Multinational Spillovers through Worker Turnover*

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JOB MARKET PAPER

University of California, San Diego

November 2006

Abstract

Labor turnover is a commonly-cited mechanism for the transmission of spillovers from multinational to domestic firms, but until now there has been little direct evidence for this mechanism. Using a novel matched establishment-worker database from Brazil, I present evidence consistent with the existence of positive multinational spillovers through worker mobility in Brazil. The paper explores *where* spillovers occur and *how* they are absorbed. The main results suggest that the magnitude of wage spillovers from multinational establishments depends on the sector and worker under consideration. The results are consistent with the hypothesis that higher-skilled former multinational-establishment workers are better able to convey information and higher-skilled incumbent domestic workers are better able to absorb information. But, the largest spillovers occur when the skill sets of the incumbent domestic worker are smaller than the skill sets of the former multinational-establishment worker, suggesting incumbent production workers learn from former multinational managers. The results are robust to various model specifications, including worker and establishment fixed effects.

*I am grateful to Marc-Andreas Muendler and James E. Rauch for their guidance and support throughout this research, and to Eli Berman, Gordon Hanson, and Craig McIntosh for helpful discussions. I also thank seminar participants at the UCSD Department of Economics, Applied Lunch Seminar and the joint Department of Economics-Graduate Institute of International Relations and Pacific Studies, International and Development Seminar, especially Kate Antonovics, Arnaud Costinot, Julie Berry Cullen, Nora Gordon, Roger Gordon, and Michelle White. Special thanks to Paulo Furtado de Castro for help with the RAIS data, and to Patricia Vanderlei Fernandes and Paulo Marcelo Cavalcanti Muniz of the *Banco Central do Brasil* for providing the RDE-IED data. Financial support from the Institute for International, Comparative, and Area Studies, the Dean of Social Sciences, and the Center for Iberian and Latin American Studies at the University of California, San Diego is acknowledged.

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1 Introduction

Despite the long history of academic work testing the implications from increased multinational presence on domestic firms, the exact mechanisms through which spillovers occur are rarely tested. Within the few studies that do address a particular mechanism of transmission, the existing empirical evidence on spillovers through worker turnover is limited, even though many multinational establishments devote a great deal of effort to retaining workers they train with valuable technological capital. In this paper, I present evidence consistent with this single mechanism for spillovers from multinational establishments locating in Brazil. More precisely, I investigate multinational spillovers resulting from worker mobility. This paper also explores *where* spillovers occur and *how* spillovers are absorbed. I discern the spillover effect by sector, and distinguish it by the skill-level of the displaced former multinational-establishment worker and the incumbent domestic worker.

Multinational enterprises (MNE) may instill positive technological knowledge on workers at their subsidiaries through labor training regarding new process innovations, high-quality intermediate inputs, and management styles. This imported technology, however, is a public good and knowledge transfer to local firms may occur as domestic firms find out about the multinational's technology and attempt to imitate it in the local production process. Domestic firms may gain access to the multinational's technology by hiring a former MNE-trained worker with special skills. It is precisely this mechanism of technology spillovers that I uncover in the analysis that follows.

This paper offers a number of important contributions to the current literature on multinational knowledge spillovers, in large part due to the depth of a novel linked employer-employee database from Brazil. First, this is the first paper, to my knowledge, to offer direct evidence from a large database for a developing country for evidence consistent with positive multinational spillovers through the worker mobility channel. Using matched establishment-worker data, I am able to trace individual workers over time across establishment types. The detailed labor force characteristics allow me to estimate heterogeneous responses of wages depending on worker-level characteristics beyond prior work. In addition, the data include a rich set of establishment-level controls. Moreover, to the best of my knowledge, this is the

first paper to span all sectors of the economy, not only an individual industry. I go beyond the common manufacturing focus and estimate multinational spillovers in the services sectors where much of the foreign investment in Brazil flowed beginning in 1996. Also, I do not restrict the analysis to senior-level management. I will show that multinational spillovers occur at all skill levels, and vary by both the skill-level of the former multinational-establishment worker and the skill-level of the incumbent domestic worker.

In contrast to earlier work on this subject, I focus on the worker rather than the firm as the unit of analysis. I measure spillovers as increases in the incumbent domestic worker's wages. Motivated by the social interactions model proposed by Manski (1993), I picture the growth of knowledge occurring when pairwise meetings between individual workers take place. Empirically, the transmission of knowledge occurs through interactions between individual workers; more precisely, between workers who are displaced from multinational establishments and rehired at domestic establishments on the one hand and the incumbent domestic workforce on the other hand. The greater the share of former multinational-establishment workers in an incumbent domestic worker's establishment, the greater the number of possible individual interactions in the domestic-owned establishment and the greater the potential transfer of knowledge. If multinational spillovers through worker mobility exist, I expect workers in establishments hiring a greater share of former multinational-establishment workers to earn higher wages through their potential social interactions with former multinational-establishment 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 for the first time in this paper 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.

The findings can be summarized as follows. The main results are consistent with the

existence of positive multinational spillovers defined to be the effects of the share of former multinational-establishment workers in the domestic-owned establishment on incumbent domestic workers' wages. The magnitude of wage spillovers from multinational establishments depends on the sector under consideration. Though multinational spillovers are not economy-wide, and in fact, most sectors and most workers do not receive spillover benefits, the results are consistent with the idea that local conditions, such as the level of education, may play an important role in the ability of a country to absorb foreign technological capital.

Evidence by skill-level of the worker supports the hypothesis that higher-skilled former multinational-establishment workers are better able to convey a multinational's technology to incumbent domestic workers and higher-skilled incumbent domestic workers are better able to absorb a multinational's technology from former multinational-establishment workers. The largest spillover effects occur when the skill sets of the incumbent domestic worker are lower than the skill sets of the former multinational-establishment worker, suggesting incumbent production workers learn from former multinational worker managers or technicians. The results are robust to worker and establishment fixed effects as well as to different specifications controlling for time-varying, establishment-specific productivity shocks, worker sorting, and the endogeneity of worker displacement.

The remainder of this paper is organized as follows. In the next section, I briefly summarize the literature on multinational spillovers and discuss in detail the evidence for the different potential mechanisms of transmission. In section 3, I discuss the empirical methodology, motivated by the social interactions model proposed by Manski (1993). Section 4 details the data with descriptive statistics. I present the results from the analysis of multinational spillovers through worker mobility in section 5 and identify the sectors that exhibit spillovers. In section 6, for the sectors with spillovers, I distinguish the spillover effect by the skill-level of the displaced former multinational-establishment worker and the incumbent domestic worker in order to uncover how spillovers are absorbed. Additional robustness checks are offered in section 7. I conclude with final remarks.

2 Literature Review

There is a long history of academic work testing the implications from increased multinational presence on domestic firms.[1] These early studies ask whether multinational spillovers exist, but the mechanisms through which spillovers occur are treated as a black box. However, foreign investment may generate productivity spillovers through a number of different channels: imitation, competition, market access, linkages, and labor turnover. Domestic competitors might successfully imitate technological innovations introduced by MNEs. Production externalities may occur if an increase in competition, as a result of foreign entry, induces firms to become more efficient or to discover new technologies. Aitken and Harrison (1999) show the competition effect may not be positive. For the case of Venezuela, they find increased foreign investment to be negatively related to productivity growth for establishments in the same sector. The authors attribute this negative relationship to the market-squeezing effect of foreign investment. Competition from foreign producers forces out low productivity domestic producers, raising the average productivity of the industry.

Another possible mechanism for the transmission of technology spillovers from multinationals is through market access. The MNE may possess strong links to the home country and world markets helping to establish informational networks for local firms. Aitken, Hanson and Harrison (1997) show that Mexican plants have a higher propensity to export the higher is the concentration of MNE exporters in the industry in which the firm produces. This is consistent with the idea that there exist informational externalities to having a foreign presence in a firm's industry. Greenaway, Sousa and Wakelin (2004) confirm the results for an industrialized country, the United Kingdom.

Local firms may also benefit from increased multinational presence if they are suppliers to MNEs. To the extent that multinational firms compete with domestic firms in the same sector, MNEs have an incentive to prevent the leakage of private technology and information. For this reason, evidence of positive *horizontal* spillovers is lacking.[2] However, it is to the benefit of the MNE if their intermediate input suppliers increase productivity and efficiency.

[1] For a review of earlier work, see Blomstrom and Kokko (1998).

[2] The literature defines horizontal spillovers to be within-industry and vertical spillovers to be between-industry.

Javorcik (2004) finds evidence consistent with positive *vertical* productivity spillovers from multinational firms to their domestic suppliers using data from Lithuanian plants. In contrast, Alfaro and Rodríguez-Clare (2004) account for the fact that multinational firms may not source inputs from local firms, but rather may import from the home country. With this in mind, they find little evidence of positive vertical spillovers created by backward linkages from multinational firms in Brazil, Chile, Mexico, and Venezuela.

There is evidence at the firm-level, however, for positive horizontal productivity spillovers in industrialized countries (e.g., see Haskel, Pereira and Slaughter (2004) for the United Kingdom and Keller and Yeaple (2004) for the United States), suggesting host country characteristics, such as the level of education of the labor force and institutions, may play an important role in the ability of the country to absorb multinational spillovers. Cohen and Levinthal (1990) first argued that a skill set must be built up by domestic workers in order to implement foreign technologies. This *absorptive capacity* of a firm or an economy is necessary in order to recognize the value of new information and to integrate it into the current production process. Keller (1995) argues that the higher initial stock of human capital in Korea relative to Brazil prior to their respective trade liberalizing experiences and faster Korean growth post-liberalization fits well with this argument.

Labor turnover Worker mobility is a commonly-cited mechanism for the transmission of multinational spillovers. Multinational corporations devote more resources to labor training than domestic firms (e.g., Lindsey (1986) and Gerschenberg (1987)). Under the assumption that this knowledge is not firm-specific, worker mobility can serve as a mechanism for a domestic worker's and domestic firms' acquisition of externally-developed knowledge. In fact, it is not a necessary condition for multinational spillovers through worker mobility that multinational firms offer formal training. If MNEs adopt a new technology or process innovation not available to domestic firms, and workers at multinational firms learn by doing, on-the-job training is a sufficient condition for absorbing and transferring the technology.

Though there is a large theoretical body of work on interfirm worker mobility and knowledge transfer (e.g., Fosfuri, Motta and Ronde (2001) and Cooper (2001)), the existing empirical literature on spillovers through labor turnover is limited to small-sample survey data

from a single industry. Gerschenberg (1987) surveyed 72 top- and middle-level managers from 41 manufacturing firms in Kenya. He finds that MNEs in Kenya provide more training for Kenyan managers than locally-owned firms and that labor mobility is lower for managers at multinational firms. He attributes this to the wage premium paid at most MNE firms. Gerschenberg's (1987) sample includes 15 managers who moved from an MNE to a local firm, 4 managers who moved from an MNE to a joint-venture firm, and 9 managers who moved from an MNE to the public sector. The author concludes that the dissemination of managerial know-how is low.

With detailed firm-level data from a sample of 204 Ghanian manufacturing firms, Gorg and Strobl (2005) focus on the owners of domestic firms who were previously employed at a foreign multinational. Using these data, the authors investigate whether domestic firms which have entrepreneurs with foreign training have a productivity advantage compared to other firms. Out of the 204 domestic firms in Gorg and Strobl's (2005) sample, owners of 13 firms have immediate prior experience working in foreign firms in the same industry, 9 have immediate prior experience working with foreign firms in different industries, and 14 received training provided by foreign firms. Gorg and Strobl (2005) find that firms whose owners once worked in MNEs in the same industry are more productive than similar domestic firms, while firms whose owners worked in MNEs in different industries have no productivity advantage. The authors argue that MNE knowledge, therefore, may be industry-specific.

Hale and Long (2006) find evidence that labor mobility facilitates multinational productivity spillovers using a sample of 1500 firms in China. In their study, the percentage of managers in domestic firms who have foreign firm experience is positively and significantly associated with FDI presence in the same industry-city cell, even after controlling for industry fixed effects and city fixed effects. Moreover, the percentage of managers with foreign work experience is positively associated with a firm's total factor productivity.

3 Empirical Methodology

The objective of this paper is to identify if multinational spillovers through worker mobility exist. In this paper, I go beyond the current literature to define wage spillovers at the

worker-level.

3.1 An econometric model of multinational spillovers

My estimation procedure derives from social interactions theory and allows an individual's outcome to depend on the characteristics of his environment.[3] In particular, the approach allows an individual's wage to be a function of a key establishment characteristic, the share of former multinational-establishment workers in the establishment, as follows:

$$\ln y_{ijt} = \gamma S_{jt} + \psi_i + \lambda_{j(i)} + \delta_t + \beta_1 X_{it} + \beta_2 Z_{jt} + \epsilon_{ijt}, \tag{3.1}$$

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 domestic-owned establishment's workforce ever employed and displaced from a multinational establishment. This variable is designed to capture the probability that an individual interacts with a former multinational-establishment worker in the establishment.

To account for the fact that periods of establishment hiring tend to coincide with general periods of increased investment, i.e., establishments hiring recently displaced multinational-establishment workers may be hiring displaced workers from other domestic-owned establishments as well, I include a control for the share of recently-hired workers from domestic-owned establishments in the establishment, as follows:

$$\ln y_{ijt} = \gamma_M S^M_{jt} + \gamma_D S^D_{jt} + \psi_i + \lambda_{j(i)} + \delta_t + \beta_1 X_{it} + \beta_2 Z_{jt} + \epsilon_{ijt}, \tag{3.2}$$

where S^M_{jt} refers to the previously-defined S_{jt}, the share of the domestic-owned establishment's workforce ever employed and displaced from a multinational establishment, superscript M. I distinguish this term from S^D_{jt}, with superscript D, the share of the domestic-owned establishment's workforce employed and displaced from another domestic-owned establishment in the immediate prior period.

Equation (3.2) is the basis for the estimation of the empirical results that follow. If pos-

[3] See Brock and Durlauf (2001b) and Manski (1993).

itive 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 (3.2) is the presence of unobservable shocks to individual wages that are correlated with the share of former multinational-establishment workers in the domestic establishment. Any positive correlation between S_{jt}^M and ϵ_{ijt} will result in overestimates of γ_M. A major advantage of using a panel linked worker-establishment-level data set 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), establishment fixed effects ($\lambda_{j(i)}$), time fixed effects (δ_t), time-varying, worker characteristics (X_{it}), such as age, experience, tenure at the establishment, education, and occupation, and time-varying, establishment characteristics (Z_{jt}), such as log average establishment size, average establishment tenure, average establishment experience, average establishment education, and average establishment occupation.

Due to the inclusion of S_{jt}^D and the desire to ensure that the estimates measure pure spillover effects and not compositional effects, I restrict the data to the retained domestic workforce.[4] Because the sample of workers are restricted to remain in the same establishment for the sample period, individual fixed effects (ψ_i) fully absorb the establishment-specific effects ($\lambda_{j(i)}$). ψ_i captures unmeasured individual characteristics that do not change over time, such as unobserved ability and motivation, while $\lambda_{j(i)}$ captures unobserved, time-invariant establishment-level characteristics, such as unobserved productivity. δ_t captures general trends in wages that affect all workers, in particular related to Brazil's currency crisis in 1999. ϵ_{ijt} represents an error term that is assumed to be well-behaved, that is, to exhibit no serial correlation, and to be orthogonal to all regressors.

4 Data

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

[4]Please see appendix B for more information on the data construction.

4.1 Worker Data

The worker data come from the Brazilian Labor Ministry (*Ministério do Trabalho e Emprego* (MTE)) which requires all formally-registered firms to report on all formally-employed workers in every year. The *Relação Anual de Informações Sociais* (RAIS) is an individual-level data set consisting of all workers for the years 1996 through 2001. The main variables of interest are the worker's identification code (*Programa de Integração* (PIS)),[5] annual real wages in *reais*, job tenure in years, contracted hours of work, month and type of accession, month and type of separation, gender, nationality, age, educational attainment of the worker, the occupational classification of the worker (*Classificação Brasileira de Ocupações* (CBO)), the tax number of the worker's establishment (*Cadastro Nacional de Pessoa Jurídica* (CNPJ)), and the industrial classification of the worker's establishment (*Classificação Nacional de Atividades Econômicas* (CNAE)).

The RAIS worker data is 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 (CNAE) cover workers beyond the common manufacturing focus. Workers in the services and utilities industries, where much of the foreign investments flowed starting in 1996 are included in the database.[6] Next, RAIS has a depth of information on the cause of separation, as well as a worker's tenure at the firm and detailed skills (as defined by occupation and education) which are paramount to the analysis.

The main advantage of the RAIS database is the ability to track individual workers in establishments over time by worker identification and establishment tax numbers, respectively. I restrict observations as follows. First, only workers with correct eleven-digit worker

[5] A worker's ID remains with the worker throughout his work history. The process for establishments to report on their workers is extensive and costly. However, PIS 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.

[6] The data include workers in all private sectors of the economy: agriculture, commerce, construction, manufacturing, and services. For this study, sectors are classified into 2-digit CNAE sectors. I exclude 7 2-digit sectors from the analysis: Manufacture of furniture, manufacture not elsewhere classified (36); Other business activities (74); Public administration and defense, compulsory social security (75); Activities of membership organizations (91); Recreational, cultural, and sporting activities (92); Other Service Activities (93); and Activities of households as employers of domestic staff (95). For some levels of analysis, I further aggregate the data into the three major sectors: primary, manufacturing, and services. Primary includes 2-digit CNAE codes 1-14; manufacturing includes 2-digit CNAE codes 15-37; and services includes 2-digit CNAE codes 40-90.

identification numbers are included.[7] Next, the sample includes only full-time, prime age workers; that is, workers between the ages of 15 and 64 years[8] who work at least 40 contracted hours per week. Following Abowd, Kramarz and Margolis (1999), I restrict the set of workers to only those workers receiving positive wages in a private sector job. Finally, for workers with multiple jobs within the same establishment in a given year, only the most recent job is included in the sample. If a worker has multiple current jobs, only the highest paying job is included.[9]

Muendler, Poole, Ramey and Wajnberg (2004) map the CBO to the *International Standard Classification of Occupations* (ISCO-88). The CBO-94 is a detailed, task-oriented classification system, while ISCO-88 reflects a less-detailed and more skill-oriented classification system. The skill classification is intended to incorporate on-the-job experience, informal training, and the technological skill content of the occupation.[10] The ISCO occupations are then grouped into four broad occupational categories following Abowd, Kramarz, Margolis and Troske (2001). I consider these occupational categories to reflect the skill intensity of the occupation. Table C.1 in appendix C presents the breakdown of the skill intensity of occupations by major ISCO occupational grouping.

4.2 Foreign Direct Investment in Brazil

Figure 4.1 shows foreign direct investment inflows as a percentage of GDP for the Brazilian economy from 1990 to 2001 (World Bank 2005). Direct investments increased significantly beginning in 1996, and more than quadrupled by 2001.[11] There is also considerable variation

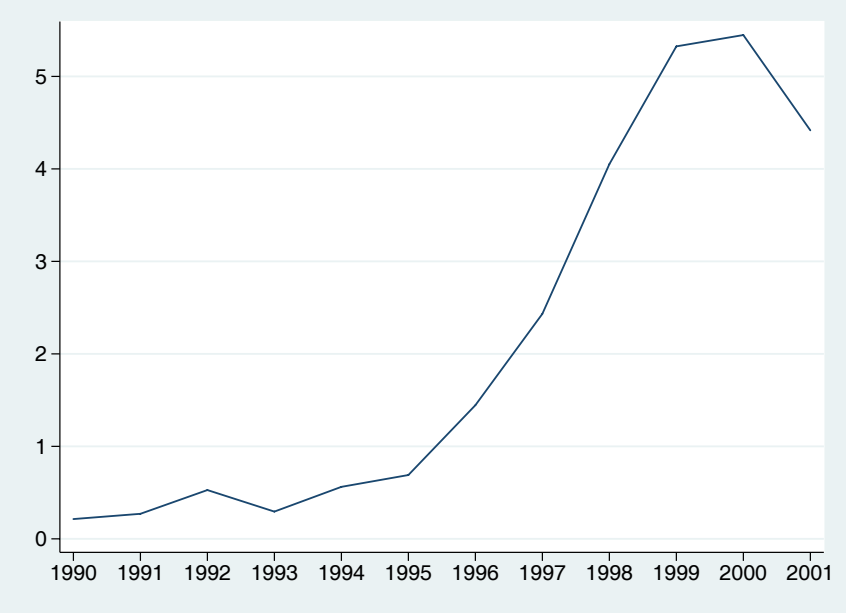
[7]Eleven digits is the traditional length of the social security number in Brazil. Firms that report false identification numbers are either reporting informal workers or the data are more likely to have measurement error due to faulty bookkeeping.

[8]The legal working age in Brazil is 16 years of age. Before the Social Security reform of 1999, the earliest retirement age for women and men in Brazil was 55 and 60, respectively.

[9]There is high turnover within establishments within a year in part due to a Brazilian labor law (*Fundo de Garantia de Tempo de Serviço* (FGTS)) in which formally-employed workers may receive a guaranteed fund upon termination. This fund is filled by the employer in monthly contributions and subsidized by the government. The Fund is meant to serve both as unemployment insurance upon layoff and as a social security payment at retirement.

[10]Created by the International Labor Organization, the ISCO is ideal for developing and industrialized cross-country comparisons. Contact the author for more details about the CBO-ISCO concordance and see Elias and Birch (1994) for more information on the skill classification of the ISCO.

[11]Appendix A offers a detailed description of the policy reforms in Brazil that contributed to the marked increases in investment inflows.



Source: World Bank, 2005.

Figure 4.1: Foreign Direct Investment Inflows as Percentage of GDP, 1990-2001

Table 4.1: Foreign Direct Investment Inflows, 1996-2001

	Average	Standard Deviation	Minimum	Maximum
Services	584.6	1,183.7	0.1	4,528.6
Manufacturing	192.8	272.5	3.2	985.0
Primary	78.0	134.1	0.0	370.2
All Sectors	346.0	816.9	0.0	4,528.6

Note: Inflows data are expressed in USD millions. Statistics are calculated across 2-digit CNAE sectors within services, manufacturing, and primary. Services includes 2-digit CNAE codes 40-90, manufacturing includes 2-digit CNAE codes 15-37, and primary includes 2-digit CNAE codes 1-14.
Source: BCB, 1996-2001.

in the amount of foreign investment across sectors. In 1995, the total stock of foreign investment in Brazil was 116 billion US dollars, with 65 percent in manufacturing, 31 percent in services, and 4 percent in agricultural industries. Starting in 1996, the scope of foreign investment shifted towards the service sectors in part due to the government's privatization of many public services (Rodrigues 2000).

Table 4.1 documents the variation across major sectors and the rise in foreign investment inflows to the services sector. Between 1996 and 2001, 73 percent of foreign investments flowed to service sectors, 24 percent flowed to manufacturing sectors, and just 3 percent to primary sectors. The telecommunications, banking, and electricity sectors, which underwent

large-scale privatizations, received the largest flows of foreign funds.

Foreign Investment Data By law, all foreign direct investment inflows to Brazil are required to be registered with the Central Bank of Brazil (BCB) in the *Registro Declaratório Eletrônico - Investimentos Externos Diretos* (RDE-IED). The RDE-IED is available from the BCB for the years 1996 through 2001. I define an establishment to be 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 foreign relationships in later years. Therefore, establishments are counted as foreign-owned in all years $\tau \geq t$ after the initial inflow in year t. Finally, I consider foreign funds at the holding-company level to affect all establishments of the corporate group. Using BCB information on corporate ownership relations among Brazilian firms, I count an establishment as foreign-owned in year $\tau \geq t$ if it is a subsidiary of a company receiving inflows of foreign capital in year t.[12]

The data are matched by establishment tax number to the RAIS worker data for the first time in this research. I define an indicator variable equal to one if and only if a worker holds a job at a foreign-owned establishment. Workers employed at foreign-owned establishments are hereafter referred to as "multinational-establishment workers", while workers employed at domestic-owned establishments are hereafter referred to as "domestic workers". The matched RAIS-RDE-IED data traces workers who "switch" between foreign-owned and domestic-owned establishments. I call workers displaced from multinational establishments and rehired in domestic establishments "MNE-to-non-MNE switchers". The sample includes 205,465 domestic establishments hiring 1,626,105 MNE-to-non-MNE switchers from 13,009 multinational establishments over the period 1996 to 2001.

Table 4.2 presents a summary of the share of foreign-owned establishments for each 2-digit CNAE sectors in my sample. As a share of the number of establishments in the sector, the health and social work and education service sectors have the smallest multinational shares, 0.03 and 0.04 percent, respectively, while almost 10 percent of the establishments in the metal mining industry received foreign investment inflows between 1996 and 2001

[12]By my definition, a foreign-owned establishment which did not receive any foreign capital inflows between 1996 and 2001 is considered a domestic-owned establishment. In combination with information on the stock of foreign investments in 2001, I am confident that I have identified all foreign-owned establishments.

Table 4.2: Multinational Share, 1996-2001

	Average	Standard Deviation	Minimum	Maximum
Services	0.0070	0.0064	0.0003	0.0193
Manufacturing	0.0181	0.0147	0.0006	0.0483
Primary	0.0289	0.0415	0.0013	0.0971
All Sectors	0.0148	0.0193	0.0003	0.0971

Note: The multinational share in the sector is defined to be the number of multinational establishments as a share of total establishments in the sector. Statistics are calculated across 2-digit CNAE sectors within services, manufacturing, and primary. Services includes 2-digit CNAE codes 40-90, manufacturing includes 2-digit CNAE codes 15-37, and primary includes 2-digit CNAE codes 1-14.
Sources: RAIS, RDE-IED, 1996-2001.

according to RDE-IED.

4.3 Descriptive Statistics

In this section, I present statistics that describe the MNE-to-non-MNE switcher workers, the domestic-owned establishments that hire them, and the incumbent domestic workforce.[13]

National Data First, I offer statistics from a nationally representative sample of workers by major industrial sector.[14] Table 4.3 displays average worker characteristics for the Brazilian labor force. Between 1996 and 2001, the average worker earned approximately 4,024 *reais* per year. He is early in his career at 33 years of age. Approximately 26 percent of the labor force is female. Fifty-seven percent of the formal-sector labor force has a primary school education, close to 30 percent has a high school diploma, and just over 13 percent has a college degree. The majority of workers in Brazil are skilled blue collar workers (43 percent). Almost 12 percent of workers are unskilled blue collar workers, 13 percent are other white collar workers, and 30 percent are professional and technical workers.

The services sector pays a wage 0.1 percent higher than average, employs older workers, and employs more women. Workers in the services sector are more skilled than the national average, by measures of education and the skill intensity of the occupation. The manufacturing sector pays 0.1 percent less than the national average and employs workers on average

[13]Please see appendix B for a complete description of the data construction.

[14]Statistics are calculated across 2-digit CNAE sectors within services, manufacturing, and primary. Services includes 2-digit CNAE codes 40-90, manufacturing includes 2-digit CNAE codes 15-37, and primary includes 2-digit CNAE codes 1-14. Detailed data are available by request from the author.

Table 4.3: National Worker Characteristics, 1996-2001

	Services	Manufacturing	Primary	All Sectors
Ave. Wage (in logs)	8.4	8.2	8.2	8.3
Ave. Age (in years)	34	32	35	33
Percent Female	0.311	0.260	0.096	0.260
Share of Workers with:				
Primary School	0.455	0.626	0.744	0.568
High School	0.346	0.285	0.187	0.298
College Degree	0.198	0.088	0.067	0.132
Share of Workers:				
Unskilled Blue Collar	0.122	0.100	0.142	0.115
Skilled Blue Collar	0.198	0.612	0.599	0.431
Other White Collar	0.221	0.071	0.045	0.132
Professional & Technical	0.442	0.197	0.187	0.301

Note: Statistics are calculated across 2-digit CNAE sectors within services, manufacturing, and primary. Services includes 2-digit CNAE codes 40-90, manufacturing includes 2-digit CNAE codes 15-37, and primary includes 2-digit CNAE codes 1-14. Source: RAIS, 1 percent random sample, 1996-2001.

one year younger. Workers in the manufacturing sector are less skilled than the national average, by both measures of skill. The primary sector pays 0.1 percent less than the national average, employs older workers, and fewer women. Workers in the primary sector are less skilled than the national average, by measures of education and the skill intensity of the occupation.

Displaced Multinational Workers Table 4.4 presents the same statistics for the set of displaced multinational workers by major industrial sector. The average wage of a switcher worker for the period 1996 to 2001 was 0.3 percent higher than the national average. The wage differential is most significant in the manufacturing and services sectors, where MNE-to-non-MNE switchers earn, on average, 0.4 percent higher than the average national worker in his sector. The higher wages may reflect the wage premium often paid by MNE establishments (e.g., Gerschenberg (1987) and Lipsey (2004)). Workers displaced from foreign-owned establishments and rehired by domestic-owned establishments are, on average, in their early careers, no different from the national average. Switchers are less likely to be female. Across all sectors, former multinational establishment workers are relatively higher skilled, as defined by education and occupation, than the average national worker. Given the evidence in

Table 4.4: Displaced Multinational Worker Characteristics, 1996-2001

	Services	Manufacturing	Primary	All Sectors
Ave. Wage (in logs)	8.8	8.6	8.4	8.6
Ave. Age (in years)	33	33	34	33
Percent Female	0.262	0.225	0.068	0.219
Share of Workers with:				
Primary School	0.313	0.455	0.651	0.421
High School	0.346	0.351	0.224	0.332
College Degree	0.330	0.194	0.125	0.243
Share of Workers:				
Unskilled Blue Collar	0.091	0.100	0.128	0.100
Skilled Blue Collar	0.191	0.534	0.606	0.396
Other White Collar	0.197	0.073	0.036	0.121
Professional & Technical	0.501	0.276	0.216	0.365
Switcher Share	0.153	0.183	0.092	0.158

Note: The switcher share in the sector is defined as the number of MNE-to-non-MNE switchers in the sector as a share of total workers in the sector. Statistics are calculated across 2-digit CNAE sectors within services, manufacturing, and primary. Services includes 2-digit CNAE codes 40-90, manufacturing includes 2-digit CNAE codes 15-37, and primary includes 2-digit CNAE codes 1-14.
Sources: RAIS, RDE-IED, 1996-2001.

the literature on the high-skill intensity of multinational establishments, it is not surprising that workers displaced from MNEs are relatively higher skilled.

Across all sectors, 15.8 percent of the workforce switched from a multinational to a domestic establishment during the period 1996 to 2001. The switcher share, defined to the number of MNE-to-non-MNE switchers in the sector as a share of total workers in the sector, is highest in the manufacturing sector at 18.3 percent. Over 15 percent of workers in the services sector are MNE-to-non-MNE switchers, while almost 10 percent of workers in the primary sector were once employed in a foreign-owned establishment.

Domestic-Owned Establishments Table 4.5 reports statistics across domestic-owned establishments that hire the MNE-to-non-MNE switchers. Here, the appropriate comparison group is the set of domestic-owned establishments that did not hire any MNE-to-non-MNE switchers. Descriptive statistics for these establishments are reported in table 4.6 that follows.

Domestic-owned establishments hiring former multinational establishment workers pay

Table 4.5: Domestic-Owned Establishments Hiring Switchers, 1996-2001

	Services	Manufacturing	Primary	All Sectors
Ave. Wage (in logs)	8.6	8.4	8.3	8.5
Percent Female	0.319	0.254	0.096	0.260
Share of Workers with:				
Primary School	0.402	0.593	0.713	0.527
High School	0.371	0.305	0.211	0.320
College Degree	0.227	0.102	0.076	0.153
Share of Workers:				
Unskilled Blue Collar	0.114	0.098	0.148	0.112
Skilled Blue Collar	0.187	0.559	0.580	0.401
Other White Collar	0.213	0.081	0.057	0.134
Professional & Technical	0.472	0.237	0.194	0.332
Ave. Establishment Size	145.3	143.6	163.0	147.0

Note: Statistics are calculated across 2-digit CNAE sectors within services, manufacturing, and primary. Services includes 2-digit CNAE codes 40-90, manufacturing includes 2-digit CNAE codes 15-37, and primary includes 2-digit CNAE codes 1-14. Source: RAIS, 1996-2001.

average wages 0.4 percent higher than establishments which did not hire switcher workers. Similarly, the average establishment size, as measured by the number of workers, is greater, across all sectors, for establishments hiring switcher workers than for establishments not hiring a single MNE-to-non-MNE switcher. The extensive literature documenting the employer-size wage premium may explain the wage differentials between these establishment types (Brown and Medoff 1989). Domestic-owned establishments hiring switchers and domestic-owned establishments not hiring switchers do not otherwise appear to be systematically different by measures of gender composition and the skill sets of the workforce.

The availability of the matched establishment-employee database allows me to control for these important observable establishment-level characteristics in the estimation of multinational spillovers through worker mobility. Furthermore, if there are unobservable characteristics underlying these observable differences, the estimation method proposed in section 3 will control for these unobservable differences through the establishment fixed effects nested within the worker fixed effects.

Incumbent Domestic Workers Descriptive statistics on the incumbent domestic workforce in the domestic-owned establishments hiring MNE-to-non-MNE switchers are reported

Table 4.6: Domestic-Owned Establishments Not Hiring Switchers, 1996-2001

	Services	Manufacturing	Primary	All Sectors
Ave. Wage (in logs)	8.2	8.0	7.9	8.1
Percent Female	0.342	0.262	0.116	0.276
Share of Workers with:				
Primary School	0.472	0.684	0.780	0.606
High School	0.383	0.258	0.157	0.298
College Degree	0.143	0.056	0.060	0.094
Share of Workers:				
Unskilled Blue Collar	0.116	0.105	0.184	0.120
Skilled Blue Collar	0.207	0.580	0.524	0.411
Other White Collar	0.226	0.076	0.074	0.140
Professional & Technical	0.435	0.207	0.190	0.303
Ave. Establishment Size	29.9	35.7	38.5	33.6

Note: Statistics are calculated across 2-digit CNAE sectors within services, manufacturing, and primary. Services includes 2-digit CNAE codes 40-90, manufacturing includes 2-digit CNAE codes 15-37, and primary includes 2-digit CNAE codes 1-14. Source: RAIS, 1996-2001.

in table 4.7. The incumbent domestic worker earned 0.1 percent more than the average national worker, across all sectors, during the period 1996 to 2001. This wage differential carries to the manufacturing and services sectors, but the average incumbent domestic worker earned equally much, on average, as the average national worker in the primary sector. With respect to displaced multinational workers, however, the incumbent domestic workforce earned 0.2 percent less over the 1996 to 2001 period, suggesting switcher workers find themselves in the top of the hiring establishment's wage distribution. I will exclude all switcher workers from the multinational spillovers regression on incumbent domestic workers' wages in order to ensure the analysis measures pure spillovers effects and not compositional effects.

The incumbent domestic worker is, on average, one year older than the national-average worker, while the MNE-to-non-MNE switcher workers are younger than the incumbent domestic workforce. The workers in domestic establishments hiring switchers in the primary sector are more likely to be female than the national-average worker in a primary sector establishment. Otherwise, the incumbent domestic workforce appears similar in terms of gender composition to the national sample. However, as I mentioned in the previous section, displaced multinational establishment workers are more likely to be male. Therefore,

Table 4.7: Incumbent Domestic Worker Characteristics, 1996-2001

	Services	Manufacturing	Primary	All Sectors
Ave. Wage (in logs)	8.5	8.3	8.2	8.4
Ave. Age (in years)	35	33	36	34
Percent Female	0.316	0.272	0.137	0.272
Share of Workers with:				
Primary School	0.456	0.646	0.711	0.573
High School	0.346	0.272	0.207	0.295
College Degree	0.198	0.082	0.081	0.132
Share of Workers:				
Unskilled Blue Collar	0.124	0.093	0.132	0.112
Skilled Blue Collar	0.188	0.621	0.568	0.427
Other White Collar	0.215	0.071	0.062	0.132
Professional & Technical	0.460	0.198	0.222	0.314

Note: Statistics are calculated across 2-digit CNAE sectors within services, manufacturing, and primary. Services includes 2-digit CNAE codes 40-90, manufacturing includes 2-digit CNAE codes 15-37, and primary includes 2-digit CNAE codes 1-14. Source: RAIS, 1996-2001.

the incumbent domestic workforce appears disproportionately female with respect to this group. Similarly, incumbent domestic workers in hiring domestic establishments mirror the skill composition of the national sample, while they are relatively less skilled than displaced multinational establishment workers. Switcher workers, on average, are among the top of the hiring establishment's skill distribution, when skill is measured by both education and occupation.

Share of Former Multinational-Establishment Workers Table 4.8 reports descriptive statistics for the main variable of interest, the share of former multinational-establishment workers.[15] The panel reports on the main variable of interest, S_{jt}^{M}. On average, 2.6 percent of manufacturing sector workers were once employed at a foreign-owned establishment, while 2.3 percent of primary sector workers and only 1.9 percent of service workers. On average, establishments in the tobacco manufacturing sector have the largest foreign presence in their workforces (10.9 percent), while the education and health services sectors have the smallest foreign presence in their workforces (0.6 percent).

[15] A detailed listing of the average shares of former multinational-establishment workers by 2-digit CNAE sector is reported in table 5.2.

Table 4.8: Share of Former Multinational-Establishment Workers, 1996-2001

	Average	Standard Deviation	Minimum	Maximum
Services	0.019	0.010	0.006	0.045
Manufacturing	0.026	0.021	0.008	0.109
Primary	0.023	0.017	0.007	0.049
All Sectors	0.023	0.017	0.006	0.109

Note: The share of former multinational-establishment workers in an establishment is defined as the number of MNE-to-non-MNE switchers as a share of the establishment workforce. Statistics are calculated across 2-digit CNAE sectors within services, manufacturing, and primary. Services includes 2-digit CNAE codes 40-90, manufacturing includes 2-digit CNAE codes 15-37, and primary includes 2-digit CNAE codes 1-14.
Source: RAIS, 1996-2001.

5 Estimation of Multinational Spillovers

Recall from section 3 the main empirical specification:

$$\ln y_{ijt} = \gamma_M S_{jt}^M + \gamma_D S_{jt}^D + \psi_i + \lambda_{j(i)} + \delta_t + \beta_1 X_{it} + \beta_2 Z_{jt} + \epsilon_{ijt}.$$

where S_{jt}^M refers to the share of the domestic-owned establishment's workforce ever employed and displaced from a multinational establishment and S_{jt}^D measures the share of the domestic-owned establishment's workforce employed and displaced from another domestic-owned establishment in the prior period. If positive multinational spillovers through worker mobility exist, I expect $\gamma_M > 0$ and $\gamma_M > \gamma_D$. Identification in this model is based on changes over time in the share of former multinational-establishment workers within an establishment for each worker. The covariates include a vector of time-varying individual-specific characteristics, X_{it}, and a vector of time-varying establishment-specific characteristics, Z_{jt}.[16] The individual characteristics include age, age-squared, experience, experience-squared, tenure at the establishment, education,[17] and the skill intensity of occupation.[18] The establishment characteristics include log average establishment size, age,[19] average establishment tenure,

[16]Because I include individual fixed effects, variables that do not change over time such as gender and nationality are not included.

[17]Education enters into the equation as 3 dummies; primary school, high school, and college graduate (primary school is the omitted category).

[18]Skill intensity of occupation enters into the equation as 4 dummies; unskilled blue collar, skilled blue collar, other white collar, and professional (unskilled blue collar is the omitted category).

[19]Age enters as 7 shares; Share of the establishment aged child (10-14 years), youth (15-17 years), adolescent (18-24 years), nascent career (25-29 years), early career (30-39 years), peak career (40-49 years), late career (50-64 years), post retirement age (65 years or older).

Table 5.1: Multinational Spillovers, 1996-2001

Dep. Variable: Log Annual Wages	(1)	(2)	(3)	(4)	(5)
$\gamma_M - \gamma_D$	0.977**	1.071**	-0.025	0.075**	0.077**
F-statistic	15.29	75.87	1.00	10.38	13.10
p-value	0.0001	0.0000	0.3183	0.0013	0.0003
Average Establishment Wages					0.220**
Robust Standard Error					(0.017)
Individual Fixed Effects	NO	NO	NO	YES	YES
Establishment Fixed Effects	NO	NO	YES	YES	YES
Time Fixed Effects	NO	YES	YES	YES	YES
Number of Observations	450,842	2,634,947	2,634,947	2,634,947	2,629,404
Overall R-squared	0.5483	0.5403	0.3948	0.2658	0.5181

Note: Robust standard errors, clustered at the establishment-level, are in parentheses. ** denotes significance at 1 percent level; * denotes significance at 5 percent level. See section 5 for other independent variables included in the estimation (not reported here).
Source: RAIS, 10 percent random sample, 1996-2001.

average establishment experience, share of the establishment female, average education,[20] and average skill intensity of occupation.[21]

5.1 Main Results

Table 5.1 presents results from the estimation of worker-level multinational spillovers with individual, establishment, and annual fixed effects, unless otherwise indicated. For this analysis, I draw a ten percent random sample of the incumbent domestic workforce across all sectors. I report the coefficient difference for $\gamma_M - \gamma_D$ and the accompanying *F-statistic* and *p-value* for the null hypothesis of a zero difference. All other independent variables that are included in the analysis are listed in the previous section. In order to precisely estimate both γ_M and γ_D, I cluster the robust standard errors at the establishment-level.[22]

In column (1), I present the cross-sectional analysis for the year 2000. The results are consistent with multinational spillovers though without establishment and individual fixed effects, the result is difficult to interpret. In column (2), I bring in the full panel of data

[20]Education enters as 3 shares; Share of the establishment with primary school, high school, and college graduate.

[21]Skill intensity of occupation enters as 4 shares; Share of the establishment unskilled blue collar worker, skilled blue collar worker, other white collar worker, and professional worker.

[22]Moulton (1990) points out that because observations are at the worker-level, yet the main variable of interest varies by establishment, standard errors may be underestimated. Furthermore, Bertrand, Duflo and Mullainathan (2004) find that serial correlation of the errors can also be a problem.

and allow for time series variation. I include establishment fixed effects in column (3), which control for any fixed factor that may affect an establishment's decision to hire former multinational-establishment workers, such as management style. The differential effect of hiring former multinational-establishment workers over other domestic hires no longer has a positive effect on incumbent workers' wages. The omitted variable bias for the establishment fixed effect is large and positive. This is consistent with the evidence presented in the descriptive statistics section−on average, establishments with higher shares of former multinational-establishment workers are also higher wage establishments.

Column (4) also includes individual fixed effects, in order to control for any unobservable individual characteristics, such as motivation or ability that may determine an individual's wages. It is clear that incumbent domestic workers are not randomly assigned to the establishments in which they work. Even after considering individual fixed effects, workers's wages increase with the proportion of co-workers in their establishment who have experience in foreign-owned establishments ($\gamma_M - \gamma_D$ is significantly different from zero). The omitted variable bias for the worker fixed effect is large, but negative. This result foreshadows those to come−low-earning individuals learn more.

In the final column, I test the inclusion of an additional time-varying establishment-level variable, average establishment wages. Ideally, my specification would include all possible time-varying, establishment-level variables so as to capture all possible establishment-level shocks. I test the inclusion of this variable separately given the so-called reflection problem discussed in Manski (1993). The main result in column (5) shows that including average establishment wages changes the result minimally and only serves to increase the explanatory power of the regression.

In my most preferred and robust specification in column (4), a one percentage-point increase in the share of former multinational-establishment workers in a domestic-owned establishment, holding the share of non-MNE switcher workers constant, increases an incumbent worker's wages by 0.1 percent. To help interpret the magnitude of the coefficient, consider that the average change in the share of former multinational-establishment workers between 1996 and 2001 was about one percentage-point per year.

5.2 Multinational Spillovers by Sector

In the previous section, I presented evidence consistent with the existence of positive multinational spillovers through worker turnover for the economy. In this section, I ask what sectors account for the multinational spillovers. The theory of social interactions considers the transfer of information between individuals an important element. So, we may expect that higher-skilled individuals are better suited to transfer information. As such, high-skill intensive sectors, as defined by the high school plus college educated share of the workforce may be expected to experience larger multinational spillovers.

Table 5.2 presents results from the estimation of worker-level multinational spillovers with individual, establishment, and annual fixed effects. Each row represents a unique individual-level regression as in equation (3.2) by 2-digit CNAE sector. I report the coefficient for $\gamma_M - \gamma_D$, as well as the individual coefficients.[23] All other independent variables that are included in the analysis are listed in section 5. As in the previous analysis, robust standard errors are clustered at the establishment-level. I report the skill-intensity of the sector, as defined by the share of the workforce with a high school or college education, and the average share of former multinational-establishment workers alongside the regression results, and sort the results by the skill-intensity of the sector. The results are also grouped into skill quintiles.

In general, the results present strong evidence for the existence of wage gains as a result of increased multinational presence in the establishment, even after controlling for the general hiring trends of the establishment. In 6 of the 51 2-digit CNAE sectors analyzed, the differential effect of the share of MNE-switcher workers in the establishment beyond the effect of non-MNE switcher workers in the establishment is positively and statistically significantly associated with an incumbent domestic worker's wages.

There is considerable variation in the magnitude of the wage spillovers from multinational establishments depending on the sector under consideration. Among the highest skill quintile, only the education sector exhibits a statistically significant positive correlation between the multinational presence in the establishment and incumbent workers' wages. For

[23]The accompanying *F-statistic* and *p-value* for the null hypothesis that the difference is zero can be found in table C.2 in appendix C.

Table 5.2: Multinational Spillovers by 2-digit CNAE Sector, 1996-2001

Dep. Variable: Log Annual Wages

2-digit CNAE	Description	$\gamma_M - \gamma_D$	γ_M	γ_D	Number of Observations	R^2	Skill Intensity	Foreign Presence Share
Highest Quintile								
65	Financial intermediation	0.179	0.085	-0.094	275,330	0.1704	0.919	0.022
66	Insurance and pension funding	0.138	0.062	-0.076	101,803	0.1403	0.897	0.025
72	Computer and related activities	0.041	0.003	-0.039	236,521	0.1295	0.865	0.045
67	Activities auxiliary to financial intermediation	0.121	0.068	-0.053	54,342	0.2457	0.813	0.028
62	Air transport	0.945	0.500*	-0.445	63,312	0.2264	0.793	0.021
11	Extraction of crude petroleum and natural gas	0.758	0.486*	-0.272	19,370	0.0831	0.742	0.049
64	Post and telecommunications	0.073	0.114	0.041	301,280	0.1554	0.731	0.033
40	Electricity, gas, steam and hot water supply	0.146	0.052	-0.095	200,086	0.0172	0.729	0.028
73	Research and development	0.939	1.165**	0.226	61,726	0.0212	0.714	0.013
30	Manufacture of office machinery and computers	-0.343	0.055	0.398	28,314	0.2723	0.695	0.045
80	Education	0.168*	0.203*	0.035	1,089,814	0.3420	0.689	0.006
4th-Quintile								
32	Manufacture of radio, television and communication equipment	0.350*	0.103**	-0.247	93,135	0.3022	0.570	0.045
85	Health and social work	0.011	0.047	0.037*	1,530,229	0.2050	0.561	0.006
22	Publishing, printing and reproduction of recorded media	0.121	0.148*	0.027	335,598	0.2717	0.534	0.014
63	Supporting and auxiliary transport activities; travel agencies	0.062	0.121**	0.060	237,425	0.2103	0.521	0.023
33	Manufacture of medical, precision and optical instruments	0.115	0.107	-0.008	77,995	0.2107	0.510	0.027
13	Mining of metal ores	0.650	0.477*	-0.173	64,470	0.1878	0.495	0.036
52	Retail trade; repair of personal and household goods	0.047**	0.046**	-0.001	2,950,440	0.1785	0.487	0.011
24	Manufacture of chemicals and chemical products	0.007	0.020	0.013	526,063	0.2239	0.486	0.030
35	Manufacture of other transport equipment	-0.188	0.039	0.226	53,986	0.4757	0.459	0.027
41	Collection, purification and distribution of water	-0.852	-0.236	0.616	259,179	0.0941	0.449	0.008
3rd-Quintile								
51	Wholesale trade and commission trade	0.105**	0.137**	0.032	989,641	0.2394	0.447	0.017
50	Sale, repair of motor vehicles; retail sale of fuel	0.041	0.025	-0.016	749,516	0.2484	0.441	0.011
61	Water transport	0.438	0.081	-0.357*	32,266	0.2575	0.433	0.023
71	Renting of machinery and equipment	0.075	0.072	-0.003	62,894	0.2337	0.430	0.020
31	Manufacture of electrical machinery n.e.c.	-0.110	-0.078	0.032	251,180	0.2591	0.397	0.028
34	Manufacture of motor vehicles, trailers and semi-trailers	0.075	0.028**	-0.047	601,943	0.4892	0.390	0.035
29	Manufacture of machinery and equipment n.e.c.	0.083	0.124**	0.041	558,131	0.2584	0.379	0.037
27	Manufacture of basic metals	0.145	0.123*	-0.022	397,222	0.4109	0.377	0.021
21	Manufacture of pulp, paper and paper products	-0.107	0.026*	0.133	260,331	0.3326	0.368	0.020
16	Manufacture of tobacco products	-0.737	0.035	0.772	40,415	0.0689	0.302	0.109
2nd-Quintile								
25	Manufacture of rubber and plastic products	0.124	0.047	-0.076	602,046	0.3360	0.290	0.021
10	Coal Mining	-0.824	-0.053	0.771	6,802	0.0159	0.287	0.007
28	Manufacture of fabricated metal products	0.109*	0.077**	-0.032	619,341	0.2490	0.287	0.024
18	Manufacture of apparel	0.042	0.101**	0.059*	678,200	0.2425	0.272	0.010
17	Manufacture of textiles	0.032	-0.033	-0.066	713,747	0.1915	0.262	0.015
55	Hotels and restaurants	-0.038**	-0.008	0.029*	1,011,209	0.1455	0.250	0.010
15	Manufacture of food products and beverages	0.262*	0.254**	-0.008	1,963,912	0.0618	0.241	0.011
70	Real estate activities	-0.002	-0.018	-0.017	446,905	0.1632	0.239	0.010
19	Manufacture of luggage, handbags, saddlery, harness and footwear	0.124	0.120*	-0.004	655,803	0.1290	0.227	0.015
60	Land transport; transport via pipelines	0.222**	0.141**	-0.081	2,311,445	0.3069	0.223	0.012
Lowest Quintile								
26	Manufacture of other non-metallic mineral products	-0.044	0.003	0.048	499,193	0.3431	0.220	0.011
23	Manufacture of coke, refined petroleum products and nuclear fuel	-0.686	-0.213	0.473	143,481	0.2300	0.209	0.008
14	Other mining and quarrying	0.060	0.157**	0.098	99,726	0.1990	0.188	0.007
45	Construction	-0.033	0.021*	0.054**	2,277,089	0.2219	0.185	0.023
37	Recycling	0.223	0.292**	0.069	15,015	0.4281	0.178	0.018
90	Sewage and refuse disposal, sanitation and similar activities	0.073	-0.038	-0.111	211,355	0.0496	0.147	0.022
20	Manufacture of wood and wood products	-0.126	-0.058	0.069	364,452	0.1939	0.133	0.009
5	Fishing	-0.182	-0.177*	0.004	20,840	0.0578	0.122	0.036
1	Agriculture	0.004	0.045*	0.042**	1,347,357	0.1391	0.103	0.008
2	Forestry	0.034	0.033	-0.001	122,164	0.0409	0.082	0.018

Note: Each row represents a unique individual-level regression as in equation (3.2) for each sector. All specifications include annual time dummies, individual, and establishment fixed effects. ** denotes significance at 1 percent level; * denotes significance at 5 percent level. Robust standard errors are clustered at the establishment-level. See section 5 for other independent variables included in the estimation (not reported here). The skill intensity of the sector is defined as the share of the workforce with a high school or college education. The foreign presence share in an establishment is defined as the number of MNE-to-non-MNE switchers as a share of the establishment workforce.
Source: RAIS, 1996-2001.

incumbent workers in this sector, a one-percentage point increase in the share of former multinational-establishment workers, all else equal, increases wages by 0.2 percent.

Positive multinational spillovers are not specific to the services sector where much of the foreign investment flowed since 1996. Workers in the radio and television equipment manufacturing sector also experience wage increases of 0.4 percent with an increase of one percentage-point in the proportion of former MNE workers in the establishment, all else equal. Though multinational spillovers are not economy-wide, and in fact, most sectors and most workers do not receive spillover benefits, the results are consistent with the idea that local conditions, such as the level of education and industry characteristics, may play an important role in the ability of a country to absorb the positive effects of foreign investment.

6 Multinational Spillovers By Worker Skill-Level

Results in the previous sections suggest that skill levels and the absorptive capacity of a sector play a role in a sector's ability to absorb a multinational's technological capital. Having uncovered in the last section where spillovers occur, I use these sectors to explore how multinational spillovers are transferred and absorbed.[24] In this section, I ask: are higher-skilled switcher workers better able to *convey* the MNE's technology to other workers, just as higher-skilled incumbent domestic workers may be better able to *absorb* the MNE's technology from the switchers?

6.1 Switcher Skill Level

I augment equation (3.2) to include the share of the domestic establishment's workforce trained and displaced from a foreign-owned establishment *and* of a specific skill-level as

[24] I call these sectors the high absorptive capacity sectors. I consider sectors to have high absorptive capacity if the coefficient on the difference $\gamma_M - \gamma_D$ from the estimation of equation (3.2) is statistically significant. These sectors are then pooled into the major sectors. The high absorptive capacity sectors include for manufacturing (CNAE 15, 28, 32) and services (CNAE 51, 52, 55, 60, 80). The primary sector does not have any high absorptive capacity sectors.

follows:

$$\begin{aligned}\ln y_{ijt} = &\gamma_{M_{prim}} S_{jt}^{M_{prim}} + \gamma_{M_{high}} S_{jt}^{M_{high}} + \gamma_{M_{grad}} S_{jt}^{M_{grad}} \\ &+ \gamma_{D_{prim}} S_{jt}^{D_{prim}} + \gamma_{D_{high}} S_{jt}^{D_{high}} + \gamma_{D_{grad}} S_{jt}^{D_{grad}} \\ &+ \psi_i + \lambda_{j(i)} + \delta_t + \beta_1 X_{it} + \beta_2 Z_{jt} + \epsilon_{ijt}, \end{aligned} \tag{6.1}$$

where the subscripts $(prim, high, grad)$ signify primary school, high school, and college graduate, respectively. To be clear that it is the skill-level of the former multinational-establishment workers and not simply that these workers are disproportionately higher-skilled than the non-MNE switcher workers, I also include the share of non-MNE switchers by skill-level.

The top panel of table 6.1 reports the results. In the services sector, the results are consistent with the hypothesis that highly-skilled switchers are better able to transfer information to the incumbent domestic workforce. A one percentage-point increase in the share of former multinational-establishment workers with a *high school education* increases wages of the incumbent domestic workforce by 0.1 percent, while workers's wages increase by 0.2 percent with a similar increase in the proportion of former multinational-establishment workers with a *college degree*. The results for MNE-switcher workers with a primary school education are not significantly different from the results for non-MNE switcher workers with this skill level.

By contrast, in the manufacturing sector spillovers do not vary by MNE-switcher skill-level. The results suggest that incumbent domestic workers benefit from interactions with MNE switchers of all skill-levels. It does not appear that the higher-skilled former multinational-establishment workers in the manufacturing sectors have an advantage at transferring information.

The lower panel of table 6.1 reports results by the MNE and non-MNE switcher worker's

Table 6.1: Multinational Spillovers, By Switcher Skill Level, 1996-2001

Dep. Variable: Log Annual Wages	Services	Manufacturing
Education		
Primary School ($\gamma_{M_{prim}} - \gamma_{D_{prim}}$)	0.044	0.222*
F-statistic	2.53	6.60
p-value	0.117	0.0102
High School ($\gamma_{M_{high}} - \gamma_{D_{high}}$)	0.064*	0.202*
F-statistic	5.94	6.50
p-value	0.0148	0.0108
College Graduate ($\gamma_{M_{grad}} - \gamma_{D_{grad}}$)	0.241**	0.379
F-statistic	8.28	3.60
p-value	0.0040	0.0576
Number of Observations	2,416,503	2,676,388
Overall R-squared	0.3419	0.0692
Occupation		
Unskilled Blue Collar ($\gamma_{M_{unskb}} - \gamma_{D_{unskb}}$)	0.035	0.570**
F-statistic	0.49	7.40
p-value	0.4835	0.0065
Skilled Blue Collar ($\gamma_{M_{skb}} - \gamma_{D_{skb}}$)	0.064*	0.124*
F-statistic	4.52	4.55
p-value	0.0335	0.0329
Other White Collar ($\gamma_{M_{whit}} - \gamma_{D_{whit}}$)	-0.025	0.339*
F-statistic	0.38	4.13
p-value	0.5402	0.0420
Professional & Technical ($\gamma_{M_{prof}} - \gamma_{D_{prof}}$)	0.185**	0.243**
F-statistic	28.16	9.10
p-value	0.0000	0.0026
Number of Observations	2,416,503	2,276,388
Overall R-squared	0.3146	0.0688

Note: Only high absorptive capacity sectors are included in analysis. All specifications include annual time dummies, individual, and establishment fixed effects. Robust standard errors are clustered at the establishment-level. ** denotes significance at 1 percent level; * denotes significance at 5 percent level. See section 5 for other independent variables included in the estimation (not reported here).
Source: RAIS, 1996-2001.

skill level, as defined by the skill intensity of occupation according to the following regression:

$$\begin{aligned}\ln y_{ijt} = {} & \gamma_{M_{unskb}} S_{jt}^{M_{unskb}} + \gamma_{M_{skb}} S_{jt}^{M_{skb}} + \gamma_{M_{whit}} S_{jt}^{M_{whit}} + \gamma_{M_{prof}} S_{jt}^{M_{prof}} \\ & + \gamma_{D_{unskb}} S_{jt}^{D_{unskb}} + \gamma_{D_{skb}} S_{jt}^{D_{skb}} + \gamma_{D_{whit}} S_{jt}^{D_{whit}} + \gamma_{D_{prof}} S_{jt}^{D_{prof}} \\ & + \psi_i + \lambda_{j(i)} + \delta_t + \beta_1 X_{it} + \beta_2 Z_{jt} + \epsilon_{ijt}, \end{aligned} \tag{6.2}$$

where the subscripts $(unskb, skb, whit, prof)$ signify unskilled blue collar, skilled blue collar, other white collar, and professional worker, respectively. The results follow the same pattern as the results for skill as measured by educational attainment. In general, for the services

Table 6.2: Multinational Spillovers, By Incumbent Skill Level, 1996-2001

Dep. Variable: Log Annual Wages	Services	Manufacturing
Education		
Incumbents with Primary School		
$\gamma_M - \gamma_D$	0.047	0.212**
F-statistic	2.73	7.62
p-value	0.0984	0.0058
Number of Observations	1,452,661	1,972,300
Overall R-squared	0.3033	0.0251
Incumbents with High School		
$\gamma_M - \gamma_D$	0.106**	0.159**
F-statistic	16.44	10.15
p-value	0.0001	0.0014
Number of Observations	731,216	567,995
Overall R-squared	0.2384	0.1490
Incumbents with College Degree		
$\gamma_M - \gamma_D$	0.241*	0.215*
F-statistic	5.14	6.63
p-value	0.0234	0.0101
Number of Observations	232,626	136,093
Overall R-squared	0.3165	0.0694

Note: Only high absorptive capacity sectors are included in analysis. All specifications include annual time dummies, individual, and establishment fixed effects. Robust standard errors are clustered at the establishment-level. ** denotes significance at 1 percent level; * denotes significance at 5 percent level. See section 5 for other independent variables included in the estimation (not reported here).
Source: RAIS, 1996-2001.

sector, the results largely confirm the hypothesis that higher-skilled MNE switcher workers are better able to transfer information, though even the least-skilled of MNE-switchers in the manufacturing industry are able to raise wages of the incumbent domestic workforce.

6.2 Incumbent Skill Level

Tables 6.2 and 6.3 report results from augmented equations (3.2) in which I restrict the set of observations for analysis to only those incumbent domestic workers with a given skill-level, as defined by either education or skill intensity of occupation.

Table 6.2 reports results from these regressions when educational attainment is used to measure the skill level of the incumbent domestic worker. In the services sectors, the results confirm the hypothesis that higher-skilled incumbent domestic workers are better able to absorb information. A one percentage-point increase in the share of former multinational-

Table 6.3: Multinational Spillovers, By Incumbent Skill Level, 1996-2001

Dep. Variable: Log Annual Wages	Services	Manufacturing
Occupation		
Unskilled Blue Collar Incumbents		
$\gamma_M - \gamma_D$	-0.041	0.505**
F-statistic	0.82	8.72
p-value	0.3658	0.0031
Number of Observations	247,492	316,208
Overall R-squared	0.1456	0.0722
Skilled Blue Collar Incumbents		
$\gamma_M - \gamma_D$	0.066*	0.169**
F-statistic	4.74	13.12
p-value	0.0295	0.0003
Number of Observations	625,241	1,713,124
Overall R-squared	0.3304	0.0115
Other White Collar Incumbents		
$\gamma_M - \gamma_D$	0.055	0.146*
F-statistic	1.89	13.12
p-value	0.1694	0.0282
Number of Observations	749,425	192,779
Overall R-squared	0.2246	0.1891
Professional & Technical Incumbents		
$\gamma_M - \gamma_D$	0.149**	0.107
F-statistic	21.24	3.60
p-value	0.0000	0.0578
Number of Observations	759,742	417,579
Overall R-squared	0.3829	0.1896

Note: Only high absorptive capacity sectors are included in analysis. All specifications include annual time dummies, individual, and establishment fixed effects. Robust standard errors are clustered at the establishment-level. ** denotes significance at 1 percent level; * denotes significance at 5 percent level. See section 5 for other independent variables included in the estimation (not reported here).
Source: RAIS, 1996-2001.

establishment workers increases wages of the incumbent domestic workforce with a *high school* education by 0.1 percent, while wages of incumbent domestic workers with a *college* education increase by 0.2 percent with a similar increase in the proportion of former multinational-establishment workers.

In the manufacturing sector, the results suggest that incumbent domestic workers of all skill-levels benefit from interactions with MNE switcher workers. In fact, there does not appear to be any confirmation of the hypothesis that higher-skilled incumbent workers are better able to absorb information from former multinational-establishment workers in the manufacturing sector.

Table 6.3 reports results from these regressions when the skill intensity of occupation is used to measure the skill level of the incumbent domestic worker. In general, the occupational classifications provide the same conclusion as do the results for the skill-level defined by education. For the services sectors, the results appear to confirm the hypothesis that higher-skilled incumbent domestic workers are better able to absorb information, while in manufacturing, all skill-levels of workers benefit from interactions with MNE switchers, except the most skill-intensive occupations.

6.3 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 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*. In this section, I use these two contrasting ideas to test the hypothesis that spillovers occur between *like* workers versus the hypotheses that spillovers occur between *unlike* workers. That is, I ask the following question: Do the magnitude of spillovers increase as the likelihood increases that the entering displaced multinational-establishment worker is similar in his skill set to the incumbent domestic worker? Do managers learn from managers and production workers learn from production workers? Or do production workers learn best from managers?

Table 6.4 reports results for the analysis of equation (6.1), where observations are restricted by the skill-level of the incumbent domestic worker for the three educational attainment groupings. If information is best transferred between *like*-groups of workers, I expect to see the largest positive and significant coefficients in the top row for the first panel (the effects of switcher workers with primary school on incumbents with primary school), the second row in the middle panel (the effects of switcher workers with high school on incumbents with high school), and the third row (the effects of switcher workers with a college degree on incumbents with a college degree). If information is best transferred between *different* workers, the data would show positive and significant coefficients for college graduate switchers when interacting with primary school incumbents, and vice versa. For the middle panel, high school incumbents should benefit most when interacting with college graduate

Table 6.4: Multinational Spillovers, By Switcher*Incumbent Skill Level, 1996-2001

Dep. Variable: Log Annual Wages	Services	Manufacturing
Incumbent with Primary School		
Primary School ($\gamma_{M_{prim}} - \gamma_{D_{prim}}$)	0.051	0.223*
F-statistic	2.37	5.37
p-value	0.1236	0.0204
High School ($\gamma_{M_{high}} - \gamma_{D_{prim}}$)	0.047	0.272**
F-statistic	1.23	9.50
p-value	0.2675	0.0021
College Graduate ($\gamma_{M_{grad}} - \gamma_{D_{grad}}$)	-0.112	0.237
F-statistic	1.61	0.59
p-value	0.2047	0.4420
Number of Observations	1,452,661	1,972,300
Overall R-squared	0.3034	0.0253
Incumbent with High School		
Primary School ($\gamma_{M_{prim}} - \gamma_{D_{prim}}$)	0.114**	0.174*
F-statistic	7.71	6.51
p-value	0.0055	0.0106
High School ($\gamma_{M_{high}} - \gamma_{D_{high}}$)	0.060	0.146
F-statistic	3.17	3.45
p-value	0.0750	0.0634
College Graduate ($\gamma_{M_{grad}} - \gamma_{D_{grad}}$)	0.225**	0.442*
F-statistic	6.78	3.88
p-value	0.0092	0.0488
Number of Observations	731,216	567,995
Overall R-squared	0.2384	0.1491
Incumbent with College Degree		
Primary School ($\gamma_{M_{prim}} - \gamma_{D_{prim}}$)	0.137	0.056
F-statistic	0.72	0.22
p-value	0.3968	0.6397
High School ($\gamma_{M_{high}} - \gamma_{D_{high}}$)	0.092	0.429*
F-statistic	0.63	4.89
p-value	0.4258	0.0271
College Graduate ($\gamma_{M_{grad}} - \gamma_{D_{grad}}$)	0.387	0.208
F-statistic	3.40	0.38
p-value	0.0650	0.5385
Number of Observations	232,626	136,093
Overall R-squared	0.3177	0.0714

Note: Only high absorptive capacity sectors are included in analysis. All specifications include annual time dummies, individual, and establishment fixed effects. Robust standard errors are clustered at the establishment-level. ** denotes significance at 1 percent level; * denotes significance at 5 percent level. See section 5 for other independent variables included in the estimation (not reported here).
Source: RAIS, 1996-2001.

switchers.

The data suggest that information is best transferred between similarly skilled groups of workers and from higher skilled switchers to lower-skilled incumbent domestic workers. Un-

der the assumption that an MNE switcher with fewer skills than a given incumbent domestic worker can be considered *similar* in their skill-sets, in both the services and manufacturing sectors, incumbent workers with a high school education benefit from interactions with former multinational-establishment workers with a primary school education (*like workers*) and former multinational-establishment workers with a college education (*different workers*). Moreover, for both sectors, spillovers are greater between different workers−from the higher-skilled former multinational-establishment worker to the lower-skilled incumbent domestic worker. This effect is prevalent in the data. In the manufacturing sector, incumbent domestic workers with a primary school education learn from like workers−switcher workers with a primary school education−, yet the spillover learning effects are greater from workers with different skill-sets, i.e., those workers with a high school education.

Table C.3 in appendix C reports results for the analysis of equation (6.2), where observations are restricted by the skill-level of the incumbent domestic worker for the four occupational groupings. The patterns are largely the same.

7 Robustness Checks

The key identifying assumption in (3.2), after controlling for individual, establishment, and time fixed effects, as well as time-varying individual-specific characteristics and time-varying establishment-specific characteristics, and general hiring trends, is that ϵ_{ijt} is uncorrelated with the main variable of interest, S_{jt}^{M}. Any positive correlation between the share of former multinational-establishment workers in the establishment and the error term will lead to upwardly biased estimates. Potential threats to this identification are 1) time-varying, productivity shocks to establishments that cause establishments to seek out former multinational-establishment workers in the unemployed labor force and 2) switcher workers who sort into high wage establishments. A final potential issue may result from the endogeneity of the former multinational-establishment worker's displacement. I assess the plausibility of each of these concerns in turn for the high absorptive capacity sectors.

Establishment-Level, Time-Varying Productivity Shocks Suppose domestic-owned establishment j experiences a positive productivity shock in time t. Suppose further this positive productivity shock causes the establishment to disproportionately seek out former multinational-establishment workers, as opposed to non-MNE switcher workers, in the unemployed labor force. This would violate the exogeneity assumption that $(E(S^M_{jt} * \epsilon_{ijt}) = 0)$.

As a test for the existence of any remaining unobservable establishment-level, time-varying effects that may be correlated with S^M_{jt}, I include the future value of the foreign presence share into the analysis. More precisely, if S^M_{jt} is correlated with ϵ_{ijt} due to time-varying, establishment-level shocks to productivity, and moreover, these shocks to productivity lead the establishment to increase hiring of former multinational-establishment workers, controlling for S^M_{jt+1} in equation (3.2) should capture this shock. However, it is the differential increase in former multinational-establishment worker hiring that is important to the estimation, so I include the future value of S^D_{jt}. I augment equation (3.2) as follows:

$$\begin{aligned} \ln y_{ijt} = {} & \gamma_{M_t} S^M_{jt} + \gamma_{M_{t+1}} S^M_{jt+1} + \gamma_{D_t} S^D_{jt} + \gamma_{D_{t+1}} S^D_{jt+1} \\ & + \psi_i + \lambda_{j(i)} + \delta_t + \beta_1 X_{it} + \beta_2 Z_{jt} + \epsilon_{ijt}. \end{aligned} \tag{7.1}$$

If time-varying, establishment-level shocks overturn my results, γ_{M_t} will be statistically insignificant.

Switcher Worker Sorting Suppose the unemployed stock of former multinational establishment workers in their decision where to accept reemployment choose establishments with higher expected future wages. In this case, S^M_{jt} is endogenous to the worker's wage and there is a simultaneous equations-feedback problem. If all unemployed workers, former multinational-establishment and domestic-owned establishment alike, equally sort to high expected wage establishments, then my control, S^D_{jt}, for the non-MNE switcher share should account for this problem. However, if former multinational-establishment workers are better at distinguishing high wage establishments, then the results are again upwardly biased.

I consider this issue by including as an additional control the future establishment-average

Table 7.1: Robustness Checks: Future Values, 1996-2001

Dep. Variable: Log Annual Wages	Services		Manufacturing	
	(1)	(2)	(3)	(4)
$\gamma_{M_t} - \gamma_{D_t}$	0.089**	0.094*	0.209**	0.214**
F-statistic	13.82	4.23	11.49	14.41
p-value	0.0002	0.0397	0.0007	0.0001
$\gamma_{M_{t+1}} - \gamma_{D_{t+1}}$		0.047		0.120**
F-statistic		1.60		6.95
p-value		0.2053		0.0084
Average Establishment Wages at t		0.203**		0.233**
Robust Standard Error		(0.037)		(0.032)
Average Establishment Wages at $t+1$		0.058**		0.027**
Robust Standard Error		(0.009)		(0.010)
Number of Observations	2,416,503	411,901	2,676,388	1,572,729
Overall R-squared	0.3412	0.5477	0.0619	0.2696

Note: Only high absorptive capacity sectors are included in analysis. All specifications include annual time dummies, individual, and establishment fixed effects. Robust standard errors are clustered at the establishment-level. ** denotes significance at 1 percent level; * denotes significance at 5 percent level. See section 5 for other independent variables included in the estimation (not reported here).
Source: RAIS, 1996-2001.

wages into equation (7.1) as follows:[25]

$$\ln y_{ijt} = \gamma_{M_t} S^M_{jt} + \gamma_{M_{t+1}} S^M_{jt+1} + \gamma_{D_t} S^D_{jt} + \gamma_{D_{t+1}} S^D_{jt+1} + \beta_{\bar{y}.t} \ln \bar{y}_{.t} + \beta_{\bar{y}.t+1} \ln \bar{y}_{.t+1} + \psi_i + \lambda_{j(i)} + \delta_t + \beta_1 X_{it} + \beta_2 Z_{jt} + \epsilon_{ijt}. \quad (7.2)$$

If former multinational-establishment workers sort for expected future wages in establishments, γ_M will again be statistically indistinguishable from zero.

Table 7.1 presents results from equation (7.2) with the future values for the share of former multinational-establishment workers, non-MNE switcher workers, and establishment-average wages included in the regression, in order to test the robustness of the multinational spillovers results to both unobservable, establishment-level, time-varying productivity shocks and MNE switcher worker sorting. Columns (1) and (3) provide the baseline results for comparison.

In general, the inclusion of the additional controls confirm that the results are robust to switcher worker sorting and establishment-level, time-varying shocks. Including future

[25]In section 5.1, I demonstrated that the inclusion of $\ln \bar{y}_{.t}$ among the vector of regressors in Z_{jt} does not affect the main results.

Table 7.2: Robustness Checks: MNEs with Massive Layoffs, 1996-2001

Dep. Variable: Log Annual Wages	Services		Manufacturing	
	(1)	(2)	(3)	(4)
$\gamma_M - \gamma_D$	0.089**	0.060**	0.209**	0.089
F-statistic	13.82	9.28	11.49	2.22
p-value	0.0002	0.0023	0.0007	0.1360
Number of Observations	2,416,503	2,416,503	2,676,388	2,789,298
Overall R-squared	0.3412	0.3044	0.0691	0.0708

Note: Only high absorptive capacity sectors are included in analysis. All specifications include annual time dummies, individual, and establishment fixed effects. Robust standard errors are clustered at the establishment-level. ** denotes significance at 1 percent level; * denotes significance at 5 percent level. See section 5 for other independent variables included in the estimation (not reported here).
Source: RAIS, 1996-2001.

values of the share of multinational-establishment workers and future values of establishment-average wages changes the main coefficient differential minimally for both the services and manufacturing sectors.

Exogenous Displacement Workers are not exogenously displaced from multinational establishments. In the absence of data on establishment closings, I identify foreign-owned establishments which experienced "massive layoffs". I define an establishment with massive layoffs if the difference in establishment workforce size between year t and year $t+1$ is greater than or equal to 50 percent; that is, the establishment workforce was downsized by half in one year. I identify 826 multinational establishments which experienced massive layoffs over the period 1996 to 2001. Workers in these establishments are more likely to have experienced an exogenous separation.

Table 7.2 presents results from the estimation of worker-level multinational spillovers from MNEs experiencing massive layoffs. Columns (1) and (3) report the baseline results for comparison. For the manufacturing sector which experienced severe layoffs during the 1990s, the differential effect of MNE switcher workers beyond non-MNE switcher workers on incumbent domestic workers' wages is insignificant. By contrast, for the services sector, the results confirm the main findings.

8 Conclusion

The goal of this paper was 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 positive multinational spillovers defined to be the effects of the share of former multinational-establishment workers in the domestic-owned establishment on domestic workers' wages. The results are robust to individual and establishment fixed effects, and to different specifications controlling for time-varying, establishment-specific productivity shocks, worker sorting, and the endogeneity of worker displacement. The magnitude of wage spillovers from multinational establishments depends on the sector under consideration. Though multinational spillovers are not economy-wide, and in fact, most sectors and most workers do not receive spillover benefits, the results are consistent with the idea that local conditions, such as the level of education, may play an important role in the ability of a country to absorb the positive effects of foreign investment.

This paper also distinguishes the multinational spillover effect by the skill-level of the displaced former multinational-establishment worker and the incumbent domestic worker. The results are consistent with the hypothesis that higher-skilled switcher workers are better able to convey the MNE's technology to incumbent domestic workers and higher-skilled incumbent domestic workers are better able to absorb the MNE's technology from switchers, especially in the services sector. The largest spillover effects occur when the skill sets of the incumbent domestic worker are lower than the skill sets of the former multinational-establishment worker, suggesting incumbent production workers learn from former multinational managers or technicians.

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A Brazilian Policy Reforms

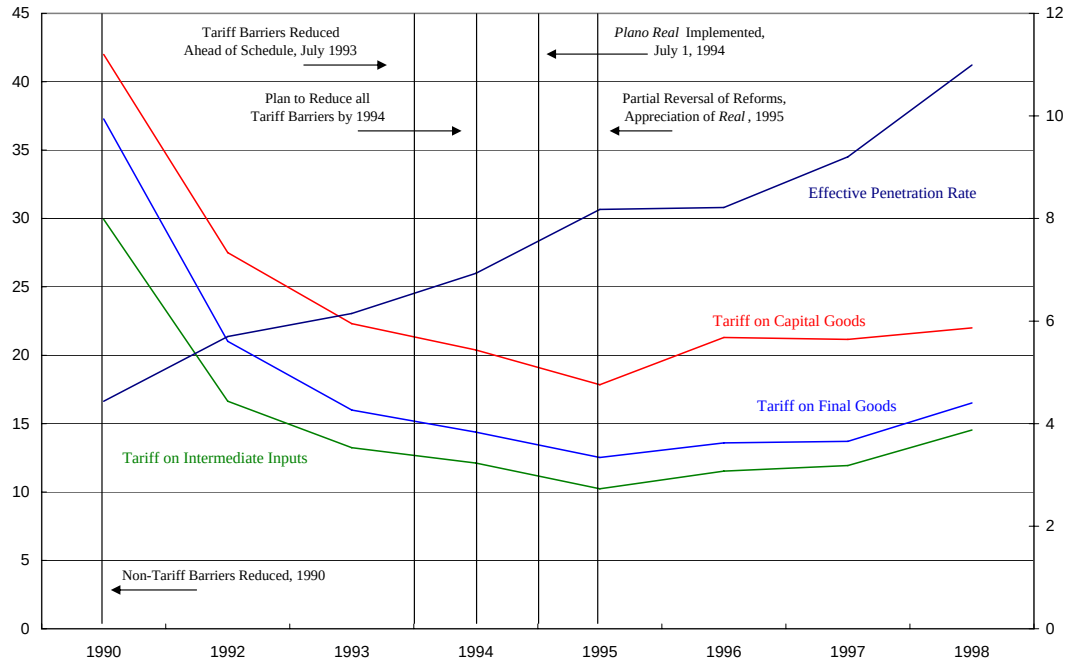
The marked increases in foreign investment inflows were largely a result of macroeconomic stabilization policies which brought down inflation levels, trade liberalization policies which encouraged foreign firms to locate in Brazil, a national privatization program, and a federal deregulation program.

Macroeconomic Stabilization After a decade of rising inflation and a number of attempts to stabilize the economy, on July 1, 1994, the Brazilian government implemented the *Plano Real* to end years of hyperinflation. In the twelve months that preceded the introduction of the new currency, inflation had reached 5,154 percent per annum. By 1998, annual inflation was only 1.7 percent. Pineiro, Giambiagi and Moreira (2001) remark that Brazil had the same inflation rate for a year that it had in a single day prior to the Real Plan. The drop in inflation allowed for increased efficiency and competition and attracted significant foreign direct investment.

Trade Liberalization The late 1980s and early 1990s witnessed sweeping changes in Brazilian trade policy. Figure A.1 charts the decline in Brazil's average tariff rates and rise in effective rates of penetration over the 1990s, alongside major policy reforms over the 1990s.[26] Beginning with the Collor de Mello administration and continuing with President Cardoso, Brazil began extensive policies of trade liberalization which paved the way for bilateral trade agreements and multilateral free trade areas with the Southern Cone countries of South America. Brazil's entry into MERCOSUL in 1991 was instrumental in beginning to attract greater inflows of FDI to the country as a regional export base for multinational firms (Pineiro and Moreira 2000).

Privatization Program In March 1990, President Fernando Collor de Mello launched the National Privatization Program (PND) under the auspices of Law No. 8,031, but it was the Cardoso administration which placed a high priority on the privatization of public services ending the discrimination against subsidiaries of foreign companies. Purchases by foreign

[26] Muendler (2003)



Source: Muendler (2003)

Figure A.1: Brazilian Protection Rates and Foreign Competition, 1990-1998

investors reached 53 percent of the total privatization sales between 1995-2001 (BNDES 2003).

Federal Deregulation Program With the intention of increasing competition among domestic producers, the Collor de Mello administration instituted the Federal Deregulation Program. Among other reforms were the elimination of legal restrictions limiting market entry into specific non-tradeable sectors by foreigners. At this time, foreign firms were also given national treatment in access to domestic preferential public credit markets.

B Constructing the Sample

For the purpose of this study, I identify workers displaced from multinational establishments and subsequently rehired at domestic-owned establishments. Using the common establishment tax identification codes in both the RAIS and RDE-IED data sets, I identify foreign-owned establishments and domestic-owned establishments as described in the data section 4.2. In this section, I describe my efforts to identify workers displaced from multinational establishments, the domestic-owned establishments at which they were rehired, and the incumbent domestic workers at the hiring domestic establishments.[27]

Step 1: Identify Displaced Multinational Workers Matching the establishment tax identification code in RAIS and RDE-IED, I identify all employees of multinational establishments. The RAIS database includes an indicator for employment on December 31. To identify workers displaced from multinational establishments, I keep workers employed in multinational establishments at some time in year t, but no longer employed on December 31 of that year. Furthermore, with information on the reason for job separation, I keep only those workers who left the job involuntarily, i.e., who were laid off.

Step 2: Identify Domestic Establishments The full employment history in RAIS allows me to track the worker beyond employment at the multinational establishment. Once an employee has received training from a multinational establishment in year t, he may transfer it to *any* establishment j he may become employed in in year $\tau \geq t$. I collect the set of establishments j in each year t and generate the share of the workforce with any previous employment spell in a multinational establishment.[28][29]

[27] As part of my empirical strategy, I also control for other domestic workers entering the establishment to control for general hiring trends. Therefore, step 1 also applies to displaced domestic-owned establishment workers.

[28] If the worker was hired by another multinational establishment, the observation is excluded from the analysis (as are all multinational establishments).

[29] The assumption that MNE switchers may take knowledge to all subsequent establishments is not used for domestic switchers. A worker is a domestic switcher only for the first establishment he enters subsequent to his initial displacement.

Step 3: Identify Incumbent Domestic Workers With the complete set of hiring domestic-owned establishments, I identify the set of incumbent domestic workers in the domestic establishments in each time period. I include only workers who remain in the establishment over the sample period. I focus on the retained worker to ensure pure spillover effects and not compositional effects.

The final matched worker-establishment database includes the full employment history of incumbent domestic formal-sector workers in domestic-owned formally-registered establishments in Brazil from 1996 through 2001. Because the sample is limited to domestic-owned establishments and their employees, it is not subject to the endogeneity problem inherent to many studies of multinational spillovers that occurs when comparing foreign and domestic firms−that is, that foreign investors may choose to invest in establishments that perform better.

C Supplemental Tables

Table C.1: ISCO Skill Intensity of Occupation, By Major Group

Major Group	Description	Skill Level	Definition
1	Legislators, senior officials, and managers	4	Professional and Technical
2	Professionals	4	Professional and Technical
3	Technicians and associate professionals	4	Professional and Technical
4	Clerks	3	Other White Collar
5	Service workers and shop and market sales workers	3	Other White Collar
6	Skilled agricultural and fishery workers	2	Skilled Blue Collar
7	Craft and related workers	2	Skilled Blue Collar
8	Plant and machine operators and assemblers	2	Skilled Blue Collar
9	Elementary occupations	1	Unskilled Blue Collar

Source: International Standard Classification of Occupations.

Table C.2: Multinational Spillovers by 2-digit CNAE Sector, 1996-2001

Dep. Variable: Log Annual Wages							
2-digit CNAE	Description	$\gamma_M - \gamma_D$	F-statistic	p-value	Number of Observations	R^2	Skill Intensity
Highest Quintile							
65	Financial intermediation	0.179	3.12	0.0772	275,330	0.1704	0.919
66	Insurance and pension funding	0.138	1.18	0.2770	101,803	0.1403	0.897
72	Computer and related activities	0.041	0.74	0.3883	236,521	0.1295	0.865
67	Activities auxiliary to financial intermediation	0.121	2.53	0.1115	54,342	0.2457	0.813
62	Air transport	0.945	3.28	0.0705	63,312	0.2264	0.793
11	Extraction of crude petroleum and natural gas	0.758	2.31	0.1298	19,370	0.0831	0.742
64	Post and telecommunications	0.073	0.70	0.4023	301,280	0.1554	0.731
40	Electricity, gas, steam and hot water supply	0.146	0.16	0.6921	200,086	0.0172	0.729
73	Research and development	0.939	3.78	0.0526	61,726	0.0212	0.714
30	Manufacture of office machinery and computers	-0.343	1.61	0.2050	28,314	0.2723	0.695
80	Education	0.168*	4.16	0.0414	1,089,814	0.3420	0.689
4th-Quintile							
32	Manufacture of radio, television and communication equipment	0.350*	6.15	0.0132	93,135	0.3022	0.570
85	Health and social work	0.011	0.10	0.7465	1,530,229	0.2050	0.561
22	Publishing, printing and reproduction of recorded media	0.121	2.31	0.1289	335,598	0.2717	0.534
63	Supporting and auxiliary transport activities; travel agencies	0.062	1.08	0.2985	237,425	0.2103	0.521
33	Manufacture of medical, precision and optical instruments	0.115	0.42	0.5166	77,995	0.2107	0.510
13	Mining of metal ores	0.650	2.03	0.0833	64,470	0.1878	0.495
52	Retail trade; repair of personal and household goods	0.047**	23.59	0.0000	2,950,440	0.1785	0.487
24	Manufacture of chemicals and chemical products	0.007	0.01	0.9190	526,063	0.2239	0.486
35	Manufacture of other transport equipment	-0.188	0.89	0.3467	53,986	0.4757	0.459
41	Collection, purification and distribution of water	-0.852	2.76	0.0970	259,179	0.0941	0.449
3rd-Quintile							
51	Wholesale trade and commission trade	0.105**	7.69	0.0055	989,641	0.2394	0.447
50	Sale, repair of motor vehicles; retail sale of fuel	0.041	3.27	0.0706	749,516	0.2484	0.441
61	Water transport	0.438	2.69	0.1015	32,266	0.2575	0.433
71	Renting of machinery and equipment	0.075	0.79	0.3750	62,894	0.2337	0.430
31	Manufacture of electrical machinery n.e.c.	-0.110	0.31	0.5771	251,180	0.2591	0.397
34	Manufacture of motor vehicles, trailers and semi-trailers	0.075	0.48	0.4903	601,943	0.4892	0.390
29	Manufacture of machinery and equipment n.e.c.	0.083	0.92	0.3378	558,131	0.2584	0.379
27	Manufacture of basic metals	0.145	1.62	0.2036	397,222	0.4109	0.377
21	Manufacture of pulp, paper and paper products	-0.107	1.36	0.2444	260,331	0.3326	0.368
16	Manufacture of tobacco products	-0.737	2.25	0.1355	40,415	0.0689	0.302
2nd-Quintile							
25	Manufacture of rubber and plastic products	0.124	2.78	0.0958	602,046	0.3360	0.290
10	Coal Mining	-0.824	2.58	0.1105	6,802	0.0159	0.287
28	Manufacture of fabricated metal products	0.109*	5.39	0.0202	619,341	0.2490	0.287
18	Manufacture of apparel	0.042	1.00	0.3180	678,200	0.2425	0.272
17	Manufacture of textiles	0.032	0.11	0.7420	713,747	0.1915	0.262
55	Hotels and restaurants	-0.038**	7.71	0.0055	1,011,209	0.1455	0.250
15	Manufacture of food products and beverages	0.262*	6.08	0.0137	1,963,912	0.0618	0.241
70	Real estate activities	-0.002	0.01	0.9261	446,905	0.1632	0.239
19	Manufacture of luggage, handbags, saddlery, harness and footwear	0.124	1.87	0.1710	655,803	0.1290	0.227
60	Land transport; transport via pipelines	0.222**	13.46	0.0002	2,311,445	0.3069	0.223
Lowest Quintile							
26	Manufacture of other non-metallic mineral products	-0.044	1.36	0.2433	499,193	0.3431	0.220
23	Manufacture of coke, refined petroleum products and nuclear fuel	-0.686	2.94	0.0875	143,481	0.2300	0.209
14	Other mining and quarrying	0.060	0.34	0.5574	99,726	0.1990	0.188
45	Construction	-0.033	4.08	0.0435	2,277,089	0.2219	0.185
37	Recycling	0.223	1.74	0.1874	15,015	0.4281	0.178
90	Sewage and refuse disposal, sanitation and similar activities	0.073	0.30	0.5808	211,355	0.0496	0.147
20	Manufacture of wood and wood products	-0.126	3.76	0.0524	364,452	0.1939	0.133
5	Fishing	-0.182	1.67	0.1970	20,840	0.0578	0.122
1	Agriculture	0.004	0.02	0.8758	1,347,357	0.1391	0.103
2	Forestry	0.034	0.15	0.6990	122,164	0.0409	0.082

Note: Each row represents a unique individual-level regression as in equation (3.2) for each sector. All specifications include annual time dummies, individual, and establishment fixed effects. ** denotes significance at 1 percent level; * denotes significance at 5 percent level. Robust standard errors are clustered at the establishment-level. See section 5 for other independent variables included in the estimation (not reported here). The skill intensity of the sector is defined as the share of the workforce with a high school or college education.
Source: RAIS, 1996-2001.

Table C.3: Multinational Spillovers, By Switcher*Incumbent Skill Level, 1996-2001

Dep. Variable: Log Annual Wages	Services	Manufacturing
Unskilled Blue Collar Incumbents		
Unskilled Blue Collar ($\gamma_{M_{unskb}} - \gamma_{D_{unskb}}$)	-0.124	0.429**
F-statistic	2.10	8.42
p-value	0.1477	0.0037
Skilled Blue Collar ($\gamma_{M_{skb}} - \gamma_{D_{skb}}$)	0.049	0.310
F-statistic	0.29	3.79
p-value	0.5874	0.0517
Other White Collar ($\gamma_{M_{whit}} - \gamma_{D_{whit}}$)	-0.164	1.091**
F-statistic	2.33	7.23
p-value	0.1270	0.0072
Professional & Technical ($\gamma_{M_{prof}} - \gamma_{D_{prof}}$)	0.029	0.189
F-statistic	0.13	0.52
p-value	0.7139	0.4458
Number of Observations	247,493	316,208
Overall R-squared	0.1459	0.0699
Skilled Blue Collar Incumbents		
Unskilled Blue Collar ($\gamma_{M_{unskb}} - \gamma_{D_{unskb}}$)	-0.050	0.572**
F-statistic	0.32	10.40
p-value	0.5720	0.0013
Skilled Blue Collar ($\gamma_{M_{skb}} - \gamma_{D_{skb}}$)	0.080*	0.161**
F-statistic	5.03	8.58
p-value	0.0249	0.0034
Other White Collar ($\gamma_{M_{whit}} - \gamma_{D_{whit}}$)	-0.060	0.050
F-statistic	0.20	0.08
p-value	0.6577	0.7770
Professional & Technical ($\gamma_{M_{prof}} - \gamma_{D_{prof}}$)	0.126	0.108
F-statistic	3.38	0.99
p-value	0.0661	0.3208
Number of Observations	625,241	1,713,124
Overall R-squared	0.3301	0.0115
Other White Collar Incumbents		
Unskilled Blue Collar ($\gamma_{M_{unskb}} - \gamma_{D_{unskb}}$)	0.044	0.264
F-statistic	0.22	1.08
p-value	0.6356	0.2982
Skilled Blue Collar ($\gamma_{M_{skb}} - \gamma_{D_{skb}}$)	0.017	0.113
F-statistic	0.04	1.24
p-value	0.8346	0.2662
Other White Collar ($\gamma_{M_{whit}} - \gamma_{D_{whit}}$)	-0.019	0.204
F-statistic	0.14	2.83
p-value	0.7075	0.0926
Professional & Technical ($\gamma_{M_{prof}} - \gamma_{D_{prof}}$)	0.216**	0.218*
F-statistic	11.42	4.57
p-value	0.0007	0.0326
Number of Observations	749,425	192,779
Overall R-squared	0.2250	0.1888
Professional & Technical Incumbents		
Unskilled Blue Collar ($\gamma_{M_{unskb}} - \gamma_{D_{unskb}}$)	0.257**	0.186
F-statistic	7.54	0.67
p-value	0.0060	0.4136
Skilled Blue Collar ($\gamma_{M_{skb}} - \gamma_{D_{skb}}$)	0.114	0.016
F-statistic	2.87	0.04
p-value	0.0902	0.8391
Other White Collar ($\gamma_{M_{whit}} - \gamma_{D_{whit}}$)	0.105	0.452*
F-statistic	2.45	4.93
p-value	0.1173	0.0264
Professional & Technical ($\gamma_{M_{prof}} - \gamma_{D_{prof}}$)	0.155**	0.191*
F-statistic	11.45	4.54
p-value	0.0007	0.0331
Number of Observations	759,742	417,579
Overall R-squared	0.3830	0.1897

Note: Only high absorptive capacity sectors are included in analysis. All specifications include annual time dummies, individual, and establishment fixed effects. Robust standard errors are clustered at the establishment-level. ** denotes significance at 1 percent level; * denotes significance at 5 percent level. See section 5 for other independent variables included in the estimation (not reported here).
Source: RAIS, 1996-2001.