robust standard errors are in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.
Table 6: Regression of the effect of judicial efficiency on technology transfer. Domestically owned plants from ESIDET 2000.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judicial Efficiency</td>
<td>0.356</td>
<td>0.481*</td>
<td>0.073</td>
<td>0.135</td>
</tr>
<tr>
<td></td>
<td>(0.268)</td>
<td>(0.284)</td>
<td>(0.083)</td>
<td>(0.139)</td>
</tr>
<tr>
<td>(Judicial Efficiency)$^2$</td>
<td>-0.070</td>
<td>-0.087*</td>
<td>-0.012</td>
<td>-0.019</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.052)</td>
<td>(0.011)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>Firm Control</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>State Control</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.020</td>
<td>0.036</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>704</td>
<td>704</td>
<td>1071</td>
<td>1071</td>
</tr>
</tbody>
</table>

Notes: Columns (1) and (2) of the table report the marginal effects of judicial efficiency and its square term from plant-level probit regressions of the foreign employee dummy on judicial efficiency and its square term, exporter dummy, the log of the number of workers, state-level per capita GDP and its square term, the distance to the border, the dummy variable indicating the capital metropolitan area, skilled worker ratio, population density, and industry fixed effects. Columns (3) and (4) report coefficients on judicial efficiency and its square term of linear regressions of technology transfer on the same set of the variables described above. Standard errors are clustered at the state level for all columns and reported in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.
for domestically owned plants is quantitatively smaller (even less than one-tenth) than that for MNC subsidiaries and is statistically insignificant. In short, the presence of foreign employees is not correlated with technology transfer from abroad for domestically-owned plants. This is consistent with the hypothesis that the advantage that foreign employees have over local employees derives from their specific experience and/or connections with the MNCs they work at.

Table 6 Columns (1) and (2) show that the results regarding the impact of judicial efficiency on foreign employees are not significant or in the opposite sign. This rules out omitted variable concerns that some characteristics of the state that correlate with judicial efficiency increase the attractiveness for the presence of foreign employees and for technology transfer.\textsuperscript{19} To the extent that these characteristics have the same impact for foreign employees in domestic and foreign owned plants, not finding a U-shaped pattern for domestic plants is reassuring. It suggests that these potentially omitted variables are not driving the correlation between foreign employees and judicial efficiency in our sample of MNC plants. Furthermore, the only specification where judicial efficiency and its square term significantly correlate with foreign employees has the opposite sign than for MNC plants. This is further evidence that a different logic applies for domestically-owned plants.

Finally, Table 6 Columns (3) and (4) show that the results concerning the impact of judicial efficiency on technology transfer are not significant either. This confirms that when foreign employees do not act as a channel for technology transfer (i.e., for domestically-owned plants) institutions do not impact the extent of technology transfer. This provides further support against the speculation that technology transfer may be more productive in states where foreign employees may adapt better.

Overall, the analysis of domestic plants rules out potential omitted variable concerns and suggests that foreign employees are a channel for technology transfer that is specific to MNCs and therefore related to MNC-specific human capital.

5 Robustness Checks

This section discusses robustness checks, including selection issues and alternative hypotheses.

\textsuperscript{19}These characteristics could include local living conditions or administrative complexities that impact the adaptation costs of foreign employees, decreasing the attractiveness of the state in a way unrelated to the mechanism described in the paper.
5.1 Alternative measure of technology transfer

Our measure of technology transfer is based on survey responses to the question “expenses for international technology transfer which includes the cost for purchase or license of patents and other non-patented inventions, revelation of know-how, and technical assistance”.20 There are two main concerns about this measure. First, plants may not disclose the true amount of purchase in the survey. Second, even if they do, technology purchase may capture only a part of actual technology transfer activities. In this section, we provide robustness checks concerning the measure of technology transfer using two approaches.

First, we address the possibility that firms that underreport the extent of technological transfer are special in some relevant dimension. To do this, we exclude plants that report zero for all spending categories of technology transfer, which suggests misreporting.21 When doing so, both the correlation between foreign employees and technology transfer intensity and the correlation between technology transfer intensity and judicial efficiency remain significant.22

Second, we use the ratio of imported intermediate materials over total cost as an alternative outcome variable. This alternative measure proxies imports from the headquarters, which are likely to be complementary to technology transfer. Keller and Yeaple (2013) use intermediate input imports from parents as a measure of technology transfer. Unfortunately, expenses on intermediate materials imported from parents are not available in the data. However, Ruhl (2013) documents that the ratio of intra-firm transactions in total US exports to Mexico (Mexican imports from the US) is between 30 and 40 percent. Since the share of intra-firm transactions in trade by MNCs must be higher than this number, imports from parents are likely to occupy a significant fraction in expenses on imported intermediate materials by foreign owned plants.23

Our main data set does not include expenses on imported intermediates. Therefore, another plant-level survey, Encuesta Industrial Anual (EIA) [annual industrial survey], is linked to the data set. The EIA is a longitudinal plant level data set, compiled by INEGI. The EIA covers plants in each industry from the largest plants to plants where the sample covers 85 percent of

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20INEGI sends trained persons (enumerators) to plants and get the companies to fill the survey. While we know how much is spent on technology transfer, the survey does not record how much of it occurs over the phone, and over visits of HQ managers to the affiliates. 80 percent of affiliates in our dataset answer zero.

21Specifically, we excluded plants that report zero for all the items in the following categories: R&D expenses, expenses for improvement of energy efficiency; expenses for preventing pollution; expenses for improving health of workers; expenses for training technology-related workers.

22These results are available upon request.

23Ramondo, Rapoport and Ruhl (2015) document important heterogeneity of reliance on intra-firm transactions among MNCs, which we acknowledge as a potential limitation of our approach in this section.
domestic sales in each industry.\textsuperscript{24}

We run the following regression.

\[
\frac{\text{Imported Intermediates/Cost}}{ij} = \beta_1 D(\text{Foreign Employees}_{ij}) + \beta_2 D(\text{Foreign Employees}_{ij}) \times R&D \text{ Intensity}_j + \beta_3 \text{Exporter Dummy}_{ij} + \beta_4 \log(\text{Employees}_{ij}) + \mu_j + \delta_s + \epsilon_{ij}
\]

and

\[
\frac{\text{Imported Intermediates/Cost}}{ij} = \beta_1 \text{Judicial Efficiency}_s + \beta_2 (\text{Judicial Efficiency}_s)^2 + (\gamma X_{ij}) + \mu_j + \epsilon_{ij}
\]

Table 7 shows the results. Columns (1) and (2) show the relation between imported intermediate materials and foreign employees. Column (1) shows that there is no statistically significant correlation between technology transfer and foreign employees for all manufacturing industries. Column (2) shows that we do find a statistically significant correlation in technology intensive industries. This is in line with Testable Implication 1.\textsuperscript{25} Furthermore, we also find a statistically significant U-shaped relation between imported intermediate materials and judicial efficiency (Column (3)). Overall, therefore, we find that the ratio of imported intermediate materials over total materials behaves in a very similar way to technology transfer.

5.2 Alternative measure of foreign employees

Throughout the paper our main measure of foreign employees is a dummy variable equal to one if the MNC hires at least one foreign employee and zero if there are no foreign employees in the MNC. In this section we discuss the robustness of the main analysis of the paper using an

\textsuperscript{24}The use of another survey unrelated to innovation activities may also mitigate the concern about measurement.

\textsuperscript{25}It is also worth mentioning that the technological content of imported intermediate materials may be higher for high-tech industries, and therefore, this measure may be a less noisy proxy for technology transfer for this type of firms. It is plausible that for industries that are less technological intensive, imported intermediate materials may be a very noisy proxy for technology transfer. Furthermore, the fact that we find that foreign employees are not significantly associated with the import of inputs (for example, raw materials) whose content may require less MNC-specific human capital.
Table 7: Regression of the imported intermediates on foreign employees. ESIDET 2000.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Imported Intermediates/Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign Employees Dummy</td>
<td>0.007</td>
<td>-0.032</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.029)</td>
<td></td>
</tr>
<tr>
<td>Foreign Employees Dummy*</td>
<td></td>
<td>0.7480*</td>
<td></td>
</tr>
<tr>
<td>Industry R&amp;D</td>
<td></td>
<td>(0.4030)</td>
<td></td>
</tr>
<tr>
<td>Judicial Efficiency</td>
<td></td>
<td></td>
<td>-1.107*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.623)</td>
</tr>
<tr>
<td>(Judicial Efficiency)^2</td>
<td></td>
<td></td>
<td>0.158*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.084)</td>
</tr>
<tr>
<td>Industry fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Plant-level Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State-level Controls</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>State fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>R^2</td>
<td>0.642</td>
<td>0.647</td>
<td>0.542</td>
</tr>
<tr>
<td>N</td>
<td>131</td>
<td>131</td>
<td>131</td>
</tr>
</tbody>
</table>

Notes: Columns (1) and (2) of the table report coefficients on the dummy variable indicating whether plants have foreign employees, its interaction term with U.S. R&D intensity at the industry level from plant-level regressions of the expenditure on imported intermediate inputs on the combinations of the dummy variable indicating whether a plant has foreign employees, its interaction term with the U.S. industry-level R&D intensity, and the log of the number of workers, exporter dummy, industry and state fixed effects. Robust standard errors are in parentheses. Column (3) reports coefficients on judicial efficiency and its square term of linear regressions of imported intermediate inputs on judicial efficiency and its square term, exporter dummy, the log of the number of workers, state-level per capita GDP and its square term, the distance to the border, the dummy variable indicating the capital metropolitan area, skilled worker ratio, population density, and industry fixed effects. Standard errors are clustered at the state level and reported in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.
alternative measure of foreign employees based on the share of foreign employees.

Table 8: Regressions using foreign employee share

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(1) Technology Transfer</th>
<th>(2)</th>
<th>(3) Foreign Employees Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Employees Share</td>
<td>7.274 (7.597)</td>
<td>-1.293 (6.768)</td>
<td></td>
</tr>
<tr>
<td>Foreign Employees Share*</td>
<td>258.154*** (88.587)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry R&amp;D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judicial Efficiency</td>
<td>-0.023* (0.013)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Judicial Efficiency)^2</td>
<td>0.003* (0.002)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Plant-level Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State-level Controls</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>State fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>R^2</td>
<td>0.242</td>
<td>0.247</td>
<td>0.191</td>
</tr>
<tr>
<td>N</td>
<td>302</td>
<td>302</td>
<td>302</td>
</tr>
</tbody>
</table>

Notes: Columns (1) and (2) of the table reports coefficients on the share of foreign employees, its interaction term with U.S. R&D intensity at the industry level, the log of the number of employees and exporter dummy from plant-level regressions of the expenditure on technology transfer from abroad on the combinations of the dummy variable indicating whether a plant has foreign employees, its interaction term with the U.S. industry-level R&D intensity, the log of the number of workers, exporter dummy, industry fixed effects and state fixed effects. The technology transfer intensities measure is the expenditure divided by total sales. Robust standard errors in parentheses. Column (3) of the table reports coefficients on judicial efficiency and its square term of regressions of the share of foreign employees on judicial efficiency and its square term, exporter dummy, the log of the number of workers, state-level per capita GDP and its square term, the distance to the border, the dummy variable indicating the capital metropolitan area, skilled worker ratio, population density, and industry fixed effects. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 8 replicates the results from Tables 2 and 3 using the share of foreign employees instead of a dummy variable. Column (1) shows the results for all manufacturing and Column (2) shows the results when interacting the share of foreign employees with U.S Industry R&D. We find similar results between the share of foreign employees and technology transfer using this alternative measure of foreign employees. This confirms our main hypothesis that foreign employees act as a channel for technology transfer in MNCs that belong to R&D intensive industries.

Our results are robust to using this alternative measure. Further, the fact that the quantity of
foreign employees also matters for technology transfer in high-tech industry MNCs suggests that foreign employees provide both non-rival and rival human capital goods. For example, these can serve as communication channel and provide technical knowledge specific to the transfer itself.

In Column (3) of Table 8 we find that there is a U-shaped relationship between judicial efficiency and the share of foreign workers. This suggests that the mechanisms at play in the model may apply both to the presence and quantity of foreign employees in MNCs.

Overall, therefore, the results of the paper are robust to using this alternative measure of foreign employees. They suggest that foreign employees act as a channel for technology transfer due to both non-rival and rival human capital.26

5.3 Selection issues

This section discusses selection issues related to the location choice of the MNC; which our model and empirical analysis take as given. In particular, we discuss how selection at the industry and at the plant levels could affect results.

First, based on the industry, plants may be more or less dependent on headquarter input and favor some states. However, this factor does not explain our finding that judicial efficiency has a U-shaped impact on plant-level foreign employee use and technology transfer, as our regressions control for industry fixed effects. See Table 4, Columns (2), (3) and (4).

Second, at the plant level, it could be that a simple productivity story explains our findings. For example, if for some reason more productive plants are likely to locate either in very bad or very good judicial efficiency environments and they are also more likely to do technology transfer and hire foreign employees, our results could be spurious. To address this concern, we analyze entry of foreign firms as function of the state judicial efficiency. We also analyze the export/sales ratio of firms in different states since export orientation correlates with plant productivity. We run the following regressions.

\[ D(\text{Foreign Ownership}_{ij}) = \beta_1 \text{Judicial Efficiency}_s + \beta_2 (\text{Judicial Efficiency}_s)^2 + (\gamma X_{ij}) + \mu_j + \epsilon_{ij} \]

26 Future work may investigate these factors in greater detail by surveying the actual practices of foreign employees, in line with Bloom et al. (2012).
\[(\text{Export/Sales}_{ij}) = \beta_1 \text{Judicial Efficiency}_i + \beta_2 (\text{Judicial Efficiency}_i)^2 + (\gamma X_{ij}) + \mu_j + \epsilon_{ij}\]

Table 9: Regression of the effect of judicial efficiency on entry and export/sales ratio. ESIDET 2000.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Foreign Ownership Dummy</th>
<th>Export/Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judicial Efficiency</td>
<td>0.382 (0.293)</td>
<td>-0.015 (0.047)</td>
</tr>
<tr>
<td>Judicial Efficiency$^2$</td>
<td>-0.063 (0.043)</td>
<td>0.049 (0.034)</td>
</tr>
<tr>
<td>Firm Control</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State Control</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry fixed effects</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.438</td>
<td>0.436</td>
</tr>
<tr>
<td>N</td>
<td>1315</td>
<td>1315</td>
</tr>
</tbody>
</table>

Notes: For Columns (1) and (2) the table reports the marginal effects of the judicial efficiency, its square term of probit regressions of the foreign ownership dummy on judicial efficiency, its square term, exporter dummy, the log of the number of workers, state-level per capita GDP and its square term, the distance to the border, the dummy variable indicating the capital metropolitan area, skilled worker ratio, population density, and industry fixed effects. Some firms are dropped when we include industry fixed effects due to collinearity, leading to the changes in the sample size between columns. For Columns (3) and (4) the table reports the coefficients of the judicial efficiency and its square term of the linear model regressions of the export/sales ratio on the same set of variables. Standard errors are clustered at the state level and reported in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 9 shows the results. Columns (1) and (2) show that judicial efficiency does not significantly impact entry of foreign plants. Column (3) shows that there is a U-shaped pattern between export/sales ratio and judicial efficiency. Yet, the square term of judicial efficiency is not significant. More importantly, the magnitude of the coefficients suggests that the bottom level of exports happens when judicial efficiency is equal to 5.5. Since this is out of the range of the judicial efficiency variable in the data, it suggests that there is a monotonically decreasing pattern between judicial efficiency and the export/sales ratio. This is further confirmed by Column (4). Overall this suggests that firms in good institutional environments are less productive. Therefore, a simple selection story based on productivity should predict that firms that would do less tech-
nology transfer and that would not hire foreign employees would select into very good judicial efficiency environments. If that was the case, we should observe a negative correlation between judicial efficiency and technology transfer, which is at odds with the U-shaped pattern that we observe in the data. To conclude, although we find some evidence of selection, it does not explain our main findings.

5.4 Alternative mechanisms

An alternative explanation regarding the use of foreign employees is that MNCs may be relying on them as a means of control over subsidiaries. It is worth mentioning that we find it difficult to reconcile the U-shaped relation between judicial efficiency and the employment of foreign employees with this alternative explanation. If MNCs use them as a means of control, their value would decrease as judicial efficiency (the degree of legal protection of contracts) increases. Then, we would observe a monotonically decreasing relationship between the use of foreign employees and judicial efficiency, which is at odds with the evidence.

6 Conclusion

This paper investigates the role of foreign employees as a channel for technology transfer in high-tech MNCs. Thus, we rely on a unique dataset combining information on technology transfer and foreign employee presence in foreign owned and domestic Mexican plants for the year 2000 together with the judicial efficiency data of the state where the MNC locates. To guide the empirical analysis, we build a simple model where the MNC faces the following trade-off. On the one hand foreign employees are more efficient at dealing with the headquarter technology. On the other hand, the cost of local inputs is higher for a foreign employee than for a domestic one. Further, the cost disadvantage of the foreign employee decreases as institutions improve. We posit that firms belonging to technologically intensive industries are the ones that benefit from foreign employees. We then analyze the institutional environments in which MNCs do not rely on foreign employees and whether these consistently predict that MNCs engage in less technology transfer. If so, this should provide further support for the hypothesis that foreign employees are indeed a channel for technology transfer.

The evidence confirms the main implications of the model concerning the role of foreign
employees as a channel for technology transfer. When institutional quality is either very bad or very good, MNCs are more likely to rely on foreign employees and, therefore, engage in more technology transfer. We do not find equivalent results for domestically owned plants. This suggests that the human capital provided by foreign employees is MNC specific and provides further support for the mechanism described in the paper. The domestic plants evidence also allows us to rule out omitted variable concerns. Because the MNC choice of state is not random, we provide a detailed analysis of possible selection issues both at the industry and plant level. We also perform robustness checks including alternative measures of technology transfer and of foreign employees. Finally, we describe and rule out a simple control story alternative, where foreign employees are a control device of the MNC.

By providing a unified analysis of the role of foreign employees as a channel for technology transfer, this paper suggests that to obtain a smooth flow of technology, both foreign plants and foreign employees may be necessary. Managerial scarcity should therefore be understood not only as the result of a deficit in human capital investments at the country level or in the local economy. At the company level, our results imply that training programs involving on-the-job experience at the headquarters of MNCs may be crucial. At the country level, visa policies and educational investments may need to take into account that foreign employees and domestic managers are imperfect substitutes.

Future work may extend our analysis of the role of foreign employees in different institutional environments, as well as in other countries. In particular it would be interesting to study the role of foreign employees in plants operating in different institutional environments/countries under the same headquarters. More broadly it may also be relevant to study whether foreign employees contribute to fostering or preventing inter-industry positive spillovers to local firms (Jacorciuk (2004) and Blalock and Gertler (2008)). Finally, surveying the managerial practices of foreign employees, along the lines of Bloom et al. (2012), may be a promising avenue for future research.
Acknowledgements

We would like to thank Arturo Blancas, Jorge Reyes, Adriana Ramírez and Gabriel Romero of INEGI for their assistance with the establishment survey. We are grateful to the editor and two anonymous referees for their comments and suggestions. We also thank André Fourçans, Gordon Hanson, Benjamin Hermalin, Daniel Hicks, Yoichi Sugita, Catherine Thomas and Eric Verhoogen for their helpful conversations. We are also grateful to the participants and organizers of the CAGE summer school at Warwick, the NEUDC, the THEMA seminar, and the IZA-World Bank conference for their useful comments. Stephanie Zonszein provided excellent research assistance. Teshima acknowledges financial support from Asociaci´on Mexicana de Cultura.
References


7 Appendix

7.1 Description of the main plant-level variables

This subsection lists the main variables of the paper from the INEGI survey, and provides the exact question number of the survey. For reference and to allow identification of the variables in the survey, we also include the original question in Spanish.

*Foreign ownership:*

Question 3: “Defina el origen del capital de la empresa mediante la participación de cada uno de los siguientes sectores: 3.1 Privado, 1.2: Con participación de capital extranjero.”

*Number of workers:*

Question 4: “Cuál fue el promedio anual de trabajadores que laboraron en la empresa (excluya al personal subcontratado) durante el periodo de enero a diciembre de 2000 y 2001?”

*Domestic employees:*

Question 4.1: “Nacional.”

*Foreign employees share:*

Question 4.2: “Extranjero.”

*Total sales:*

Question 5: “Anote en miles de pesos el total de las ventas netas anuales de los productos o servicios realizados por la empresa durante 2000 y 2001.”

*Exports:*

Question 5.2: “Exportaciones.”

*Technology transfer:*

Question 26: “Anote en miles de pesos el monto de los gastos efectuados por adquisición de tecnología en 2000 y 2001, de acuerdo a los siguientes conceptos, del exterior” with individual categories including the cost for purchase or licence of patents and other non-patented inventions, revelation of know-how, and technical assistance corresponding to:

26.1.1. “Compra de patentes”

26.1.2. “Compra de inventos no patentados”
26.1.3. “Revelación de Know-how”

26.1.4. “Regalías por licencias de patentes”

26.1.5. “Regalías por derechos de propiedad industrial (marcas, modelos y franquicias)”

26.1.6. “Pagos por estudios técnicos, consultorías y trabajos de ingeniería.”

7.2 Description of the main industry-level variables

This subsection lists the variables used in the paper from the EIA survey to construct industry-level variables. We provide the exact question number of the survey. For reference and to allow identification of the variables in the survey, we also include the original question in Spanish.

Export ratio:

Export ratio=Exports/Total sales

Question 27: Exports. “Ventas netas al mercado extranjero (exportaciones)”.

Question 28: Total sales. “Total de las ventas netas”.

Value added ratio:

Value added ratio=(Total sales-Cost)/Total sales

Question 20: Cost. “Total de costos y gastos”.

Labor productivity:

Labor productivity=(Total sales-Cost)/Total employment

Question 1: Total employment. “Personal ocupado total (Incluya obreros y empleados)”

Imported intermediate ratio:=(Foreign input)/Cost

Imported intermediate ratio=(Foreign input)/Cost

Question 7: Foreign input. “Materias primas y partes y componentes importados consumidos”.

Renumeration per worker:

Renumeration per worker=(Total wage bill)/Total employment

Question 4 and 5: Total wage bill. “Total de remuneraciones (Incluya Salarios, Sueldos, Indemnizaciones, Liquidaciones, Prestaciones Sociales y Contribuciones Patronales a la seguridad social)”.
7.3 Description of state-level variables

We next describe how we constructed each state-level variable of the paper. The raw data as well as the code could be obtained through the corresponding author for replication purpose.

**Judicial Efficiency.**


**Distance to the US border.**

We calculate the minimum road distance from the center of each municipality to each customs on the US-Mexico border. Then, we take the minimum distance for each municipality. Since our main regional variable (judicial efficiency) varies at the state level, we calculate the mean of the municipality-level minimum distance to the customs to calculate state-level distance to the customs. The road and other input for processing geographical information is downloaded at the INEGI website.

http://www3.inegi.org.mx/sistemas/mapa/espacioydatos/

**Population, GDP, Areas.**

Population, GDP and areas at the state level as of 2000 for each state was downloaded at the INEGI website. We calculate GDP per capita and population density using these variables.

**Skilled worker ratio.**

We use micro-level data ENEU (Encuesta Nacional de Empleo Urbano [National Survey of Urban Employment]) of 2000. Among the people from 15 to 65 years, we regard those who have at least 12 years of education as skilled population. Then we take the share of the skilled population workers in the people from 15 to 65 years. The micro-level data can be obtained at the INEGI website.