KNOWLEDGE TRANSFERS FROM MULTINATIONAL TO DOMESTIC FIRMS: EVIDENCE FROM WORKER MOBILITY

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Abstract—Labor turnover is a commonly cited mechanism for the transmission of technology from multinational to domestic firms. Using a matched establishment-worker database from Brazil, I present evidence consistent with positive multinational wage spillovers through worker mobility. When workers leave multinationals and are rehired at domestic establishments, continuing-workers' wages increase. To my knowledge, this avenue for wage spillovers has not previously been explored. The paper also investigates where spillovers occur and how they are absorbed to demonstrate heterogeneous impacts. Higher-skilled former multinational workers are better able to transfer information, and higher-skilled incumbent domestic workers are better able to absorb information.

I. Introduction

MULTINATIONAL enterprises (MNEs) may instill technological knowledge on workers at their subsidiaries through labor training regarding process innovations, high-quality intermediate inputs, and management styles, for example. This technology can be a public good, and knowledge transfer to local firms may occur as they learn about this foreign technology. In particular, domestic firms may gain access to the multinational's technology by hiring a former MNE-trained worker with special skills. In this paper, I present evidence consistent with this single mechanism for productivity spillovers from multinational establishments locating in Brazil. I also explore where spillovers occur and how they are absorbed. I discern the multinational spillover effect by industry characteristics and distinguish it by the skill level of the former multinational worker and the incumbent domestic worker.

Despite the long history of academic work testing the implications from an increasing multinational presence on domestic firms,[1] the exact mechanisms through which productivity spillovers occur are rarely tested.[2] Within the few studies that do address a particular mechanism of transmission, the empirical evidence on multinational spillovers through worker turnover is further limited.[3] This is surprising given that worker mobility is a commonly cited mechanism for the transmission of multinational spillovers and given the great deal of effort many multinational firms devote to retaining the workers they train (Lindsey, 1986; and Gerschenberg, 1987). There is, however, a large theoretical body of work on interfirm worker mobility and knowledge transfer (e.g., Fosfuri, Motta, & Ronde, 2001; Cooper, 2001; Markusen, 2001; Glass & Saggi, 2002; Dasgupta, 2010).

This research offers a number of important contributions to the literature on multinational knowledge spillovers, in large part due to the depth of a novel linked employer-employee database from Brazil. This is the first research, to my knowledge, to offer direct evidence for a developing country for positive multinational wage spillovers through the worker mobility channel. Using matched establishment-worker data, I trace individual workers over time across establishment types. The detailed labor force characteristics allow the estimation of heterogeneous responses of wages, which depend on worker-level characteristics. In addition, the data include a rich set of establishment-level controls. Moreover, this is the first research to span all sectors of the economy rather than a single industry case study. I go beyond the usual manufacturing focus and estimate multinational spillovers in the services sector, where much of the foreign investment in Brazil flowed beginning in 1996. Also, I do not restrict the

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[1] For a review of earlier work, see Blomstrom and Kokko (1998), Saggi (2002), Keller (2004, 2009), and Harrison and Rodríguez-Clare (2010).

[2] Exceptions include the following. Production externalities may occur if an increase in competition, as a result of foreign entry, induces firms to become more efficient, for example. Aitken and Harrison (1999), however, document for the case of Venezuela that competition from foreign producers in the same sector offsets any potential positive technology spillovers. Hale and Long (2008) consider that foreign and domestic producers also compete on input markets, particularly for skilled labor inputs. Aitken, Hanson, and Harrison (1997) and Greenaway, Sousa, and Wakelin (2004) study the possibility that MNEs have stronger links to foreign markets that help to enhance exports, consistent with the notion of informational networks in international trade (Rauch, 1999). Javorcik (2004) and Alfaro and Rodríguez-Clare (2004) investigate vertical productivity spillovers to intermediate input suppliers. In contrast to the market-stealing effects found in Aitken and Harrison (1999), it is advantageous for MNEs if their intermediate input suppliers increase efficiency. Javorcik (2004) finds evidence of this positive spillover in Lithuania, while Alfaro and Rodríguez-Clare (2004) note the effect is weakened in Latin America as many foreign firms source inputs from abroad.

[3] Gerschenberg (1987) argues, using a small-sample survey from Kenya, that managerial knowledge dissemination is low. Gorg and Strobl (2005), with a small survey from Ghana, find that firms whose owners once worked in multinationals in the same industry are more productive than similar domestic firms. Using data from Colombia, Markusen and Trofimenko (2009) offer evidence to support the hypothesis that "experts" hired from abroad can transfer skills to domestic workers. Balsvik (2011) documents that workers with experience in an MNE contribute to the productivity of domestic plants in Norway.

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analysis to senior-level management. I show that multinational spillovers occur for average workers and vary by both the skill level of the former multinational worker and the skill level of the incumbent domestic worker.

Most important, in contrast to earlier work on this topic, I focus on the worker rather than the plant, firm, or industry as the unit of analysis and provide a detailed empirical assessment of the wage spillovers from the workforce of MNEs to workers with no multinational experience. I measure multinational spillovers as increases in the wages of existing (incumbent) domestic workers and model these wage increases as a function of the proportion of workers employed at the domestic establishment with some multinational experience.

Motivated by the social interactions model proposed by Manski (1993), I picture the growth of knowledge occurring when meetings between workers take place. Empirically, the transmission of knowledge occurs through interactions between workers—more precisely, between workers who separate from multinational establishments and are rehired at domestic establishments, on the one hand, and the existing domestic establishment workforce, on the other hand. The greater the share of former multinational workers in the domestic workforce, the greater the number of possible workplace interactions and potential transfer of knowledge. If multinational spillovers through worker mobility exist, I expect workers in domestic establishments hiring a higher share of former multinational workers to earn higher wages through their potential social interactions in the workplace with former multinational workers.

I estimate worker-level regressions using a matched employer-employee data set from Brazil. The Brazilian worker data are collected by the Brazilian Labor Ministry and record characteristics for all formally registered workers at formally registered establishments for the years covering 1996 through 2001. The foreign direct investment inflows data are from the Brazilian Central Bank's Registry of Foreign Capital. The two data sources are matched by establishment tax number to identify workers at foreign-owned and domestic-owned establishments over time. The main benefit of the matched data is the ability to trace workers who switch between foreign-owned and domestic-owned establishments. In addition, the longitudinal nature of the data offers controls for permanent and time-varying worker and establishment heterogeneity.

The findings can be summarized as follows. The main results are consistent with the existence of positive multinational wage spillovers. Ex ante, identical workers in establishments with a higher proportion of workers with some experience at a multinational establishment earn higher wages. At the average wage for a typical domestic worker, a 10 percentage point increase in the share of former multinational workers in his establishment increases wages by $23 per year. For the average domestic establishment in Brazil, with approximately sixty workers, the total implied wage effect from an enhanced foreign presence is roughly $1,400. These figures have the potential to generate increased GDP growth throughout the economy. Furthermore, they capture only spillovers transferred to workers in the form of wages and not direct increases in establishment productivity and profitability.

The magnitude of these worker-level wage spillovers varies with the characteristics of the domestic establishment's industry, such as labor market institutions and levels of education. Heavily unionized industries, where wage and employment policies are less flexible to reward increases in productivity, offer no multinational wage spillovers despite greater worker bargaining power in these industries. Also, consistent with the evidence found in Keller and Yeaple (2009), significant worker-level wage spillovers are found only in high-skill-intensive industries. Therefore, the results illustrate that multinational spillovers are not economy-wide; that is, most workers do not receive spillover benefits. In fact, evidence by the skill level of the worker supports the hypothesis that higher-skilled former multinational workers are better able to transfer a multinational's technology to incumbent domestic workers and higher-skilled incumbent domestic workers are better able to absorb the MNE's technology from former multinational workers. Moreover, the data also report that knowledge is best transferred between similarly skilled groups of high-skilled workers.

The remainder of this paper is organized as follows. The next section details the data and provides summary statistics on worker separations and rehiring rates. I present a conceptual framework and an econometric model of multinational spillovers in section III. The main results from the analysis of multinational spillovers through worker mobility are discussed in section IV, with additional robustness tests for alternative explanations alongside. In section V, I distinguish the spillover effect by the skill level of former multinational workers and incumbent domestic workers in order to uncover how knowledge is best transferred and absorbed. I conclude with final remarks.

II. Data

My main data source is a registry of Brazilian formal sector workers and their employers. I match key worker characteristics to a complementary data source on establishment-level foreign investment inflows.

A. *Worker Data*

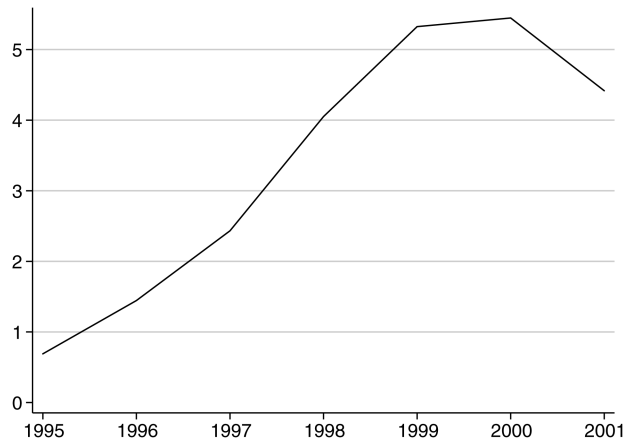
The Brazilian Labor Ministry requires all formally registered firms to report on all workers in every year. The Relação Anual de Informações Sociais (RAIS) is an individual-level record of all formally employed workers beginning in 1986, of which I use the years 1996 through 2001 when I also have complementary information on foreign investment inflows.

The main variables of interest are the worker's identification code,[4] annual real wages in reais,[5] job tenure in months, type of job separation, age, educational attainment, occupational classification, the tax number of the worker's establishment, and the industrial classification of the worker's establishment.

The RAIS worker data are particularly valuable to this research agenda as it offers variables beyond the available information in many other matched employer-employee databases. First, the industry classifications cover workers beyond the usual manufacturing focus. Workers in the services and utilities industries, where much of the foreign investments flowed starting in 1996, are included in the database. Next, RAIS has a depth of information on the reason for job separation, as well as a worker's tenure at the establishment and detailed skill levels, as defined by both occupation and education, that are paramount to the analysis.[6]

The main advantage of the RAIS database is the ability to trace individual workers across establishment types over time by time-invariant worker identification numbers and establishment tax numbers in order to control for unobservable individual-level and establishment-level heterogeneity. I draw a 1% random sample of the national data and restrict observations as follows. First, only workers with correct eleven-digit worker identification numbers are included.[7] Next, the sample includes only full-time, prime-age workers between the ages of 15 and 64 years. Following Abowd, Kramarz, and Margolis (1999), I restrict the set of to those workers receiving positive wages in a private sector job. For workers with multiple jobs within the same establishment in a given year, I include only the most recent job. If a worker has multiple current jobs, only the highest-paying job is included.[8] To ensure the proper identification of worker fixed effects and establishment fixed effects, I further restrict the sample to establishments with data for at least two periods and workers in the sample for at least two years.

FIGURE 1.—FOREIGN DIRECT INVESTMENT INFLOWS, PERCENTAGE OF GDP, 1995–2001



Source: World Bank (2005).

B. *Foreign Direct Investment Data*

Figure 1 shows foreign direct investment inflows as a percentage of GDP for the Brazilian economy from 1995 to 2001. Direct investments increased significantly beginning in 1996 and more than quadrupled by 2001 (World Bank, 2005), largely as a result of Brazil's substantial macrostabilization in 1994 and trade liberalization program early in the decade (Rodrigues, 2000).

By law, all foreign investments must be registered with the Central Bank of Brazil (Banco Central do Brasil, BCB) in the Registro Declaratório Eletrônico–Investimentos Externos Diretos (RDE-IED). These establishment-level data are not publicly available, but the BCB made available portions of the RDE-IED for the years 1996 through 2001 for the purpose of this research, including information on both flows and stocks of foreign investment. The data include a list of all establishment tax numbers with a positive inflow of FDI for the years 1996 through 2001 and a list of all establishments with a positive stock of foreign capital in the year 2001. Lacking direct information on an establishment's FDI stock by year, these data allow a procedure to infer with considerable confidence which establishments are at least partially foreign owned in a given year between 1996 and 2001.

Specifically, I define an establishment to be at least partly foreign owned in year t if the establishment received an inflow of foreign capital in year t. I note that establishments receiving inflows of foreign capital in year t may maintain a stock of foreign capital in later years. Therefore, establishments with a positive stock of foreign capital in 2001 are classified as foreign owned in all years $\tau \geq t$ after the initially observed inflow at year t, even if no inflow is observed in the intervening years. If I observe no FDI inflow to an establishment but a foreign investment stock in 2001, I consider

[4] A worker's ID remains with the worker throughout his or her work history. The process for establishments to report on their workers is extensive and costly. However, RAIS records are used to administer payment of the annual public wage supplements to every formally employed worker, thus creating a strong incentive for workers to urge their employers to report accurately.

[5] RAIS reports an average monthly wage (in multiples of the current minimum wage) for each job in which a worker is employed in each year. In combination with information on the number of months a worker is employed during the year and deflated minimum wage information in reais from the Brazilian Central Bank, I calculate an annual real wage for each worker.

[6] Muendler et al. (2004) map the Brazilian classification of occupations to the International Standard Classification of Occupations (ISCO-88). The ISCO occupations are then grouped into four broad occupational categories following Abowd et al. (2001). I consider these occupational categories to reflect the skill intensity of the occupation.

[7] Eleven digits is the traditional length of the social security number in Brazil. Firms that report false identification numbers are more likely to have made a measurement error due to faulty bookkeeping.

[8] There is high turnover within establishment years in part due to a Brazilian labor law (Fundo de Garantia de Tempo de Serviço) in which formally employed workers may receive a guaranteed fund on termination. This fund is filled by the employer in monthly contributions and subsidized by the government. It is meant to serve both as unemployment insurance at displacement and a social security payment at retirement.

TABLE 1.—WORKER SEPARATIONS, 1996–2001

	Foreign Owned			Domestic Owned		
	Separations	Layoff	Quit	Separations	Layoff	Quit
Number	4,056	3,296	351	180,936	139,557	24,334
Percent of separations						
Not rehired	0.648	0.542	0.056	0.651	0.516	0.080
Rehired	0.365	0.282	0.032	0.434	0.353	0.061
of which:						
In same establishment	0.051	0.033	0.003	0.107	0.084	0.010
In MNE	0.104	0.070	0.010	0.012	0.009	0.002
In domestic	0.293	0.232	0.025	0.428	0.348	0.060

Source: RAIS, 1% random sample, RDE-IED, 1996–2001.

the establishment foreign owned for the entire sample period. Conversely, if I observe no foreign ownership stock in 2001, I assign the year with the last FDI inflow as the final year of foreign ownership.[9]

I also consider partial foreign ownership of a holding company to affect all establishments of the corporate group. Using BCB information on the corporate ownership relations among Brazilian firms, I count an establishment as at least partly foreign owned in year t if it is a subsidiary of a foreign-owned enterprise. By this method, 12,401 multinational establishments were operating in Brazil over the 1996–2001 period.

C. Matched Data

The establishment-level foreign inflows data are matched by establishment tax number to the RAIS 1% random sample to identify 3,814 multinational establishments over the 1996–2001 period. I define an indicator variable equal to 1 if a worker holds a job at a foreign-owned establishment and 0 otherwise.

In the matched RAIS-RDE-IED sample are 12,793 multinational workers and 305,774 domestic workers. Table 1 reports job flow statistics for these workers by establishment type and cause of separation. Of the 12,793 MNE workers in the 1% random RAIS sample, 4,056, or approximately 31%, left the MNE at some point over the sample period. One-third of workers may seem high, but this is a relatively low separation rate in comparison to domestic establishments where almost two-thirds of all workers separated from the firm at least once during the sample period (59%, or 180,936 workers).

Conditional on separating, 81% of workers employed at multinational establishments parted involuntarily (3,296 workers), while only 9% quit (351 workers). Workers at domestic establishments are more likely to quit than their multinational counterparts (conditional on separating, 13% leave voluntarily) and are less likely to be laid off: 77% of separating workers are displaced.[10] The remaining workers have their contracts terminated, are transferred within the firm, retire, or die. In the analysis that follows, I consider only workers who are laid off or who quit because these are the most important separation categories in Brazil.

An important aspect of this research is that workers are rehired on separation. Conditional on separating, approximately 40% of separated workers find reemployment before the end of the sample period, while just over 60% are never rehired.[11] Workers from multinational and domestic establishments have roughly equal chances of reemployment after job separation (37% compared to 43%). However, the type of establishment in which workers are rehired does vary depending on the initial establishment type and type of job separation. Approximately 5% of workers separating from a multinational are rehired by the same multinational establishment within the sample period. Separating domestic workers are twice as likely to be rehired by the same domestic establishment (11%). Workers separating from a multinational firm are more likely to be rehired at another MNE than workers separating from domestic firms (10.4% compared to 1.2%).

This paper covers the approximately 1,200 multinational workers who switched into domestic establishments after separating from an MNE (around 30% of separations). Conditional on separation, domestic workers are about one and a half times more likely to be reemployed at a domestic-owned establishment. Roughly 23% of displaced MNE workers are rehired at domestic-owned establishments, while 34.8% of laid-off domestic workers are rehired in similar establishments. This statement, however, does not apply

[9] Consider the following examples. An establishment with foreign investment inflows in 1997 and 1998 and a stock of foreign capital in 2001 is classified as a foreign-owned establishment for the years 1997 through 2001. If an establishment with foreign inflows in 1997 and 1998 records no stock of foreign capital by 2001, the establishment is classified as foreign owned for 1997 and 1998 only. Finally, an establishment with a positive stock of foreign investment in 2001, but without any recorded inflows over the period 1996 to 2001, is classified as foreign owned for the years 1996 to 2001.

The main concerns are establishments without any recorded inflows of foreign investment and no stock of foreign capital in 2001. By my definition, these are considered domestically owned enterprises. Therefore, I may miss foreign-owned establishments if there was an initial inflow of foreign capital before the sample period and a full divestiture at some point during the sample period. Retained earnings, however, are inflows under common FDI definitions such that inflows are likely to be observed in every year of foreign ownership.

[10] Layoff rates include workers fired with justification and laid off without justification.

[11] Percentages may add to more than 100% because some workers may be separated from multiple jobs during the sample period.

equally to workers who separate by choice. Quitting multinational workers are about one-third as likely to be rehired in domestic-owned establishments as domestic worker quitters (2.5% as compared to 6.0%). For this reason, evidence for the diffusion of knowledge from multinational quitters may be scarce (Gerschenberg, 1987).

III. Empirical Methodology

The objective of this paper is to establish if multinational spillovers through worker mobility exist. I go beyond the existing literature to define wage spillovers at the worker level.

A. A Conceptual Framework for Multinational Spillovers

I define *multinational spillovers* as the relationship between a domestic worker's wages and the share of workers in his or her establishment with some experience at an MNE. The greater is the share of former multinational workers in the domestic worker's establishment, the greater is the probability of workplace interaction and the probability of a transfer of knowledge or technology. If positive multinational knowledge spillovers through worker turnover exist, I expect workers in establishments with higher shares of former multinational workers to earn higher wages, all else equal.

These worker-level multinational wage spillovers and the plant-level multinational productivity spillovers that previous studies have researched do not have an obvious relationship. Given data availability, what exactly occurs inside the domestic worker's establishment is beyond the scope of this paper and remains an open and fruitful question for future research. I highlight some possibilities as follows.

If firm performance and wages are linked (for example, through a simple assumption of rent-sharing or fair-wage compensation packages), the wage outcomes for otherwise homogeneous workers may differ depending on the mix of workers within the establishment.[12] Suppose, for instance, the newly hired former MNE worker advances the organizational structure of the domestic-owned establishment, increasing the establishment's productivity and profitability. Similarly, the former multinational worker may have knowledge about physical capital, process innovations, intermediate inputs, or export markets previously unavailable to the domestic firm. Incorporating these new strategies into the production process may increase the domestic establishment's profitability. In both cases, under the assumption that some portion of profits is shared with workers, these increases in establishment performance lead to higher wages for the existing domestic workers.[13] Because not all former MNE workers carry productive knowledge, the higher is the share of MNE switchers in the domestic establishment's workforce, the higher is the probability of knowledge transfer and domestic worker wage gains.

By contrast, if labor markets are competitive, wage outcomes depend on a worker's marginal productivity. Workers in globally engaged firms are often more productive (Schank, Schnabel, & Wagner 2007). The theory that Antràs, Garicano, and Rossi-Hansberg (2006) outlined describes a scenario in which the wages of southern workers unambiguously increase after globalization as they match with better northern managers. The greater match quality allows an increase in the marginal productivity of all workers. Similarly, Mas and Moretti (2009) use data from cashier clerks at a local supermarket chain to investigate the impact of high-productivity coworkers. They report that social norms outweigh the potential for free-riding and suggest that having highly productive peers at work increases the marginal productivity of existing workers. Along these lines, individual workplace interactions between more productive former MNE workers and domestic workers may help to transfer human capital, increasing the marginal productivity of domestic workers. In each of these scenarios, the higher is the share of former multinational workers in the domestic establishment, the higher is the likelihood that any given domestic worker will interact (with a better manager, through social norms, or through a direct transfer of human capital, for example) with a former multinational worker, thus increasing his or her marginal productivity and wage.

B. An Econometric Model of Multinational Spillovers

My estimation procedure derives from the social interactions theory developed by Manski (1993) and allows an individual's wage outcome to depend on the characteristics of the individual's economic environment, that is, the establishment in which he works. In particular, the approach models an individual's wage as a function of a key establishment-level characteristic, the share of former multinational workers in the worker's establishment, as follows,

$$\ln y_{ijt} = \gamma S_{jt} + \psi_i + \lambda_{j(i)} + \delta_t + \beta_1 X_{it} + \beta_2 Z_{jt} + \epsilon_{ijt}, \quad (1)$$

where i indexes the individual, j indexes the establishment, t indexes time, and $\ln y_{ijt}$ are individual-level log wages. S_{jt} refers to the share of the establishment's workforce with previous experience in a multinational establishment. This variable is designed to capture the probability that the worker interacts with a former multinational worker now employed in his or her establishment.

The purpose of this exercise is to uncover multinational wage spillovers—indirect effects on domestic workers' wages of a foreign presence in the domestic establishment. For this reason, beyond the sample restrictions described in section II, I limit the sample of study to domestic workers in domestic establishments. Because the sample is restricted to

[12] Recent applications in international trade with imperfectly competitive labor markets include Egger and Kreickemeier (2009), Helpman, Itskhoki, and Redding (2010), Davis and Harrigan (2011), and Amiti and Davis (2012).

[13] Arai (2003) demonstrates the links between firm performance and wages in Sweden, as well as the importance of the bargaining system for influencing rent sharing.

domestically owned establishments and their employees, it is not subject to the estimation bias that has plagued many similar studies—that foreign investment flows to already more productive firms.

In an ideal setting, domestic firms would randomly draw new employees from the unemployed labor pool, which includes former multinational workers, workers with experience at other domestic establishments (but no experience at a multinational firm), and workers new to the labor force with no previous work experience. In the absence of such a randomization, I exploit the differential effect of hiring decisions within the establishment—the differential effect of hiring an additional worker with multinational experience over an additional worker without any multinational experience.

This estimation strategy serves two purposes. First, periods of establishment hiring may coincide with general periods of increased investment. Establishments hiring unemployed former MNE workers may be hiring unemployed workers with experience in other domestically owned establishments as well. To the extent that employment growth is correlated with the profitability of the establishment, these growing establishments may also be increasing wages for all continuing domestic workers. Second, if workers from other domestically owned firms also bring knowledge or technology previously unavailable to the domestic workforce, I would not want to attribute this domestic spillover—plausibly, a more general human capital spillover of the form found in Moretti (2004)—to former multinational workers. For these reasons, I include a control for the share of workers in the domestically owned establishment with experience in other such establishments (but no experience at a multinational firm), as follows:

$$\ln y_{ijt} = \gamma_M S^M_{jt} + \gamma_D S^D_{jt} + \psi_i + \lambda_{j(i)} + \delta_t + \beta_1 X_{it} + \beta_2 Z_{jt} + \epsilon_{ijt}, \quad (2)$$

where S^M_{jt} refers to the previously defined S_{jt}, the share of the domestically owned establishment's workforce with experience in a multinational establishment. I distinguish this term from S^D_{jt}, the share of the domestically owned establishment's workforce hired from another such establishment (with no previous experience at a multinational establishment).

Equation (2) is the basis for the estimation of the empirical results that follow. If positive multinational spillovers through worker mobility exist, I expect $\gamma_M > 0$ and $\gamma_M > \gamma_D$. The main concern in estimating the key coefficient γ_M in equation (2) is the presence of unobservable shocks to an individual's wage that are correlated with the hiring of former MNE workers. Any positive correlation between S^M_{jt} and ϵ_{ijt} will result in overestimates of γ_M. A major advantage of using a panel of linked worker-establishment data is that I am able to control for many permanent and time-varying factors that may affect both wages and the overall hiring share. Specifically, I estimate a model that includes individual fixed effects (ψ_i) to account for unobserved individual-specific ability, establishment fixed effects ($\lambda_{j(i)}$) to control for establishment heterogeneity, and time fixed effects (δ_t) to capture any average wage impact on all workers in a given year (for example, due to Brazil's currency crisis in 1999). Identification in this model, then, is based on changes over time in the share of former multinational workers within an establishment for each worker. The issue of what determines the establishment's hiring choice is mitigated as the coefficient of interest measures the differential effect of hiring an additional worker with multinational experience over an additional worker with no multinational experience.

Other covariates include a vector of time-varying, individual-specific characteristics, X_{it}, and a vector of time-varying, establishment-specific characteristics, Z_{jt}. The individual characteristics include age, age-squared, tenure at the establishment, education, and the skill intensity of the worker's occupation.[14] The establishment characteristics include log employment, average tenure of the workforce, share of the establishment female, average education of the workforce, and average occupational skill intensity of the workforce.

Due to the inclusion of S^D_{jt} and the desire to ensure that the estimates measure pure spillover effects and not establishment-level compositional effects, I further restrict the sample of domestic workers as follows. I estimate the impact of MNE-switcher workers on the retained domestic workforce, defined as the set of workers who have never switched into or out of any domestic establishment, thus creating a balanced panel of the incumbent domestic workforce. Because the sample of domestic workers remains in the same domestic establishment, individual fixed effects (ψ_i) fully absorb the establishment-specific effects ($\lambda_{j(i)}$) (Abowd et al., 1999).

IV. Estimation of Multinational Spillovers

The final matched worker-establishment database for analysis includes the full employment history of incumbent domestic workers in domestically owned establishments in Brazil from 1996 through 2001. This amounts to 97,644 worker-establishment-year observations, with 16,274 workers and 8,532 establishments covering 57 industrial categories.[15]

A. *Main Results*

Table 2 presents results for the estimation of worker-level multinational wage spillovers. I report the coefficient difference for $\gamma_M - \gamma_D$ as the multinational spillover effect and the corresponding F-statistic and p-value for the null hypothesis

[14] Education enters as three dummies: less than high school, at least high school, and more than high school (less than high school is the omitted category).

The skill intensity of occupation enters as four dummies: unskilled blue collar, skilled blue collar, other white collar, and professional/technical (unskilled blue collar is the omitted category).

[15] I exclude workers in the domestic services industries (CNAE 95) and international organizations (CNAE 99).

TABLE 2.—MULTINATIONAL SPILLOVERS, 1996–2001

Dependent Variable: Log Annual Wages	(1)	(2)	(3)	(4)
$\gamma_M - \gamma_D$	0.258***	0.277***	0.048*	0.051**
F-statistic	35.46	41.32	3.37	4.21
p-value	0.00	0.00	0.07	0.04
γ_M	0.259***	0.279***	0.053**	0.056**
	(0.043)	(0.043)	(0.026)	(0.025)
γ_D	0.001	0.003	0.005***	0.006***
	(0.004)	(0.004)	(0.002)	(0.002)
Year FE	No	Yes	Yes	Yes
Establishment FE	No	No	Yes	Yes
Individual FE	No	No	No	Yes
Number of observations	96,560	96,560	96,560	96,560
R^2	0.5075	0.5101		
Within R^2			0.3402	0.1792

Robust standard errors, clustered at the establishment-year level, are in parentheses. Significant at ***1%, **5%, and *10%. See section III for other independent variables included in the estimation (not reported here).

Source: RAIS, 1% random sample, RDE-IED, 1996–2001.

of a zero difference, as well as the separate γ_M and γ_D coefficients. In order to precisely estimate both γ_M and γ_D, robust standard errors are clustered at the establishment-year level to account for any within-establishment correlation in errors following Moulton (1990).

In column 1, I estimate multinational wage spillovers by pooled ordinary least squares. The results are consistent with multinational spillovers, though without controls for individual and establishment heterogeneity, the result is difficult to interpret. In column 2, I allow for average wage trends across all workers. The large, positive effects in columns 1 and 2 resemble the early generations of work on knowledge spillovers from multinational enterprises (for example, Blomstrom & Kokko, 1998, and the references there). All other independent variables included in the analysis are listed in the previous section but are not reported to conserve space.[16]

I include establishment fixed effects (FE) in column 3, which control for any fixed factor that may affect an establishment's decision to hire former multinational workers, such as management style or time-invariant productivity levels. As was found in the third generation of studies on multinational spillovers (Aitken & Harrison, 1999; Javorcik, 2004), establishment heterogeneity matters. That the coefficient on γ_M falls substantially between columns 2 and 3 suggests that omitting the establishment FE (what could be considered to be the omitted variable bias associated with establishment FE) has a large and positive effect. This is consistent with the idea that on average, establishments hiring many former MNE workers are also high-productivity, high-wage establishments.

Column 3, however, does not allow within-establishment heterogeneity across workers. In column 4, I include individual FEs to control for time-invariant, unobservable worker characteristics, such as innate ability or motivation. With individual FEs, the coefficients of interest are more precisely estimated, and it becomes clear that domestic workers are not randomly assigned to the establishments in which they work. Incumbent domestic workers' wages increase with the proportion of coworkers in the establishment who have experience in foreign-owned establishments ($\gamma_M > 0$).

Interestingly, incumbent domestic workers' wages also increase with the proportion of coworkers in the establishment who have experience in other domestically owned establishments ($\gamma_D > 0$). As I highlighted earlier, a positive γ_D could reflect domestic human capital spillovers but may also reflect that growing firms are also likely to simultaneously increase wages for all workers. For this reason, I concentrate on the differential impact of hiring workers with multinational experience over workers with no multinational experience ($\gamma_M - \gamma_D$). A 10 percentage point increase in the share of former multinational workers, holding the share of non-MNE switcher workers constant, increases an incumbent worker's wages by approximately 0.6%.

This is the main contribution and new result of this paper. When multinational workers leave multinational establishments and are rehired at domestic establishments, the wages of continuing domestic workers increase. This avenue for multinational spillovers, to my knowledge, has not previously been explored. At the average wage for a typical domestic worker of $3,841 (R$6,522 at average annual exchange rates during the 1996–2001 period), this is an increase of approximately $23 per year per worker, equivalent to one more month of job tenure within the establishment. While this may seem to be a small impact, it is also an appropriately sized impact for the average worker.

More important, these estimates are worker-level wage spillovers and not plant-level productivity spillovers, as in previous studies. For the average domestic establishment in Brazil, with a workforce of approximately sixty, the total implied wage effect from 10 percentage point increase in the share of former multinational workers is roughly $1,400 per year. According to RAIS, in 1998 there were 1,795,798 establishments in Brazil, approximately 98% of which were domestically owned. Therefore, this average impact has the potential to generate $2.5 billion in wage spillovers across all of Brazil (in the range of 0.3% of GDP). Furthermore, these figures capture only spillovers transferred to workers in the form of wages, not direct increases in establishment productivity and profitability, as discussed in section III, if profits are not shared with workers.

B. Robustness Checks

Industry characteristics. In section III, I discussed possibilities for how these worker-level multinational wage spillovers relate to the more common literature on plant-level multinational productivity spillovers. Recall that one hypothesis suggests that worker-level wage spillovers will result

[16] Coefficients are in line with expectations: wages are increasing in age at a decreasing rate, increasing with a worker's tenure at the establishment, increasing in the level of education and the skill intensity of the worker's occupation, and increasing in the establishment's employment.

TABLE 3.—MULTINATIONAL SPILLOVERS, BY INDUSTRY CHARACTERISTICS, 1996–2001

	Unionization		Skill Intensity	
Dependent Variable: Log Annual Wages	High Unionized	Low Unionized	High Skilled	Low Skilled
$\gamma_M - \gamma_D$	0.035	0.066*	0.108***	0.030
F-statistic	1.20	3.01	6.13	1.04
p-value	0.27	0.08	0.01	0.31
γ_M	0.038	0.072*	0.111**	0.036
	(0.031)	(0.038)	(0.044)	(0.029)
γ_D	0.003	0.006***	0.003	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
Year FE	Yes	Yes	Yes	Yes
Establishment FE	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes
Number of observations	52,477	43,371	45,325	51,235
Within R^2	0.1650	0.2015	0.1817	0.1808

Robust standard errors, clustered at the establishment-year level, are in parentheses. Significant at ***1%, **5%, and *10%. See section III for other independent variables included in the estimation (not reported here).

Source: RAIS, 1% random sample, RDE-IED, 1996–2001; PNAD, 1992–2001.

when former MNE workers bring knowledge in the form of physical capital, for example, enhancing the productivity and profitability of the domestically owned establishment. When establishment profits are shared with workers in an imperfectly competitive labor market setting, domestic workers will see improvements in wages. In this case, worker-level wage spillovers occur only because of plant-level productivity spillovers. In yet another hypothesis, the labor market is assumed to be competitive, and multinational workers directly interact and transfer knowledge in line with the social interactions theory. In this case, worker-level wage (productivity) spillovers may lead to firm-level productivity spillovers.

A main difference between these two hypotheses is the structure of the labor market. For this reason, in the first panel of table 3, I estimate equation (2) separately for heavily unionized and low-unionized industries.[17] Arai (2003) documents for Sweden the importance of the bargaining system for influencing profit sharing. Therefore, if the results in column 4 of table 2 are mainly driven by the first hypothesis, a strong, positive coefficient is expected for heavily unionized industries, where workers are assumed to have greater bargaining power and establishments are more likely to share additional profits resulting from multinational knowledge transfer. On the contrary, the results in the first panel of table 3 suggest that the wage spillovers found in table 2 mostly occur in less unionized industries where wage and employment policies may be more flexible to reward productive workers. This is consistent with the evidence that Hale and Long (2008) presented, which documents the differential impact of foreign investment on wages in China on private firms relative to state-owned enterprises with restrictive wage policies.

While these results cannot provide concrete answers to illustrate the differences among the two hypotheses, they detract from a story of worker bargaining power and lend some support to a story of knowledge transfer in the workplace. The theory of workplace interactions considers the transfer of information among individuals as an important element. Therefore, highly skilled industries may be expected to experience larger worker-level multinational wage spillovers.[18] In the second panel of table 3, I divide observations by the industry's time-invariant skill intensity—industries above the median value of skill, as defined by the share of the workforce with at least a high school education in 1995, are considered high-skilled industries.[19] Consistent with the evidence Keller and Yeaple (2009) presented for firm-level productivity spillovers, worker-level wage spillovers are present only in high-skill-intensive sectors.

Together, the results in table 3 demonstrate that multinational spillovers are not economy-wide. In fact, many workers do not benefit from a greater foreign presence in the establishment. The results also confirm the idea that local conditions, such as the level of education and labor market institutions, may play an important role in the ability of a firm to absorb the positive effects of foreign investment. A portion of the strong productivity spillovers found for high-tech sectors in Keller and Yeaple (2009) therefore could be attributed to knowledge transfer through worker mobility—worker-level wage spillovers that lead to firm-level productivity spillovers.

Considering the relevance of industry-level characteristics, such as the bargaining power of workers and the sector-level skill intensity for worker-level multinational wage spillovers, in table 4, I also include interactive industry-by-year fixed effects to absorb any time-varying, industry-level characteristics that may influence wages and coincide with the establishment's hiring of multinational workers. Column 1 also includes interactive region-by-year effects, as some authors have suggested that Brazil's currency crisis affected workers in Brazil's regions differentially. Because multinationals tend to be regionally concentrated (Aguayo-Tellez, Muendler, & Poole, 2010), this may also bear on the reallocation of multinational workers. The first column of table 4, therefore reports results from the following regression:

$$\ln y_{ijt} = \gamma_M S_{jt}^M + \gamma_D S_{jt}^D + \psi_i + \lambda_{j(i)} + \delta_{kt} + \delta_{rt} + \beta_1 X_{it} + \beta_2 Z_{jt} + \epsilon_{ijt}, \quad (3)$$

[17] I define the unionization status of the establishment's industry using Brazil's household survey, Pesquisa Nacional por Amostra de Domicilios, which contains information on the household member's industry of employment and whether the household member belongs to a union. With industry-level unionization rates for each of Brazil's four-digit industries over time, I then generate a time-invariant dummy variable equal to 1 if the value of the unionization measure for the industry is greater than the median value across all industries in 1992 and 0 otherwise.

[18] Horizontal spillovers have eluded many authors, with the exception of Haskel, Pereira, and Slaughter (2007) and Keller and Yeaple (2009) for the United Kingdom and the United States, respectively, suggesting that host characteristics, such as the level of education and institutions, play an important role in the ability of a country, sector, or firm to absorb knowledge transfers from multinationals.

[19] A high school education is often used as a more meaningful representation of skill in Brazil (Gonzaga, Menezes-Filho, & Terra, 2006).

TABLE 4.—MULTINATIONAL SPILLOVERS, 1996–2001

Dependent Variable: Log Annual Wages	(1)	(2)
$\gamma_M - \gamma_D$	0.046*	0.036*
F-statistic	3.57	3.29
p-value	0.06	0.07
γ_M	0.050**	0.035*
	(0.024)	(0.019)
γ_D	0.004**	−0.001
	(0.002)	(0.002)
Establishment FE	Yes	Yes
Individual FE	Yes	Yes
Industry-year FE	Yes	Yes
Region-year FE	Yes	Yes
Number of observations	96,560	57,136
Within R^2	0.1958	0.1953

Robust standard errors, clustered at the establishment-year level, are in parentheses. Significant at ***1%, **5%, and *10%. See section III for other independent variables included in the estimation (not reported here).

Source: RAIS, 1% random sample, RDE-IED, 1996–2001.

TABLE 5.—MULTINATIONAL SPILLOVERS, OMITTED VARIABLES, 1996–2001

Dependent Variable: Log Annual Wages	Exporters	Future Exporters	Future Wage Growth
$\gamma_M - \gamma_D$	0.046*	0.073**	0.075**
F-statistic	3.54	4.77	5.14
p-value	0.06	0.03	0.03
γ_M	0.050**	0.078**	0.080**
	(0.024)	(0.033)	(0.033)
γ_D	0.004**	0.005***	0.005**
	(0.002)	(0.002)	(0.002)
Establishment FE	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes
Number of observations	96,560	80,412	79,607
Within R^2	0.1965	0.1953	0.1876

Robust standard errors, clustered at the establishment-year level, are in parentheses. Significant at ***1%, **5%, and *10%. See section III for other independent variables included in the estimation (not reported here).

Source: RAIS, 1% random sample, RDE-IED, SECEX, 1996–2001.

where δ_{kt} and δ_{rt} reflect the industry-year and region-year dummies, respectively. The main results from column 4 of table 2 hold.

Next, to allay concerns that the 1% random sample of the population of Brazil's formal sector workforce is not representative of Brazil's firms and workers, in the second column of table 4, I repeat the analysis in column 1 beginning with a 5% random sample of formal sector males living in metropolitan areas. The main results are robust to using a different sample.[20] Moving forward, the analysis relies on these robust regressions, substituting simple year effects for industry-year and region-year fixed effects, as in equation (3).

Omitted variables. The key identifying assumption in equation (2) is that ϵ_{ijt} is uncorrelated with the main variable of interest, S^M_{jt}. Potential threats to this identification are time-varying, productivity shocks to establishments that cause them to seek out former multinational-establishment workers in the unemployed labor pool and MNE switcher workers who sort into high-wage-growth establishments. In both instances, high-quality workers disproportionately match with high-quality establishments.

Suppose domestically owned establishment j experiences a positive productivity shock in time t. Suppose further this positive productivity shock causes the establishment to disproportionately hire former multinational-establishment workers, as opposed to non-MNE switcher workers, in the unemployed labor pool (perhaps with the intention of upgrading the skill level of the workforce). Ideally, the econometrician would have access to data on establishment-level investment or intermediate inputs as proxies for shocks to productivity in order to test for such time-varying, establishment-level heterogeneity. In the absence of such data, I rely on a now-well-established finding in the international economics literature that even within narrowly defined industrial categories, globally engaged firms and domestically oriented firms are substantially different in terms of their productivity, size, employment composition, and wages (Bernard & Jensen, 1995, 1997; Melitz, 2003). Recent work also emphasizes firm heterogeneity along the extensive margin of products and destinations (Bernard, Redding, & Schott, 2011).

As a test for time-varying, establishment-level productivity shocks, I include a control for the global engagement of the firm into estimating equation (3).[21] Firms that become exporters in time t may also hire disproportionately more former MNE workers from the unemployed pool with the purpose of upgrading the skill composition of the workforce for export markets.[22] I also include as controls the number of products and the number of destinations (and quadratic terms of each to account for nonlinearities) as added measures of firm-level productivity that may correlate with the propensity to hire former multinational workers. Other work has suggested that in anticipation of exporting, firms prepare the workforce by hiring workers from other exporters (Molina & Muendler, 2009). Therefore, I include controls for one-period future values of the exporter variables to allow this possibility. Table 5 reports results with these additional controls. The first column has controls for the contemporaneous export variables, while the second column also includes

[20] The coefficient of interest is slightly smaller. However, the analysis using only metropolitan areas initially represents fewer MNEs than the national sample and, by extension, fewer MNE switchers.

[21] Since Brazilian establishment tax numbers are common across many databases, I match the information from RAIS to a complementary firm-level data source from the Brazilian Customs Office (SECEX) to determine whether the firm is an exporter in time t. SECEX records all legally registered firms in Brazil with at least one export transaction. This is my definition of an exporter: a positive dollar value of export sales. The SECEX data also include information on the products the firms export and the destinations to where firms export.

[22] See Yeaple (2005), Verhoogen (2008), and Kugler and Verhoogen (2012) for theory and evidence to support the quality-upgrading hypothesis.

one-period-future export variables.[23] The main coefficients of interest are unchanged from column 1 of table 4 with the addition of these time-varying, firm-level proxies for shocks to productivity.

These results offer some evidence against the idea that high-quality domestically owned establishments disproportionately seek out high-quality MNE workers. However, suppose the unemployed stock of former MNE workers, in their decision of where to accept reemployment, choose establishments with higher expected future wage growth—that is, high-quality MNE workers sort into high-quality domestically owned establishments. If all unemployed workers, former multinational and domestic establishment alike, equally sort to high-expected-wage-growth establishments, then the control S_{jt}^{D} for the non-MNE switcher share will account for this concern. However, if former multinational workers are better at distinguishing high-wage-growth establishments, then the results may be upwardly biased. In the final column of table 5, I include the one-year future value of the establishment's wage growth to test for differential switcher worker sorting.[24] Once again, the main coefficients of interest are robust.[25] In general, including these additional controls fails to find evidence of time-varying, establishment-level productivity shocks or switcher worker sorting as the motivating factor behind the worker-level multinational wage spillovers.

C. Alternative Explanations

Multinational screening. The argument in this paper rests on workers' learning while employed at the multinational establishment and having the ability to transfer this external knowledge to workers at the domestically owned establishment. As an alternative explanation, suppose multinational establishments are simply better at screening worker quality—either preemployment or on-the-job—than are domestically owned establishments.[26] In this case, the findings in this paper do not support a transfer of technological capital from foreign-owned to domestically owned establishments through worker turnover. Rather, workers with some unobservable attribute—an attribute better identified by managers at MNEs, for example—offer human capital spillovers.

[23] To conserve space, I do not report the additional controls. Note, however, that the point estimates report the expected signs: workers employed at firms producing a greater number of products for the foreign market and shipping to a greater number of destinations earn higher wages.

[24] Once again, additional controls are omitted to conserve space. Note, however, that workers in establishments with higher wage growth are predicted to earn more.

[25] Increases in the coefficients in the second and third columns reflect changes in the number of observations due to the addition of future values. Results from column 1 of table 4 for a consistent sample, available by request, confirm that coefficients are unchanged.

[26] Among other features, complementarities between firm productivity and worker ability in the model presented in Helpman et al. (2010) imply that more productive firms have an incentive to screen more intensively.

TABLE 6.—MULTINATIONAL SPILLOVERS, MNE SCREENING, 1996–2001

Dependent Variable: Log Annual Wages	Job Tenure	Layoff versus Quitting
$\gamma_{M_{low}} - \gamma_{D_{low}}$	0.021	0.053**
F-statistic	0.39	4.46
p-value	0.53	0.03
$\gamma_{M_{high}} - \gamma_{D_{high}}$	0.077**	0.008
F-statistic	4.78	0.01
p-value	0.03	0.94
Establishment FE	Yes	Yes
Individual FE	Yes	Yes
Industry-year FE	Yes	Yes
Region-year FE	Yes	Yes
Number of observations	96,560	96,560
Within R^2	0.1959	0.1958

Robust standard errors, clustered at the establishment-year level, are in parentheses. Significant at ***1%, **5%, and *10%. See section III for other independent variables included in the estimation (not reported here).

Source: RAIS, 1% random sample, RDE-IED, 1996–2001.

As a first test for this alternative explanation, I augment equation (3) to include the MNE-switcher worker's tenure at the multinational establishment. The main variables of interest, S_{jt}^{M} and S_{jt}^{D}, are disaggregated into shares with low tenure and shares with high tenure.[27] The longer a worker is employed at the multinational establishment, the greater the potential knowledge and technology to be absorbed and transferred. By contrast, if a worker is only briefly employed at an MNE and multinational knowledge spillovers still exist, the argument for acquired knowledge transfer diminishes and the argument for a screening mechanism strengthens. Earlier results may capture only a signal of the quality of the former MNE worker.

The results in the first column of table 6 confirm the hypothesis that the longer the MNE-switcher worker was employed at the multinational establishment, the better able is the worker to transfer information to the incumbent domestic workforce in the form of higher wages.[28] An increase in the share of workers with experience at a multinational establishment of greater than the median tenure across all workers significantly increases incumbent domestic workers' wages, controlling for the share of workers in the establishment from other domestic establishments with above-median tenure. The share of former multinational workers with less than the median experience at a multinational establishment does not have a significant impact on incumbent domestic workers' wages.

Similarly, perhaps MNE managers are better than domestic managers at screening workers on the job (rather than preemployment). The strong, positive wage spillovers from high-tenure former MNE workers could reflect that these workers managed to hold on to the position and were not

[27] Based on the sample of workers described in section II, I define all workers to be either low-tenure workers or high-tenure workers based on the sample's median tenure of approximately two years.

[28] From here forward, individual γ_* coefficients are suppressed because of space constraints but are available on request.

TABLE 7.—MULTINATIONAL SPILLOVERS, BY PRODUCTIVITY, 1996–2001

Dependent Variable: Log Annual Wages	Exporter	High Wage
$\gamma_{M_{low}} - \gamma_{D_{low}}$	0.035	0.019
F-statistic	0.51	0.13
p-value	0.47	0.72
$\gamma_{M_{high}} - \gamma_{D_{high}}$	0.055**	0.058**
F-statistic	3.74	4.25
p-value	0.05	0.04
Establishment FE	Yes	Yes
Individual FE	Yes	Yes
Industry-year FE	Yes	Yes
Region-year FE	Yes	Yes
Number of observations	96,560	96,560
Within R^2	0.1958	0.1959

Robust standard errors, clustered at the establishment-year level, are in parentheses. Significant at ***1%, **5%, and *10%. See section III for other independent variables included in the estimation (not reported here).

Source: RAIS, 1% random sample, RDE-IED, SECEX 1996–2001.

laid off due to a poor match quality. Because the RAIS data include an indicator for the reason for job separation, I test separately MNE workers who were laid off and MNE workers who left the multinational by choice.[29] If multinational managers are better on-the-job screeners than domestic employers, displacing poor-quality workers, there should be little knowledge spillover to the domestic workforce from laid-off workers.

The second column in table 6 shows that, on the contrary, displaced MNE workers offer significant wage spillovers to incumbent domestic workers, while there is little evidence of knowledge transfer in the form of wage gains from quitting MNE workers. This is likely due to the limited diffusion of quitting MNE workers into the domestic workforce. Recall from section II that only 2.7% of multinational workers quit the job. More important, even potentially low-quality MNE workers (those who were displaced involuntarily) transfer knowledge in the form of wage spillovers to incumbent domestic workers. Together, the results in table 6 fail to find substantial support for the view that multinational enterprises are simply better able to screen for high-quality workers.

Multinational or productive? As I have previously hinted, multinational establishments are, on average, more productive than domestic establishments (Helpman, Melitz, & Yeaple, 2004). This raises yet another possible explanation for the main findings in this paper: knowledge transfer from high-productivity establishments. In the absence of direct information on establishment-level productivity, I consider two proxies to separate multinational and domestic establishments into high- and low-productivity establishments in table 7.

In the first column, following Bernard and Jensen (1995, 1997) and Melitz (2003), in which the more productive firms within an industry are exporters, I distinguish former multinational workers into former MNE exporting workers (high productivity) and former MNE nonexporting workers (low productivity). I conduct a similar disaggregation for the share of other domestic workers in the domestically owned establishment, such that the analysis captures hiring high-productivity MNE-switcher workers over high-productivity domestic workers. Controlling for the share of highly productive non-MNE switcher workers in the establishment, the data report significant wage spillovers from former multinational workers. This provides supportive evidence against the hypothesis that the previous results reflected solely the productivity of the multinational.

High-productivity establishments also tend to have high average wages, often because they have highly skilled workforces (both observable and unobservable) (Abowd et al., 1999). In the second column of table 7, I rely on this well-established finding to separate establishments into high-wage and low-wage establishments as follows. Using the complete sample outlined in section II, in a first stage, I run a simple Mincer (1974) wage regression. The analysis includes all of the covariates discussed until now, and importantly, establishment fixed effects. I define high-wage establishments to be those with an estimated establishment FE above the median value.[30] Following the previous analysis, I then consider former high-wage MNE workers, former low-wage MNE workers, other high-wage domestic workers, and other low-wage domestic workers. Once again, high-wage MNE workers transfer knowledge in the form of wage gains to incumbent domestic workers beyond any impact of high-productivity domestic workers.[31] The main results are not likely due to large, productive domestic establishments; rather, there is a strong component due to specific multinational activity.

V. Multinational Spillovers by Worker Skill Level

The previous section provided convincing and robust evidence that when workers leave multinational establishments and are rehired in domestic establishments, the continuing domestic-establishment workforce benefits through increased wages. Moreover, the strongest evidence for knowledge transfers from multinational to domestic establishments through worker mobility was found in high-skill-intensive industries, suggesting that a sector's absorptive capacity may play a role in the transfer of a multinational's technological capital. In this section, I consider heterogeneity in worker-level skills: Are higher-skilled former multinational workers

[29] In table 6, "low" indicates a multinational worker who was laid off, while "high" indicates a multinational worker who quit.

[30] Because the regression controls for the observable worker and establishment characteristics, high establishment fixed effects correspond to high unobserved establishment-level productivity, possibly reflecting the composition of unobservable worker attributes within the establishment.

[31] Moreover, one might question whether hiring an additional high-productivity domestic worker over an additional low-productivity domestic worker contributes to incumbent domestic workers' wages. In unreported results, the F-statistics and p-values for these tests suggest an insignificantly differential impact.

TABLE 8.—MULTINATIONAL SPILLOVERS, BY SWITCHER SKILL LEVEL, 1996–2001

Dependent Variable: Log Annual Wages	Education	Occupation	Ability
$\gamma_{M_{low}} - \gamma_{D_{low}}$	0.036	0.029	0.029
F-statistic	1.03	0.85	0.66
p-value	0.31	0.36	0.42
$\gamma_{M_{high}} - \gamma_{D_{high}}$	0.060*	0.073*	0.051
F-statistic	3.22	3.21	2.63
p-value	0.07	0.07	0.11
Establishment FE	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes
Number of observations	96,560	96,560	96,560
Within R^2	0.1958	0.1959	0.1959

Robust standard errors, clustered at the establishment-year level, are in parentheses. Significant at ***1%, **5%, and *10%. See section III for other independent variables included in the estimation (not reported here).

Source: RAIS, 1% random sample, RDE-IED, 1996–2001.

TABLE 9.—MULTINATIONAL SPILLOVERS, BY INCUMBENT SKILL LEVEL, 1996–2001

Dependent Variable: Log Annual Wages	Education	Occupation	Ability
Low-skilled incumbents			
$\gamma_M - \gamma_D$	0.015	0.039	0.018
F-statistic	0.23	1.48	0.13
p-value	0.63	0.22	0.71
Number of observations	58,670	46,275	29,229
Within R^2	0.1854	0.1913	0.2111
High-skilled incumbents			
$\gamma_M - \gamma_D$	0.077**	0.047	0.056**
F-statistic	3.82	1.63	4.03
p-value	0.05	0.20	0.04
Number of observations	37,890	50,285	67,331
Within R^2	0.2241	0.2016	0.1990

Robust standard errors, clustered at the establishment-year level, are in parentheses. Significant at ***1%, **5%, and *10%. See section III for other independent variables included in the estimation (not reported here).

Source: RAIS, 1% random sample, RDE-IED, 1996–2001.

better able to transfer the MNE's technology? Are higher-skilled incumbent domestic workers better able to learn the MNE's technology?

Workers are grouped into high-skilled and low-skilled categories along three separate dimensions: the worker's educational attainment, the skill intensity of the worker's occupation, and the worker's unobservable "ability" conditional on observable skills. Workers are considered high skilled if they have a high-school education or more, if they are employed in a white-collar profession (secretarial, managerial, or other technical), or if the estimated worker fixed effect is greater than the median value across all workers.[32]

A. *Switcher Skill Level*

The ideas presented in this paper rely on the fact that the former multinational worker learns while at the MNE and transfers the external knowledge on rehire to the domestically owned establishment. It is probable that this learning process and knowledge transfer would be facilitated by higher-skilled individuals. In table 8, I consider whether the skill level of the former multinational worker matters for multinational wage spillovers. The main variables of interest are now disaggregated into those of low-skilled switchers and those of high-skilled switchers.

The first column reports results by the education level of the switcher worker. The second column uses the skill intensity of the worker's occupation to categorize worker's skills, and the final column offers results for skills based on a worker's unobservable ability. By and large, the results are consistent with the hypothesis that higher-skilled former multinational workers are better able to transfer information to the incumbent domestic workforce, evidenced by increases in domestic workers' wages. In all three columns, the point estimate on the differential $\gamma_M - \gamma_D$ is larger for high-skilled switchers than for low-skilled switchers. Moreover, the differential impact is statistically significant only for high-skilled switchers, when skill is defined by education and occupation (and significant at the 11% level when skill is defined by ability).

B. *Incumbent Skill Level*

Following the same line of thought, it is also reasonable to imagine that higher-skilled individuals within the domestically owned establishment are better prepared to incorporate any external knowledge brought by former multinational workers. In table 9, I test whether the skill level the incumbent domestic worker has an impact on the magnitude of the multinational spillover effect. For the regressions in table 9, I further restrict the set of observations for analysis to incumbent domestic workers with a given skill level, as defined by education, occupation, or unobservable ability.

Again, the results fail to reject the hypothesis that higher-skilled incumbent domestic workers are better able to absorb information from former multinational workers. Across all three skill classifications, the worker-level multinational wage spillover effect is larger in magnitude for high-skilled incumbents, though the differential impact is not statistically significant when the skill level of the incumbent domestic workforce is defined by the worker's profession, possibly due to the limited workplace interaction of professional and managerial workers.

C. *Knowledge Matching and Knowledge Spillovers*

Jovanovic and Rob (1989) argue that informational spillovers will be greater the larger the knowledge distance between the agents, that is, the greater the informational

[32] Similar to the analysis in the previous section, using the complete worker sample from section II, I estimate a wage regression with observable worker and establishment characteristics and worker fixed effects. Because the regression controls for observable characteristics, high estimated values for the worker fixed effects reflect high unobservable worker attributes.

TABLE 10.—MULTINATIONAL SPILLOVERS, BY SWITCHER AND INCUMBENT SKILL LEVEL, 1996–2001

Dependent Variable: Log Annual Wages	Education	Occupation	Ability
Low-skilled incumbents			
$\gamma_{M_{low}} - \gamma_{D_{low}}$	0.022	0.042	0.003
F-statistic	0.33	1.00	0.00
p-value	0.57	0.32	0.97
$\gamma_{M_{high}} - \gamma_{D_{high}}$	0.002	0.039	0.035
F-statistic	0.00	0.72	0.27
p-value	0.97	0.39	0.61
Number of observations	58,670	46,275	29,229
Within R^2	0.1854	0.1915	0.2111
High-skilled incumbents			
$\gamma_{M_{low}} - \gamma_{D_{low}}$	0.072	0.033	0.045
F-statistic	0.97	0.43	1.26
p-value	0.32	0.51	0.26
$\gamma_{M_{high}} - \gamma_{D_{high}}$	0.080*	0.058	0.056
F-statistic	3.42	1.05	2.54
p-value	0.06	0.30	0.11
Number of observations	37,890	50,285	67,331
Within R^2	0.2241	0.2015	0.1990

Robust standard errors, clustered at the establishment-year level, are in parentheses. Significant at ***1%, **5%, and *10%. See section III for other independent variables included in the estimation (not reported here).

Source: RAIS, 1% random sample, RDE-IED, 1996–2001.

asymmetry between the agents, while Moretti (2004) finds human capital spillovers are greater for industries that are economically close than for industries that are economically distant, considering measures of economic distance such as input-output tables, technological distance, and linkages based on patent citations. I use these two contrasting ideas to test the hypothesis that spillovers occur between like workers versus the hypothesis that spillovers occur between unlike workers. I consider whether the magnitude of spillovers increases as the likelihood increases that the entering multinational worker is similar in his or her skill set to the incumbent domestic worker. Do managers learn from managers and production workers from production workers? Or do production workers learn best from managers?

Table 10 distinguishes switchers by skill as in table 8 and restricts the sample for analysis by the skill level of the incumbent domestic worker as in table 9. The data provide suggestive evidence that information is best transferred between similarly skilled groups of high-skilled workers. Most notably in the first column, when skill is denoted by workers' educational attainment, former multinational workers with at least a high school education offer the largest wage gains to incumbent domestic workers with at least a high school education. Similarly, though significant only at the 11% level, controlling for high-ability non-MNE switcher workers, a 10 percentage point increase in the share of high-ability MNE switcher workers increases high-ability incumbent domestic workers' wages by 0.6% (the point estimates on the differential increase monotonically). Overall, it seems plausible that the robust evidence for multinational wage spillovers through worker mobility is driven by strong worker-level wage spillovers from high-skilled former MNE workers to high-skilled incumbent domestic workers.

VI. Conclusion

The goal of this paper is to investigate the impact of foreign direct investment in Brazil on the local labor market through worker mobility and knowledge transmission. Though anecdotal evidence suggests informational externalities may be created by the movement of workers who have been trained by multinational establishments into jobs outside those establishments, thus allowing the benefits of the training to spill to agents outside the MNE, empirically identifying these effects has been difficult. This paper offers the first direct evidence from a large database on a developing country for positive multinational wage spillovers through worker turnover.

The main results are consistent with the existence of knowledge transfers from multinational to domestic establishments as identified by increases in incumbent domestic workers' wages. Ex ante identical workers in establishments with a higher proportion of workers with some experience at a multinational establishment earn higher wages. The results are robust to individual and establishment fixed effects, as well as different specifications controlling for time-varying, establishment-level productivity shocks and alternative explanations concerning multinational labor screening and knowledge transfers from high-productivity establishments.

The magnitude of these worker-level wage spillovers varies with characteristics of the domestic establishment's industry, such as labor market institutions and levels of education. Therefore, the results confirm that multinational spillovers are not economy-wide; that is, most workers do not receive spillover benefits. In fact, evidence by the skill level of the worker supports the hypothesis that higher-skilled former multinational workers are better able to transfer a multinational's technology to incumbent domestic workers and higher-skilled incumbent domestic workers are better able to absorb the MNE's technology from former multinational workers. Moreover, the largest wage gains occur when the skill sets of the incumbent domestic worker match the skill sets of the former multinational worker: high-skilled incumbent workers learn from high-skilled MNE switchers.

Interesting avenues for future work may exploit more fully the depth of the data in order to uncover the explicit timing of multinational spillovers, providing answers about the learning process and the transfer of technology within the firm, as well as the dynamics of wages for multinational switcher workers as they relate to the literature on on-the-job training.

REFERENCES

Abowd, John M., Francis Kramarz, and David N. Margolis, "High Wage Workers and High Wage Firms," *Econometrica* 67 (1999), 251–333.

Abowd, John. M., Francis Kramarz, David N. Margolis, and Kenneth R. Troske, "The Relative Importance of Employer and Employee Effects on Compensation: A Comparison of France and the United States," *Journal of the Japanese and International Economies* 15 (2001), 419–436.

Aguayo-Tellez, Ernesto, Marc-Andreas Muendler, and Jennifer P. Poole, "Globalization and Formal-Sector Migration in Brazil," *World Development* 38 (2010), 840–856.

Aitken, Brian, Gordon H. Hanson, and Ann E. Harrison, "Spillovers, Foreign Investment, and Export Behavior," *Journal of International Economics* 43 (1997) 103–132.
Aitken, Brian, and Ann E. Harrison, "Do Domestic Firms Benefit from Foreign Direct Investment? Evidence from Venezuela," *American Economic Review* 89 (1999), 605–618.
Alfaro, Laura, and Andrés Rodríguez-Clare, "Multinationals and Linkages: An Empirical Investigation," *Economia* (Spring 2004), 113–169.
Amiti, Mary, and Donald R. Davis, "Trade, Firms, and Wages: Theory and Evidence," *Review of Economic Studies* 79 (2011), 1–36.
Antràs, Pol, Luis Garicano, and Esteban Rossi-Hansberg, "Offshoring in a Knowledge Economy," *Quarterly Journal of Economics* 121 (2006), 31–77.
Arai, Mahmood, "Wages, Profits, and Capital Intensity: Evidence from Matched Worker-Firm Data," *Journal of Labor Economics* 21 (2003), 593–618.
Balsvik, Ragnhild, "Is Labor Mobility a Channel for Spillovers from Multinationals? Evidence from Norwegian Manufacturing," this REVIEW 93 (2011), 285–297.
Bernard, Andrew B., and J. Bradford Jensen, "Exporters, Jobs and Wages in U.S. Manufacturing, 1976–87," *Brookings Papers on Economic Activity: Microeconomics* (1995), 67–112.
——— "Exporters, Skill Upgrading, and the Wage Gap," *Journal of International Economics* 42 (1997), 3–31.
Bernard, Andrew B., Stephen J. Redding, and Peter K. Schott, "Multi-Product Firms and Trade Liberalization," *Quarterly Journal of Economics* 126 (2011), 1271–1318.
Blomstrom, Magnus, and Ari Kokko, "Multinational Corporations and Spillovers," *Journal of Economic Surveys* 12 (1998), 247–277.
Cooper, David P., "Innovation and Reciprocal Externalities: Information Transmission via Job Mobility," *Journal of Economic Behavior and Organization* 45 (2001), 403–425.
Dasgupta, Kunal, "Learning and Knowledge Diffusion in a Global Economy," unpublished manuscript (2010).
Davis, Donald R., and James Harrigan, "Good Jobs, Bad Jobs, and Trade Liberalization," *Journal of International Economics*, 84 (2011), 26–36.
Egger, Hartmut, and Udo Kreickemeier, "Firm Heterogeneity and the Labor Market Effects of Trade Liberalization," *International Economic Review* 50 (2009), 187–216.
Fosfuri, Andrea, Massimo Motta, and Thomas Ronde, "Foreign Direct Investment and Spillovers through Workers' Mobility," *Journal of International Economics* 53 (2001), 205–222.
Gerschenberg, Irving, "The Training and Spread of Managerial Know-How, A Comparative Analysis of Multinational and Other Firms in Kenya," *World Development* 15 (1987), 931–939.
Glass, Amy, and Kamal Saggi, "Multinational Firms and Technology Transfer," *Scandinavian Journal of Economics* 104 (2002), 495–513.
Gonzaga, Gustavo, Naércio-Aquino Menezes-Filho, and Cristina Terra, "Trade Liberalization and the Evolution of Skill Earnings Differentials in Brazil," *Journal of International Economics* 68 (2006), 345–367.
Gorg, Holger, and Eric Strobl, "Spillovers from Foreign Firms through Worker Mobility: An Empirical Investigation," *Scandinavian Journal of Economics* 107 (2005), 693–709.
Greenaway, David, Nuno Sousa, and Katharine Wakelin, "Do Domestic Firms Learn to Export from Multinationals?" *European Journal of Political Economy* 20 (2004), 1027–1043.
Hale, Galina, and Cheryl Long, "Did Foreign Direct Investment Put an Upward Pressure on Wages in China?" Federal Reserve Bank of San Francisco working paper 2006–25 (2008).
Harrison, Ann, and Andrés Rodríguez-Clare, "Trade, Foreign Investment, and Industrial Policy for Developing Countries" (pp. 4039–4214), in Dani Rodrik and Mark Rosenzweig (eds.), *Handbooks in Economics* (Amsterdam: Elsevier, 2010).
Haskel, Jonathan E., Sonia Pereira, and Matthew J. Slaughter, "Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms?," this REVIEW 89 (2007), 482–496.
Helpman, Elhanan, Marc J. Melitz, and Stephen R. Yeaple, "Export versus FDI with Heterogeneous Firms," *American Economic Review* 94 (2004), 300–316.
Helpman, Elhanan, Oleg Itskhoki, and Stephen Redding, "Inequality and Unemployment in a Global Economy," *Econometrica* 78 (2010), 1239–1283.
Javorcik, Beata Smarzynska, "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages," *American Economic Review* 94 (2004), 605–627.
Jovanovic, Boyan and Rafael Rob, "The Growth and Diffusion of Knowledge," *Review of Economic Studies* 56 (1989), 569–582.
Keller, Wolfgang, "International Technology Diffusion," *Journal of Economic Literature* 42 (2004), 752–782.
——— "International Trade, Foreign Direct Investment, and Technology Spillovers," in B. Hall and N. Rosenberg (eds.), *Handbook of the Economics of Innovation* (Amsterdam: North-Holland, Elsevier, 2009).
Keller, Wolfgang, and Stephen Yeaple, "Multinational Enterprises, International Trade, and Productivity Growth: Firm-Level Evidence from the United States," this REVIEW 91 (2009), 821–831.
Kugler, Maurice, and Eric A. Verhoogen, "Prices, Plant Size, and Product Quality," *Review of Economic Studies* 79 (2012), 609–644.
Lindsey, C. W., "Transfer of Technology to the ASEAN Region by U.S. Transnational Corporations," *ASEAN Economic Bulletin* 3 (1986), 225–247.
Manski, Charles, "Identification of Endogenous Social Effects: The Reflection Problem," *Review of Economic Studies* 60 (1993), 531–542.
Markusen, James R., "Contracts, Intellectual Property Rights, and Multinational Investment in Developing Countries," *Journal of International Economics* 53 (2001), 189–204.
Markusen, James R., and Natalia Trofimenko, "Teaching Locals New Tricks: Foreign Experts as a Channel of Knowledge Transfers," *Journal of Development Economics* 88 (2009), 120–131.
Mas, Alexandre, and Enrico Moretti, "Peers at Work," *American Economic Review* 99 (2009), 112–145.
Melitz, Marc J., "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica* 71 (2003), 1695–1725.
Mincer, Jacob, *Schooling, Experience, and Earnings* (New York: Columbia University Press, 1974).
Molina, Danielken, and Marc-Andreas Muendler, "Preparing to Export" unpublished manuscript (2009).
Moretti, Enrico, "Workers' Education, Spillovers, and Productivity: Evidence from Plant-Level Production Functions," *American Economic Review* 94 (2004), 656–690.
Moulton, Brent R., "An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Units," this REVIEW 72 (1990), 334–338.
Muendler, Marc Andreas, Jennifer P. Poole, Garey Ramey, and Tamara Wajnberg, "Job Concordances for Brazil: Mapping the Classificação Brasileira de Ocupações (CBO) to the International Standard Classification of Occupations (ISCO-88)," unpublished manuscript (2004).
Rauch, James E., "Networks versus Markets in International Trade," *Journal of International Economics* 48 (1999), 7–35.
Rodrigues, Denise Andrade, "Investment in Brazil in the 1990s: Sectorial and Regional Views," unpublished manuscript, Banco Nacional de Desenvolvimento Econômico e Social (2000).
Saggi, Kamal, "Trade, Foreign Direct Investment, and International Technology Transfer: A Survey," *World Bank Research Observer* 17 (2002), 191–235.
Schank, Thorsten, Claus Schnabel, and Joachim Wagner, "Do Exporters Really Pay Higher Wages? First Evidence from German Linked Employer-Employee Data," *Journal of International Economics* 72 (2007), 52–74.
Verhoogen, Eric A., "Trade, Quality Upgrading and Wage Inequality in the Mexican Manufacturing Sector," *Quarterly Journal of Economics* 123 (2008), 489–530.
World Bank, *World Development Indicators* (Washington, DC: World Bank, 2005).
Yeaple, Stephen Ross, "A Simple Model of Firm Heterogeneity, International Trade, and Wages," *Journal of International Economics*, 65 (2005), 1–20.