Cross-Industry Interlinkages in Employment Growth: Evidence from Brazil*

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Abstract

Using industry- and establishment-level data from Brazil and employment data by sector and economic area from the United States, we estimate the extent to which firm- and industry-level employment and entry decisions respond to changes in the employment decisions of geographically and economically proximate firms, comparing Brazil's experience to a developed country benchmark. We instrument for employment changes by following Bartik (1991) and Blanchard and Katz (1992), combining national-level changes in employment by industry with municipality-level variation in the initial distribution of firms to predict such changes between 1995 and 2005, a period which witnessed significant turbulence in exchange rates in Brazil. Our analysis suggests the existence of economically and statistically significant effects of municipality-level shocks in other industries on the employment and entry decisions of firms, likely reflecting positive productivity effects of employment expansions; that employment and employment growth occur differentially in relatively high-skill firms; and that spillovers are heterogeneous and vary based on municipality income, industry relatedness, distance from regional economic centers, and transport costs, as suggested by theoretical models of growth and regional development. *JEL codes: O1, O2, J2, F4, R1, R3*

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1 Introduction

Interlinkages in production and employment decisions across firms and industries give rise to variation in both the scope and speed of economic development across places (Banerjee and Duflo, 2005; Jones and Olken, 2007). These interlinkages may be particularly strong within cities or regions, encouraging the development of geographic clusters of economic activity and innovation.

The advantages of proximity may take many forms, including knowledge spillovers leading to higher productivity (Marshall, 1890; Jacobs, 1969; Moretti, 2004; Greenstone, Hornbeck, and Moretti, 2008; Kremer, 1993); lower transport costs to producers of inputs or consumers (Krugman, 1991a; Krugman, 1991b); better ability to enforce contracts with more proximate producers or financial intermediaries; a thicker market for producers of intermediate goods (Ciccone and Hall, 1996); better quality of the worker-firm match in thicker labor markets; lower risk for both workers and firms, along with the ability to insure through longer-term contracts, financial institutions, or informal arrangements (Lucas, 1988); and shared amenities that may be location-specific or increasing in population density (Banerjee, 2004; Glaeser, Kallal, Scheinkman, and Shleifer, 1992; Davis and Weinstein, 2002).

A recent paper by Acemoglu and Dell (2009) also suggests the quality of institutions and public goods as important factors in explaining the extent to which incomes vary within countries and between countries over time.

For example, knowledge spillovers and location-specific amenities are widely cited as the driving factors behind the phenomena of the rapid development of high-tech industries in places such as Bangalore or Hyderabad (Manova and Shastry, 2006). Knowledge spillovers may occur through collaborative development of technological advances, as well as the spread of new technologies and managerial best practices through informal interactions between workers in similar industries in geographically proximate places. They may also occur through job transitions across employers in which mobile employees from one firm spread scientific ideas or organizational and managerial strategies across firms in related industries in the same region. Cities are also centers of culture and creative production, allowing for coordinated investments in what otherwise might be thin markets for specialized consumption goods and cultural and other amenities.

The externalities across workers and firms described above may amplify underlying differences in factor endowments across regions or allow for multiple equilibria when industry location is not uniquely determined by fundamentals, more so in the absence of adjustment costs. These mechanisms may also contribute to explaining the historical persistence in the locations of industrial production. Proximity to natural resources or other fundamentals could theoretically determine the long-run location of production; however, some development experiences seem to follow from accidents of history[1].

We develop an empirical methodology to quantify the magnitude of spillovers in employment across industries within municipalities and apply it to Brazilian data. This is closely related to discussions of multipliers in macroeconomics. Using a dataset on the universe of manufacturing establishments in Brazil, we construct a Bartik-style instrument that combines the cross-industry variation in growth of Brazilian industries between 1995 and 2005 and the cross-municipality variation in pre-period industry composition to test for spillovers across industries located in the same municipality (Blanchard and Katz, 1992). This period was characterized by a sudden shift in exchange rate regimes in 1999, leading to large changes in exports relative to 1995 and large swings in formal employment in Brazilian industries over that period, particularly in industries sensitive to export variation, such as in textiles, chemicals, energy and auto manufacturing.

Note that much of the empirical literature on cities and growth focuses on either total output or total factor productivity estimates, where total output can include changes in inventories of intermediate inputs. In these data, we observe only employment, and do not have measures of either total output or capital stock.[2] In some circumstances, consumers and investors may be imperfectly informed, inferring future prospects for productivity growth from the number of new businesses or firms operating in an area; from visible changes in employment and investment in physical capital; and from final goods prices. A stronger concern in this context is that capital and new capital investments may be mismeasured, as the period we study follows a hyperinflation, and as the underlying value of capital investments may also be mismeasured due to local price variation.[3]

[1]Adjustment costs may break the long-run indeterminacy in the location of physical capital predicted by some models as a consequence of equalization of rates of return across places, although targeted subsidies are common.

[2]Data on capital investments are available in the PIA, and could be used to complement this analysis.

[3]Heterogeneity across firms, aggregation and difficulties in measuring capital stocks may predictably skew productivity estimates. For commentary on forecasting and economic indicators, see Auerbach, Alan J. (1982): "The Index of Leading Indicators: Measurement Without Theory, Thirty-Five Years Later", *Review of Economics and Statistics*.

In contrast to much of the existing literature on cities and knowledge spillovers, we look here at employment rather than firm or plant productivity as our primary outcome, and find evidence for economically significant interlinkages in employment growth across industries in our data for Brazil. We combine national-level changes in employment by industry with municipality-level variation in the initial distribution of firms to predict such changes between 1995 and 2005, a period which included shocks to global financial markets reflected in the Asian financial crisis, bond defaults in Russia, and sharp changes in the value of the U.S. dollar relative to other candidate reserve currencies, as well as changes in exchange rate policies in both Argentina and Brazil. Our analysis suggests the existence of economically and statistically significant effects of municipality-level shocks in other industries on the employment and entry decisions of firms, possibly reflecting medium-term changes in productivity from job search frictions for highly skilled managers and employees with accumulated firm-specific human capital.

As noted, much of the literature on productivity spillovers finds similar evidence for local agglomeration effects (Hornbeck et al., 2008). We further justify the choice to focus on employment by noting that (1) local price variation may be greater in developing country contexts than in the United States, leading to potentially greater distortions in productivity estimates; (2) our data follow a period of hyperinflation, where measurement error in prices and thus productivity may be particularly severe; (3) the period under study witnessed a geographically uneven but significant expansion in export manufacturing, which may contribute to mismeasurement; and that (4) employment growth is an important outcome in its own right, in addition to productivity estimates, and an important indicator of the real economy. We also note that as in Blanchard and Katz (1992), simultaneous increases in both employment and compensation reflect increases in labor demand, and are thus likely reflect productivity increases driven by knowledge spillovers or other positive externalities.

We largely ignore dynamic considerations in presenting a simple and somewhat general static theoretical framework relating employment levels and firm entry to productivity, capital investments and output; although in our empirical work we estimate lagged effects of employment in other industries and firms on employment. We examine finely aggregated data on hours worked, total wages paid and the skill composition of employment at the establishment level, using occupational categories as a rough indicator of skill level. In equilibrium, higher productivity firms will attract more skilled workers, and the skill composition of firms may be viewed as a proxy for productivity levels. Fully dynamic models with job search costs have similar predictions (Shimer, 2005). Productivity growth may be reflected in changes in wages and hours worked, and complementing the analysis described above, we find that employment expansions lead to increases in productivity as reflected in wages in firm-level data for Brazil. Industry level aggregate data on the wage bill by industry and economic area for the United States suggest more neutral or possibly negative wage effects of expansions in employment in other industries in contrast, although these estimates are in some places imprecise.

We find that the employment of manufacturing firms seem to change in response to arguably exogenous shifts in employment in other industries located in the same municipality. These results are robust across several specifications. We test and find little evidence to support alternative explanations for our results, such as measurement error in our industry variables. The estimated spillovers appear only over sufficiently long time horizons to suggest that they reflect causal effects on employment demand rather than common shocks at the municipality level. Additional results also suggest that these effects do not purely reflect spillovers through income effects and externalities through consumer demand.

We also find that predicted employment increases in other industries are related to a net increase in wages and the net number of establishments, suggesting that employment changes reflect productivity increases and appear both within existing businesses and in changes in the number of firms operating in an industry. Analyses of census-based data for Brazil and the United States show similar effects for broader industry categories, such as agriculture, retail and services, manufacturing, and mining and construction and utilities, suggesting that the employment interlinkages observed are more broadly relevant, although relative effects on employment and compensation may be dependent on context. Given that for Brazil, both wage and employment effects are consistently positive in response to predicted employment innovations, we interpret the observed effects as evidence for positive shocks to labor demand linked to productivity increases at the level of the firm and industry.

A straightforward improvement on past estimates of spillover effects across sectors and industries is the use here of data directly aggregated from individual employment records. The data used in this paper were aggregated from individual-level records for the full universe of formal workers in

Brazil. We also compare these to magnitudes of estimates to those using data from Brazil's censuses across broader industry categories, and present preliminary estimates of employment spillovers using yearly aggregates for the United States from the Bureau of Economic Analysis, finding similar magnitudes at more aggregated levels of employment.[4]

Another contribution of the paper is to document where employment interlinkages may be most important, finding that they are greater when firms are more geographically and economically proximate; when firms are located in richer and more urban municipalities; when firms are more proximate to regional economic centers; and when transport costs are an important factor in production and lower, lending support to the theories discussed above of growth and regional and urban development.

Finally, we find that both employment levels and growth are higher in firms that are skilled relative to municipality or industry averages, and that productivity gains may differentially occur within incumbent firms through employment growth in relatively skilled firms. In looking at new entrants, we find also that new entrants are smaller and likely to have differential productivity from incumbents, although we lack direct data on firm productivity here and use skill levels as a weak proxy for labor productivity in some of the discussion below. We motivate our discussion of employment and the skill composition of firms by noting that productivity externalities encouraging employment growth and investment in high-skill firms and industries may have differentially higher returns, particularly in manufacturing industries especially dependent on innovation and in which knowledge externalities may be particularly important.[5]

Section 2 provides a brief discussion of employment in Brazil during the period which we study in this paper. Section 3 outlines a theoretical framework for the paper, Section 4 describes the data and 5 empirical methods, and Section 5 describes the results and discusses preliminary robustness checks. Section 6 describes briefly supplemental estimates for the United States, and Section 7 concludes and discusses directions for future work.

[4]We compare these administrative data-based estimates to estimates of spillovers across more broadly defined sectors using both census data for Brazil and annual data on employment for local economic areas in the United States from the Bureau of Economic Analysis, finding effects of comparable magnitudes. These estimates, given the level of aggregation, may in addition to the possible productivity effects discussed in the literature and for which we find preliminary evidence here, reflect aggregate demand externalities may also contribute significantly to the estimates we observe in these data.

[5]An example of a relevant industry would be pharmaceuticals, in which Brazil has the potential to be a major innovator as well as producer of lifesaving essential medicines for developing and middle-income, as well as developed country, markets.

2 Employment Changes in Brazil

We use data on employment at the industry, firm and establishment level to test for local effects of national-level changes in employment in manufacturing industries between 1995 and 2005.

Figure 1 shows changes in employment by industry over this period for a subset of industries, indexed to initial levels in 1995. Percentage changes in employment vary widely, with some industries decreasing or increasing employment levels more than 25 percent within the decade. While hours worked trended similarly, the total wage bill by industry appear to have increased during this period (Figures 2 and 3).

Most industries decreased employment levels prior to a sudden change in the exchange rate with respect to the US Dollar in 1999. The large, unexpected exchange rate devaluation in January 1999 led the real to more than double in value relative to the US Dollar (see Figure 4), and was followed by large percentage increases in the quantity of exports in certain industries, possibly reflecting low initial levels of production for export (see Figure 5).

Prior to this exchange rate devaluation, Brazil experienced a period of hyperinflation, followed by an exchange rate regime characterized by a crawling peg to the US dollar. This exchange rate policy, initiated in 1994 as part of an economic stabilization plan, was maintained through the end of 1998 with small, controlled adjustments to the exchange rate. A new floating exchange rate was instituted following the resignation of Brazil's central banker in January 1999, in response to nonpayment of debts from state governments in Brazil to its national government.

A major shift in exchange rate policy, this floating exchange rate may have also been coupled with changes in interest rates and access to finance in Brazil and in the region, leading to aggregate shocks to production and employment reflecting the cost of borrowing to finance ongoing operations.

In these data, earnings implied by average hours worked and the wage bill per year looks a little low compared to GNI per capita, but this may be adjusted or service-sector jobs and government jobs not included in these data may be better compensated.

3 Theoretical Framework

Much of the literature on cities and agglomeration focuses on either total output or productivity estimates. In these data, we observe only employment, and do not have measures of either total output or capital stock. This may be interesting because in some circumstances, consumers and investors may be imperfectly informed, inferring future prospects for productivity growth from the number of new businesses or firms operating in an area; from visible changes in employment and investment in physical capital; and from final goods prices. We present a simple and somewhat general theoretical framework to relate employment levels and firm entry to productivity, capital investments and output.

Changes in the exchange rate may have led to fluctuations in effective input and output prices – if capital and labor are complementary, then firms may readjust input bundles or the level of production, leading to changes in employment levels.

Suppose that each firm has a production function that uses both labor and a CES aggregate of other inputs (capital goods):

$$Y_i = A_i L_i^{\alpha} \left(\int x_{ij}^{\frac{1-\theta}{\theta}} dj \right)^{\frac{\theta}{1-\theta}}$$

where A_i is a firm-specific productivity factor, L_i is total employment, x_{ij} is the quantity of each other input used. This allows for flexible elasticities of substitution as well as returns to each factor. Suppose also that output prices, wages and prices of inputs vary across municipalities. Then firms solve:

$$\max P_m A_i L_i^{\alpha} \left(\int x_{ij}^{\frac{1-\theta}{\theta}} dj \right)^{\frac{\theta}{1-\theta}} - w_m L_i - \int p_{jm} x_{ij} dj$$

Note that in a symmetric equilibrium, prices will be constant across input goods. This then simplifies to:

$$\max P_m A_i L_i^{\alpha} \left(N^{\frac{\theta}{1-\theta}} x \right) - w_m L_i - N p_m x_i$$

Taking first order conditions and taking logs, we can find an expression for the relationship between total capital inputs $(N_x)_i$ and employment:

$$\log \alpha + \log(Nx)_i - \log L_i = \log w_m - \log p_m$$

We can then substitute this into the production function to obtain an expressions for total output and employment as a function of prices and parameters:

$$\log Y_i \quad = \quad \log A_i + (\alpha + 1) \log L_i + \log w_m - \log p_m + \left[\left(\frac{2\theta - 1}{1 - \theta} \right) \log N - \log \alpha \right]$$

and

$$\log L_i = -\frac{1}{\alpha} \log A_i - \frac{2}{\alpha} \log w_m + \frac{1}{\alpha} \log p_m + \frac{1}{\alpha} \log P_m - \left[\left(\frac{2\theta - 1}{\alpha(1 - \theta)} \right) \log N \right]$$

Note that in this model, capital investments are symmetric across goods and determined by this optimal choice of labor, and can also be rewritten as a function of parameters and prices:

$$\log x_i \quad = \quad -\frac{1}{\alpha} \log A_i + \left(1 - \frac{2}{\alpha} \right) \log_m + \left(\frac{1}{\alpha} - 1 \right) \log p_m + \frac{1}{\alpha} \log P_m + \left[-\frac{\theta}{1 - \theta} \log N - \log \alpha \right]$$

We look at employment in industry i as our primary outcome. Prices, wages and the productivity parameter A_i may vary with the level of output and employment in other industries, which motivates looking at the effect of changes in employment in all other industries on employment in own firm or industry:

$$\begin{aligned} \frac{d \log L_i}{d(\log \sum_{j \neq i} L_j)} \quad = \quad & -\frac{1}{\alpha} \frac{d \log A_i}{d(\log \sum_{j \neq i} L_j)} - \frac{2}{\alpha} \frac{d \log w_m}{d(\log \sum_{j \neq i} L_j)} + \frac{1}{\alpha} \frac{d \log p_m}{d(\log \sum_{j \neq i} L_j)} \\ & + \frac{1}{\alpha} \frac{d \log P_m}{d(\log \sum_{j \neq i} L_j)} \end{aligned}$$

This also suggests some comparative statics – if the relevant mechanism is a thicker local market for intermediate inputs, this should show up as lower input prices ($\log p_m$). If the relevant mechanism is search costs, wages should be lower on average, because with less friction in labor markets, the average search time should be lower and match quality higher. If the relevant mechanism is transport costs, this will affect both the output price and input prices.

Note that this supposes that the choice of technology is stable (the number of varieties used in production doesn't change), that there are diminishing or increasing returns to technological improvements depending on the value of θ, and that the underlying parameters of the model do not change with $\sum_{j \neq i} L_j$).

The degree to which economic activity occurs in cities may be somewhat surprising, given that proximity to other firms and people may bid up prices for certain goods or factors of production, such as labor or land. Higher prices on some inputs must be offset by either lower costs on other inputs, productivity improvements, or other benefits that follow from proximity to other firms.

Finally, without directly observing input and output prices, or capital investments, this model shows that our data are not enough to separately estimate the spillovers in firm-specific productivity A_i, as in other papers estimating local productivity spillovers due to employment expansions or plant openings. However, our theory has predictions for simultaneous changes in employment in existing firms, entry of new firms, and wages that suggest that productivity effects may outweigh price effects and local competition effects in these data.

We note that productivity increases, or increases in A_i, may have differing implications for these patterns and next relate our production function to the entry and exit decisions of firms.

We also derive an expression for profits in terms of output prices, the quantity of output, and the parameter determining marginal returns to labor inputs, scaled appropriately. Profits for the firm are given by:

$$\Pi = P_m Y_i - w_m L_i - N p_m x$$

We can rewrite the first order conditions, equations (1) and (2), as:

$$\frac{\alpha P_m Y_i}{L_i} = w_m$$

and

$$\frac{P_m Y_i}{x_i} = N p_m$$

We can then write profits as:

$$\begin{aligned} \Pi &= P_m Y_i - \alpha Y_i - Y_i \\ &= (P_m - (1+\alpha)) Y_i \end{aligned}$$

Taking this very simple model one step further, firms enter if profits are larger than entry costs, or if:

$$\begin{aligned} (P_m - (1+\alpha))Y_i - entrycost &> 0 \\ (P_m - (1+\alpha))A_i L_i^{\alpha} \left(\int x_{ij}^{\frac{1-\theta}{\theta}} dj \right)^{\frac{\theta}{1-\theta}} - entrycost &> 0 \end{aligned}$$

As net profits are $(P_m - (1+\alpha))Y_i - C$, and Y_i conditional on producing should be increasing in A_i, the parameter indexing productivity, to first order, entry increases as productivity increases, and technological shifts raising total productivity A_i lead to more entry of firms. Here the productivity term includes the quality of the worker-firm match, firm- or sector-specific human capital, and possible relationship- specific human capital, as modeled in Moretti (2004) and Levin (year). As shown above, if productivity rises, employment should as well, both leading to both inframarginal increases in employment as well as new entry. An additional implication of the model is that wages increase when productivity rises, to first order. As described below, we test empirically for these patterns of effects in our data.

4 Data and Empirical Strategy

4.1 Data

We use annual data on employment for establishments in manufacturing industries in Brazil, constructed from the RAIS (see Data Appendix for more detail). We aggregate these data to the industry-municipality level for some of the analysis.

Table I presents the summary statistics for the sample of firms/municipalities used in our analysis. The sample includes 31,861 firms located across 3,453 municipalities. It is worth noting that while firms represent a small fraction of their industry employment at the national level, on average they represent 10 percent of the local municipality employment, and an even larger fraction of their industry local employment.

4.2 Empirical Strategy

We combine national-level changes in employment by industry with municipality-level variation in the initial distribution of firms to predict such changes between 1995 and 2005.

We predict employment for each municipality-industry-year from the base year share of employment in each industry in each municipality interacted with the national level of employment in each industry-year, excluding own municipality[6].

$$\tilde{Y}_{mjt} = \left(\frac{Y_{mj95}}{Y_{j95}}\right) \cdot \sum_{n \neq m} Y_{njt}$$

For a firm i in municipality m, industry j and at time t, $\tilde{Y}_{mjt}$ provides a measure of the expected municipality employment level in the firm's own industry.

For each firm/municipality, we then construct a yearly measure of the predicted employment for firms in all other industries in the same municipality by then summing these predicted employment over all industries in each municipality-year excluding the industry of firm i.

[6] We also plan to follow Autor and Duggan (2004) in excluding own municipality from national trends in the construction of this type of instrument. However, note that in our sample, no single municipality accounts for an important share of national employment in any of the industries under consideration, and we predict that our results are robust to the exclusion of this adjustment.

$$\tilde{Y}_{m-jt} = \sum_{k \neq j} \tilde{Y}_{mkt}$$

We first check for the predictive power of these estimates by regressing the log of municipality-level manufacturing employment on the log of these predicted employment changes:

$$ln(Y_{mt}) = \alpha_m + \theta_t + \beta \cdot ln(\tilde{Y}_{mt}) + \epsilon_{mt}$$

We then explore the reduced form relationship between employment for firm i and the predicted employment of other industries in the same municipality by regressing the log of employment for firm i on a full set of firm/state fixed effects, year arbitrary shocks, the log of predicted employment in own industry and the log of predicted employment in other industries:

$$ln(Y_{imjt}) = \alpha_i + \theta_t + \beta_1 \cdot ln(\tilde{Y}_{mjt}) + \beta_2 \cdot ln(\tilde{Y}_{m-jt}) + \epsilon_{imjt}$$

The coefficient of interest is β_2. This coefficient tells us the average additional growth experienced by firms in an industry when the other industries in the same city are predicted to expand by 100 percent.

In our main specification, we use this predicted employment for other industries in the same municipality as an instrument for the actual employment of other industries in the same municipality. More precisely, we estimate

$$ln(Y_{imjt}) = \alpha_i + \theta_t + \beta_1 \cdot ln(\tilde{Y}_{mjt}) + \beta_2 \cdot ln(Y_{m-jt}) + \epsilon_{imjt}$$

using $\tilde{Y}_{m-jt}$ as an instrument for Y_{m-jt}. The coefficient of interest here is also β_2, which now tells us the average additional growth experienced by firms in an industry when the other industries in the same city expand by 100 percent.

The identification of this effect comes from comparing firms which are located near different industries, which experience expansions and contractions (at the national level) in different points in time. Most of the variation reflects differences in magnitudes of changes, not necessarily different timing of changes in employment trends.

Next, we allow for a more flexible specification by allowing the year effects to differ across industries and across states. We estimate:

$$ln(Y_{imjt}) = \alpha_i + \gamma_{jt} + \lambda_{st} + \beta_1 \cdot ln(\tilde{Y}_{mjt}) + \beta_2 \cdot ln(Y_{m-jt}) + \epsilon_{imjt}$$

where s indexes the state containing municipality j. Again, we instrument for Y_{m-jt} using $\tilde{Y}_{m-jt}$. In this specification we restrict identification further, by comparing firms in the same state and sector, but located near different industries, which experience expansions and contractions (at the national level) in different points in time.

We also characterize the timing of the effect. We implement this by using our approach to estimate the effects of changes in the employment of other industries in the same municipality on changes in employment at firm i over 1, 3, 5 and 7-year horizons. We use the following specification:

$$\begin{aligned} ln(Y_{imjt}) - ln(Y_{imj(t-l)}) = \theta_t + \beta_1 \cdot (ln(\tilde{Y}_{mjt}) - ln(\tilde{Y}_{mj(t-l)})) \\ +\beta_2 \cdot (ln(Y_{m-jt}) - ln(Y_{m-j(t-l)})) + \epsilon_{imjt} \end{aligned}$$

where $ln(\tilde{Y}_{m-jt}) - ln(\tilde{Y}_{m-j(t-l)})$ is an instrument for $ln(Y_{m-jt}) - ln(Y_{m-j(t-l)})$. The estimation of this equation for different time horizons allows us to understand how long does it take for firms to adjust in response to expansions by other industries in the same municipality.

We then estimate the extent to which employment expansions and contractions appear as net changes in the number of establishments in an industry and municipality. We regress:

$$N_{mjt} = \alpha_i + \theta_t + \beta_1 \cdot ln(\tilde{Y}_{mjt}) + \beta_2 \cdot ln(\tilde{Y_{m-jt}}) + \epsilon_{mjt}$$

and

$$ln(N_{mjt}) = \alpha_i + \theta_t + \beta_1 \cdot ln(\tilde{Y}_{mjt}) + \beta_2 \cdot ln(\tilde{Y_{m-jt}}) + \epsilon_{mjt}$$

We then look at preliminary estimates of demand spillovers across industries, estimating the coefficient on the interaction between expected employment changes and the share of inputs from each industry.

New hires may differ from incumbents, and we run regressions to estimate whether employment increases reflect increases in the average skill level of establishments relative to their local labor markets, defined as the municipality or the industry. We also estimate this with employment growth as the outcome.

Changes in wages and hours worked as a function of predicted employment changes are examined using specifications similar to those in Table III.

We look at the characteristics of new entrants relative to incumbents.

Finally, we check whether our main results are robust to the inclusion of more flexible sets of fixed effects.

5 Results

We first show that our approach leads to a strong predictor for the local employment of industries across municipalities. We then report the results using this predictor to estimate how firms' local employment growth responds to expansions in the local employment of other industries in the same municipality. In the second part, we report the importance of these effects for different time horizons. We then present and discuss several checks to refine and test the robustness of our results. We then discuss effects of predicted employment changes in other industries on the number of firms operating in a given industry in a municipality.

5.1 National and Local Employment Trends: "First Stage"

The first basic question that we address empirically is whether our approach actually leads to a strong predictor for the local employment of industries across regions. Table II reports the estimation of equation (3) with the log of municipality employment as the outcome. We are simply testing how changes over time in the predicted employment for all industries in a municipality are correlated with the actual overall employment in that municipality. We are controlling for fixed differences across municipalities and year fixed effects, so identification comes from comparing municipalities with industries that experienced different shocks (at the national level) in a given point in time. The point estimate implies that a predicted change of 100 percent in the employment of a given municipality is associated with a statistically significant actual change of 56.6 percent.

5.2 Cross-industry Employment Effects Within Municipalities

Column (1) of Table III reports the reduced form effects on the local employment of firms in a given industry, using our approach to predict the employment of other industries in the same municipality. The result is based on the estimation of equation (4). The estimated effect is a statistically significant expansion of 5.1 percent on the average employment of firms in a given industry in response to a predicted expansion of 100 percent in other industries.

Column (2) of Table III reports the IV estimator based on this approach. More precisely, we estimate equation (5) using the log of predicted employment in other industries as an instrument for the log of actual employment in other industries. There is an estimated average expansion of 16.5 percent in the local employment of firms in a given industry in response to an actual expansion of 100 percent in the employment of other industries.

This result suggests the existence of economically and statistically important agglomeration spillovers. In the absence of such spillovers, an expansion in the demand for labor and other immobile factors in a given industry should bid up their prices and reduce the growth of firms in other industries.

5.3 Timing of Effects

Our first strategy to refine the evidence on the importance of spillovers is to look at the timing of the effects. To the extent that our results are actually driven by agglomeration spillovers they should be particularly important over longer time horizons. We implement our approach for different time horizons by estimating equation (6) with different time intervals.

Columns (1) to (4) of Table IV-A present the reduced form results based on this approach. Columns (1) to (4) of Table IV-B present the IV estimates. The results reveal that the impact of expansions to other industries in the same municipality are especially important over longer horizons. Indeed, firms in a given industry do not experience economically or statistically significant higher growth over one year in response to expansions in other industries. On the other hand, over a horizon of five years, firms in a given industry are estimated to expand on average by 26 percent in response to an expansion by 100 percent of other industries. It is also worth noting that the economic magnitudes of the effects increases over longer time horizons, but becomes stable after 5 years.

Together, these results provide additional support for the importance of agglomeration spillovers.

Although we have data over a relatively short time horizon, we find evidence for the persistence of effects of exchange rate shocks on employment levels in local labor markets. Shocks 1, 3, 5, 7, 9 years ago still matter for employment levels, which may reflect the movement of top-level, highly skilled managers across plants, cities, and firms.

The mechanisms through which these employment spillovers across sectors may operate include productivity effects generated by knowledge sharing or scale effects that influence innovation, straightforward demand effects that can be empirically characterized by examining input-output interlinkages across firms and industries, transport costs or costs of contract negotiation and enforcement that explain the persistence of local production relationships across firms, and insurance motivations.

5.4 Net Entry of Establishments and Characteristics of New Entrants

We also estimate the effect of local predicted employment changes on the net number of establishments operating within a given industry in a municipality. We find that there are substantial and statistically significant effects of predicted employment changes on net entry of establishments, in both levels and logs (Table V, results in logs not shown).

Some characteristics of new entrants are shown in Table VI: they are likely to be smaller and less productive than existing firms, as suggested by employment and employment structure, reflected in wages and hours worked.

5.5 Firm Interlinkages

Finally, we estimate but do not report the effect of insurance provided by having a larger estimated number of downstream buyers. We use an industry-level input-output matrix for Brazil to estimate spillovers that may be stronger among firms that are linked by production relationships. Table VIII shows preliminary estimates of these interactions.

We might expect that expansions in employment in upstream and downstream industries might benefit firms, reflecting demand effects and insurance provided by having more downstream buyers. This could include quality monitoring or insurance against shutdown in the case of economic shocks that differentially affect the poorest consumers or countries.

Interlinkages through financial institutions and intermediaries potentially have less strong predictions about the correlations in employment growth and investment reflecting direct demand spillovers. A literature about the informational advantages of local and regional banks, as well as a set of related papers about financial openness and growth, suggests that improvements in access to finance lead to firm growth, with firms in industries dependent on external finance responding more to changes in access as measured by conventional indicators of financial openness (Fisman and Love, 2004; Rajan and Zingales, 1998). Unfortunately, we do not test directly for this here.

5.6 Interactions with Municipality Characteristics, Distance and Transport Costs

When interacting our measure of predicted employment growth in other industries with measures of municipality characteristics, including income, our estimates show strong patterns in interactions with municipality characteristics (Table VII). We find that richer municipalities and those more proximate evidence stronger spillover effects in industry growth when looking at employment as an outcome.

Employment interlinkages across firms are stronger in municipalities that with higher incomes, as reflected in both per capita income and in the share of households with access to electricity and piped water; that are more urban, and have more employment in either services or manufacturing, relative to agriculture; and surprisingly with higher unemployment rates. We find weaker spillovers in municipalities with a higher share of the population out of the labor force, although this is likely to be correlated with agricultural employment.

We find no effects of other municipality demographic characteristics, including indicators of religious and ethnic composition, on the strength of employment interlinkages in our estimates, but do find strong effects of distance to the nearest state capital and a measure of the cost of transporting goods to the state capital (Table IX). In both cases, the effects of distance weaken employment interlinkages, although we find no discernable effects when looking at distance measures to the federal capital, Brasilia, or transport costs to Sao Paolo, the largest city or metropolitan area in Brazil.

5.7 Skills, Wages and Hours Worked

We also examine data on hours worked, total wages paid and the skill composition of employment at the establishment level, using occupational categories as a rough indicator of skill level. In equilibrium, higher productivity firms will attract more skilled workers, and the skill composition of firms could be viewed as a proxy for productivity levels. Fully dynamic models with job search costs have similar predictions (Shimer, 2005). Productivity growth from inframarginal skill investments and unobserved capital investments may be reflected in changes in wages and hours worked, complementing the analysis described above.

We test for whether employment levels and growth are greater in more skilled relative to less skilled firms, looking within firms and industries, and find that both employment levels and growth are higher in relatively skilled firms, benchmarked to the skill levels of the industries and the municipalities in which they are located (Tables X and XI).

We find that employment expansions in other industries leads to if anything higher wage growth and increases in hours worked (Table XII), consistent with productivity increases from possible knowledge spillovers associated with employment growth in other sectors.

5.8 Robustness Checks and Census Based Estimates of Employment Growth Interlinkages

One potentially important concern with our results is the possibility of measurement error in our industry variables. Even after conditioning on industry controls, firms located near a given industry might be economically closer to that industry. If this is the case, our results could be simply reflecting the possibility that close industries experience similar shocks at the national level.

The timing of the effects goes against this interpretation, since it is not clear why this mechanical correlation should be particularly important for longer time horizons and not important at all over the horizon of one year.

A second strategy to deal with this concern is to compare the estimates across specifications that include different controls for firms' own industries. Columns (1) and (2) of Table VI respectively present the IV estimates from equation (5) with and without the control for the firms' own industry. The estimated magnitudes become larger when we add the controls for the firms' own industry. This is exactly the opposite that we would expect if the results were driven by measurement error in the industry variables.

As an additional robustness check, we present the results including state/year and sector/year fixed effects. The results are based on the estimation of equation (6). The addition of those fixed effects restricts the identification of the results only to comparisons across firms in the same industry and states. Another approach to control for differences across firms in their location and industry is to simply include the average employment of other firms in the same industry, state and year as a control in the estimation of equation (5).

Columns (3) to (5) of Table V present the IV estimates based on these approaches. The results across a variety of specifications support the existence of economically and statistically significant agglomeration spillovers.

Finally, we test the importance of spillovers through consumer aggregate demand in explaining our results. As local expansions in other industries translate into higher wage income, this can lead can to an expansion in local consumer aggregate demand for local goods. To the extent that some manufacturing firms are producing local goods, this could expand the demand for their goods. Additionally, an expansion in the demand for local services could amplify this effect. A central prediction from agglomeration spillovers driven only by this story is that spillovers should be particularly important in municipalities where manufacturing represents a sizeable fraction of the local economy. One way to measure this local importance of manufacturing is to look at the fraction of the working population employed in manufacturing.

In non-reported results we first test if the estimated spillovers are more important in municipalities where manufacturing corresponds to a greater fraction of the total labor force. We found no economically or statistically important evidence that this is the case. Additionally, we found economically and statistically important effects even when we restricted our sample to municipalities where manufacturing represents a very small fraction of the labor force. Together, these results suggest that our findings are not mainly driven by consumer aggregate demand spillovers.

Unfortunately, we do not directly examine other production externalities that may directly affect employment, affect the choice of production technology, or influence wages through compensating differentials that would be necessary to retain workers. A recent paper by Lipscomb and Mobarak (2007) examines the relationship between industrial production and water quality in Brazil by estimating how county boundaries matter for measures of water quality within the same basin.

Longer-run estimates derived from Census data on employment by industry for Brazil also suggest large employment growth interlinkages across more broadly defined sectors, as well as within manufacturing, suggesting that the channels of employment interlinkages extend beyond knowledge spillovers and growth and may include strong direct demand effects.

6 Annual Estimates for Economic Areas in the United States

As a short exercise to benchmark these census-based estimates, we look at data for Census Economic Areas between 2001 and 2009 and run an analogous specification to estimate the strength of employment interlinkages across sectors within local economic areas during this period, which included the recent financial crisis.

Sectors are defined somewhat differently in these data than in either the census-based or administrative data-based datasets we use for Brazil, and include non-manufacturing sectors as well as manufacturing sectors.

We estimate national-level trends by sector as above, and regress employment in these sectors and economic areas on the predicted changes for other industries in the same area, defined as pre-period employment multiplied by the percentage change at the national level.

We find similar magnitudes of estimates of spillovers or interlinkages for employment, and smaller spillovers for wages, suggesting that employment spillovers are larger for lower-skilled workers, or that employment increases are at least temporarily offset by slower productivity growth.

These estimates provide additional confidence of the external validity of our results. A similar exercise could be conducted using Census data on employment for the United States to check the validity of estimates for longer-run effects of employment growth across sectors, as for the analysis for Brazil in the subsection preceding.

7 Conclusion and Future Work

In this paper we develop an empirical methodology to quantify the magnitude of spillovers across industries within municipalities and apply it to Brazilian data. We document the existence of economically important spillovers in the growth decisions of firms. Firms grow substantially more in response to expansions by other industries in the same municipality. Our results support the importance of theories predicting that agglomeration spillovers can explain the spatial concentration of economic activity by amplifying underlying differences in factor endowments across regions or generating multiple equilibria when location is not uniquely determined by fundamentals.

Note that this paper focuses on the interlinkages in employment decisions across firms and industries, without using data on the capital structure or output of firms. Theoretically, firms could adopt new technologies or change the mix of labor and capital inputs to production in response to productivity or price changes. We develop a method for analyzing the employment decisions of firms and industries that may be more robust to variation in input and output prices, with panel data on firms over time. One limitation of this approach is that it is derived from the optimizing behavior on the part of firms; however, the results should still hold when relatively small effective price or productivity changes lead to departures from optimal choices of inputs.

These results highlight the importance of learning about the underlying structural sources explaining agglomeration spillovers. What is the relative importance of factors such as knowledge externalities and transportation costs in explaining them? How do they actually lead to agglomeration spillovers? What is the relative importance of spillovers across and within industries? Our approach can be extended to address these questions. We can test if our effects are particularly important in human capital intensive industries or in places with high transportation costs, for example. We can also test if our effects are particularly important for industries producing similar goods. More broadly, we can use our approach to estimate the importance of spillovers across several pairs of industries to test the relative importance of competing theories which predict agglomeration spillovers. We believe this is a very fruitful area for future research.

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Data Appendix

Employment Data

We use an administrative database to construct aggregated annual measures of employment by plant, firm, industry, and location. This database (RAIS) is administered by the Brazilian Ministry of Labor. All firms formally hiring workers in Brazil are required to provide information to the Ministry of Labor for this registry.[7]

The underlying dataset contains unique plant and firm identifiers, and information on the plant's sector of production, as well as a rich set of information on individual workers. For each worker in the dataset, the data include a unique worker identifier, educational attainment in nine categories, an occupation code, as well as dates of accession and separation.[8]

We use an aggregated version of these worker level records to construct annual plant, firm-by-municipality, and industry-by-municipality measures of employment. We also construct these measures disaggregated by education category.

For any given plant and year, we tracked all workers that worked in that plant/year and computed the fraction of the year that each individual worked at the plant. We then aggregate this for all existing workers. The unique plant and firm identifiers allow one to both track firms and plants over time, as well as track plants to firms at any given period. Finally, we construct measures of the total number of plants operating in each firm and industry in each municipality and year.

We do not include years prior to 1995 due to the existence of very high inflation prior to this period. Firms are included in the sample if they had average total employment above 50 workers over this sample period. We track those firms and all their plants over all the sample period. Firms drop out of the data only when they leave the social security registry, which can happen either due to true exit (bankruptcy or acquisition) or due to a change in the firm tax code (unique firm identifier).

Population and Municipality Characteristics

We complement the employment data with data on municipality characteristics from the 2000 Census. Municipalities are uniquely matched based on the Brazilian system of municipality codes. The main variable from the Census of interest for our analysis is the overall size of the municipality working force. Together with the information on manufacturing employment, this allows us to measure the importance of manufacturing in a given municipality.

[7]Explain here that Daniel constructed the aggregated measures on-site at IPEA offices in Brazil. Acknowledgements, etc.

[8]Reference Melo (2008) for more detail on these data?

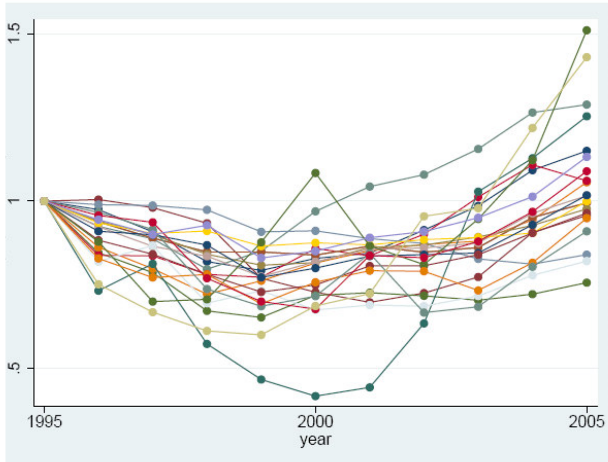

Figure 1: Employment by 2-digit manufacturing industry, indexed to 1995

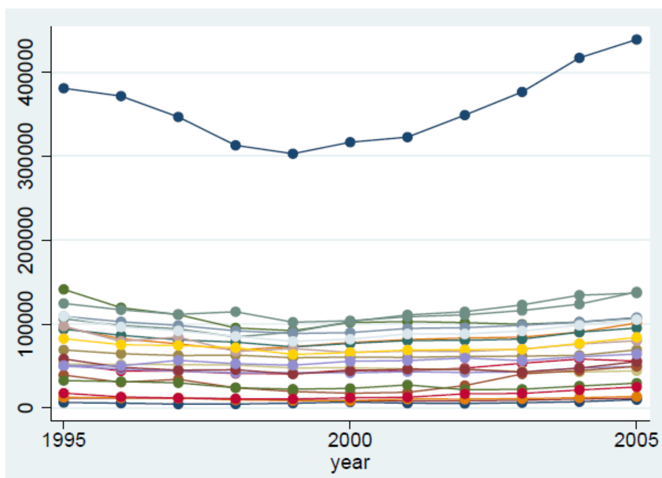

Figure 2: Hours worked by 2-digit manufacturing industry (hundreds)

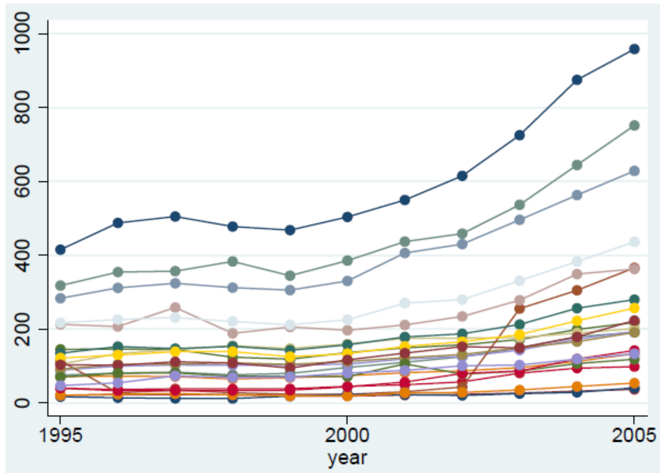

Figure 3: Total wage bill by 2-digit manufacturing industry (millions of Reals)

Figure 4: Exchange rate (Real vs. US dollar)

TABLE I: Summary Statistics by Firm-Municipality-Year

Local Firm Employment	148.42
	(385.00)
Local Firm Employment Growth	-0.01
	(0.34)
Total Firm Employment	958.32
	(2717.76)
Share of Firm to Municipality Total Employment	0.10
	(0.24)
Share of Firm to Municipality Industry Employment	0.26
	(0.31)
Total Firm Number of Municipalities	7.77
	(18.70)
Observations	273675

Note: Observations here are Firm/Municipality/Year. Variables are averaged over all observations in the sample over the period 1995-2005.
Numbers in brackets are standard deviations over that same sample and period.
The sample consists of firms which had average total formal employment, over the years the firm existed in this period, above 50 employees.

TABLE II: "First Stage"
Dependent variable: Log($Employment_t$)

	(I)
Log(Predicted Employment)	0.566***
	(0.033)
Constant	-0.008***
	(0.002)
Municipality Effects	Yes
Year Effects	Yes
Observations	22158
R-squared	0.140

Robust standard errors in parentheses, clustered at municipality level.
* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE III: Reduced Form and Instrumental Variable Estimates
Dependent variable: Log($Employment_t$)

	(I)	(II)	(III)	(IV)
	Industry-Municipality		Firm-Municipality	
	Reduced Form	IV	Reduced Form	IV
Log(Predicted Employment in Own Industry)	0.602***	0.718***	0.051***	0.070***
	(0.032)	(0.035)	(0.009)	(0.010)
Log(Predicted Employment in Other Industries)	0.175***	0.237***	0.047***	0.165***
	(0.015)	(0.023)	(0.017)	(0.043)
Constant	-0.043***	-1.844***	-0.000	-1.510***
	(0.002)	(0.171)	(0.000)	(0.457)
Industry-Municipality Effects	Yes	Yes	No	No
Firm-Municipality Effects	No	No	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
Observations	53984	51565	239111	232604
R-squared	0.094		0.021	

Robust standard errors in parentheses, clustered at municipality level. * significant at 10%; ** significant at 5%; *** significant at 1%

TABLE IV-A: Reduced Form Estimates over 1, 3, 5 and 7 Year Horizons

Dependent variable: Log($Employment_t$) - Log($Employment_{t-X}$)

	(I) 1 year	(II) 3 years	(III) 5 years	(IV) 7 years
Δ Log($PredictedEmploymentinOwnIndustry_t$)	0.030***	0.045***	0.064***	0.075***
	(0.008)	(0.008)	(0.013)	(0.016)
Δ Log($PredictedEmploymentinOtherIndustries_t$)	0.000	0.050***	0.093***	0.114***
	(0.008)	(0.016)	(0.025)	(0.032)
Constant	-0.001	-0.000	-0.075***	-0.099***
	(0.006)	(0.012)	(0.017)	(0.016)
Firm-Municipality Effects	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
Observations	185831	113302	66694	35470
R-squared	0.006	0.012	0.014	0.011

Robust standard errors in parentheses, clustered at municipality level.

* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE IV-B: Instrumental Variables Estimates over 1, 3, 5 and 7 Year Horizons

Dependent variable: Log($Employment_t$) - Log($Employment_{t-X}$)

	(I) 1 year	(II) 3 years	(III) 5 years	(IV) 7 years
Δ Log($PredictedEmploymentinOwnIndustry_t$)	0.030***	0.055***	0.084***	0.100***
	(0.007)	(0.008)	(0.013)	(0.017)
Δ Log($PredictedEmploymentinOtherIndustries_t$)	0.010	0.152***	0.257***	0.260***
	(0.026)	(0.037)	(0.043)	(0.043)
Constant	-0.001	-0.004	-0.064***	-0.073***
	(0.005)	(0.010)	(0.009)	(0.012)
Firm-Municipality Effects	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
Observations	180530	110137	64882	34552
R-squared	0.006	0.007		

Robust standard errors in parentheses, clustered at municipality level.

* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE V-A: Reduced Form Estimates

Dependent variable: Total Number of Firms Operating in 2-digit Industry by Municipality

	Reduced Form	IV
	(I)	(II)
Log(Predicted Employment in Own Industry)	0.960***	1.015***
	(0.265)	(0.281)
Log(Predicted Employment in Other Industries)	0.872***	0.871***
	(0.079)	(0.079)
Constant	0.021***	-7.686***
	(0.001)	(0.480)
Industry-Municipality Effects	Yes	Yes
Year Effects	Yes	Yes
Observations	47812	47812
R-squared	0.036	0.111

Robust standard errors in parentheses, clustered at municipality level.

* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE V-B: Reduced Form Estimates

Dependent variable: Log(Number of Firms Operating in 2-digit Industry by Municipality)

	Reduced Form	IV
	(I)	(II)
Log(Predicted Employment in Own Industry)	0.070**	0.038***
	(0.027)	(0.037)
Log(Predicted Employment in Other Industries)	0.248***	0.247***
	(0.011)	(0.012)
Constant	0.012***	-2.193***
	(0.001)	(0.117)
Industry-Municipality Effects	Yes	Yes
Year Effects	Yes	Yes
Observations	46583	46583
R-squared	0.096	0.173

Robust standard errors in parentheses, clustered at municipality level.

* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE VI: Characteristics of New Entrants
OLS estimates, Dependent variable: Establishment Level

	Employment (I)	Wages (II)	Hours Worked (III)
New Entrant	-86.570***	-99830.78***	-3749.519***
	(4.396)	(7139.029)	(189.069)
Sector effects	Yes	Yes	Yes
Year effects	Yes	Yes	Yes
Observations	247715	247715	247715
R-squared	0.025	0.025	0.025

Robust standard errors in parentheses, clustered at municipality level.
* significant at 10%; ** significant at 5%; *** significant at 1%
Excludes the first year of the sample.

TABLE VII: Spillovers interacted with municipality characteristics from 1991 Census

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)
Log (Predicted Employment in Other Industries)	-0.081***	-0.120*	0.026	0.322**	-0.059	0.036*	-0.116	-0.042	0.156	0.099***
	(0.022)	(0.064)	(0.027)	(0.133)	(0.051)	(0.021)	(0.102)	(0.039)	(0.124)	(0.035)
Log (Predicted Employment in Own Industry)	0.047***	0.047***	0.048***	0.047***	0.048***	0.047***	0.047***	0.047***	0.048***	0.047***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Log (Predicted Employment in Other Industries)*Income	0.026***									
	(0.005)									
Log (Predicted Employment in Other Industries)*Share Urban		0.243***								
		(0.094)								
Log (Predicted Employment in Other Industries)*Unemployment			1.935*							
			(1.107)							
Log (Predicted Employment in Other Industries)*Out of Labor Force				-0.529**						
				(0.256)						
Log (Predicted Employment in Other Industries)*Share in Services					0.316**					
					(0.135)					
Log (Predicted Employment in Other Industries)*Share in Manufacturing						0.204**				
						(0.102)				
Log (Predicted Employment in Other Industries)*Share of Households with Electricity							0.208*			
							(0.124)			
Log (Predicted Employment in Other Industries)*Share of Households with Water								0.149**		
								(0.066)		
Log (Predicted Employment in Other Industries)* Share Catholic									-0.098	
									(0.139)	
Log (Predicted Employment in Other Industries)*Share Nonwhite										-0.060
										(0.052)
Municipality-Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	221000	221000	221000	221000	221000	221000	221000	221000	221000	221000
R-squared	0.022	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021

Robust standard errors in parentheses, clustered at municipality level. * significant at 10%; ** significant at 5%; *** significant at 1%

TABLE VIII: Effects of Production Interlinkages Across Industries
Dependent variable: Log($Employment_t$)

Log($PredictedEmploymentinOwnIndustry_t$)	0.790***
	(0.017)
Log($PredictedEmploymentinOtherIndustries_t$)	0.106***
	(0.031)
Flow from industry i to industry j * Log(Industry j Employment)	0.038***
	(0.006)
Flow to industry j from industry i * Log(Industry j Employment)	-0.015***
	(0.005)
Industry i fixed effects	Yes
Year fixed effects	Yes
Observations	204658
R-squared	0.639

Robust standard errors in parentheses, clustered at municipality level.
* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE IX: Spillovers by Measures of Distance and Transport Costs from IPEA

	(I)	(II)	(III)	(IV)
Log (Predicted Employment in Other Industries)	0.089***	0.015	0.069***	0.042
	(0.030)	(0.034)	(0.025)	(0.027)
Log (Predicted Employment in Own Industry)	0.050***	0.050***	0.050***	0.051***
	(0.009)	(0.009)	(0.009)	(0.009)
Log (Predicted Employment in Other Industries)*Distance to nearest state capital	-0.208***			
	(0.080)			
Log (Predicted Employment in Other Industries)*Distance to federal capital		0.031		
		(0.028)		
Log (Predicted Employment in Other Industries)*Transport cost to nearest state capital			-0.066**	
			(0.033)	
Log (Predicted Employment in Other Industries)*Transport cost to Sao Paolo				0.005
				(0.015)
Municipality-Industry Effects	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
Observations	239111	239111	239111	239111
R-squared	0.021	0.021	0.021	0.021

Robust standard errors in parentheses, clustered at municipality level.

* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE X: Interaction with Average Skill Level Relative to Industry or Municipality
Dependent variable: Log($Employment_t$)

	(I)	(II)	(III)	(IV)
(Average skill level of establishment)	0.306***	0.284***		
- (Average skill level of municipality)	(0.026)	(0.028)		
(Average skill level of establishment)			0.270***	0.247***
- (Average skill level of industry			(0.029)	(0.030)
Average skill level of municipality	0.162***	0.269***		
	(0.036)	(0.043)		
Average skill level of industry			0.302***	0.186***
			(0.027)	(0.028)
Log(Predicted employment in own industry)		0.356***		0.378***
		(0.014)		(0.010)
Log(Municipality population in 2000)		-0.294***		-0.366***
		(0.028)		(0.016)
Share of municipality employment in manufacturing		2.385***		1.342***
		(0.280)		(0.345)
State fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	273647	245899	273647	245899
R-squared	0.086	0.226	0.082	0.204

Robust standard errors in parentheses, clustered at state level.
* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE XI: Interaction with Average Skill Level Relative to Industry or Municipality

Dependent variable: Log($Employment_t$) - Log($Employment_{t-1}$)

	(I)	(II)	(III)	(IV)
(Average skill level of establishment)	0.009***	0.010***		
- (Average skill level of municipality)	(0.002)	(0.002)		
(Average skill level of establishment)			0.008***	0.008***
- (Average skill level of industry)			(0.002)	(0.002)
Average skill level of municipality	0.012***	0.015***		
	(0.002)	(0.003)		
Average skill level of industry			0.003	0.002
			(0.002)	(0.002)
Δ Log(Predicted employment in own industry)		0.000***		0.000***
		(0.000)		(0.000)
Log(Municipality population in 2000)		0.001		-0.003***
		(0.003)		(0.002)
Share of municipality employment in manufacturing		0.220		0.170***
		(0.043)		(0.038)
State fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	212073	192542	212023	192542
R-squared	0.009	0.009	0.008	0.008

Robust standard errors in parentheses, clustered at state level.

* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE XII: Wages and Hours Worked

OLS estimates, Dependent variable: Municipality-Industry Level

	Log(Wages)	Log(Hours Worked)
	(I)	(II)
Log(Predicted Employment in Own Industry)	0.620***	0.587***
	(0.033)	(0.030)
Log(Predicted Employment in Other Industries)	0.187***	0.187***
	(0.017)	(0.015)
Firm-municipality effects	Yes	Yes
Year effects	Yes	Yes
Observations	53975	53998
R-squared	0.216	0.092

Robust standard errors in parentheses, clustered at municipality level.

* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE XIII: Spillovers by Sector, 1980 through 2000 Censuses, Brazil

	Overall	Agriculture	Retail/Services	Manufacturing	Mining/Construction/Utilities	Public
	(I)	(II)	(III)	(IV)	(V)	(VI)
Log (Predicted Employment in	-0.226***	-0.491***	1.295***	0.492***	0.767***	0.749***
Other Industry/Industries)	(0.014)	(0.020)	(0.074)	(0.030)	(0.048)	(0.050)
Log (Predicted Employment in	0.832***	0.883***	0.868***	0.903***	0.894***	0.896***
Own Industry)	(0.006)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)
Municipality-Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	20810	16622	16631	16601	16622	16424
R-squared	0.500	0.701	0.573	0.576	0.593	0.490

Robust standard errors in parentheses, clustered at municipality level.

* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE XIV: Spillovers by Sector, U.S. Economic Areas (Bureau of Economic Analysis)

	Employment		Compensation	
	(I – not in logs)	(II – in logs)	(III – not in logs)	(IV – in logs)
Log (Predicted Employment in Other Industries)	-0.007	0.092*	0.000***	0.037***
	(0.004)	(0.053)	(0.000)	(0.003)
Log (Predicted Employment in Own Industry)	0.954***	0.996***	0.978***	0.958***
	(0.011)	(0.003)	(0.009)	(0.003)
Constant	123029.1*	-1.503*	6778.177	-0.191***
	(63426.7)	(0.908)	(9222.783)	(0.035)
Area-Industry Effects	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
Observations	31009	29154	102892	89608
R-squared	0.999	0.997	0.988	0.992

Robust standard errors in parentheses, clustered at municipality level.

* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix

APPENDIX TABLE I: Robustness Checks, Log of Firm/Municipality Employment

	(I)	(II)	(III)	(IV)	(V)
Log (Employment in Other Industries)	0.135***	0.145***	0.141***	0.149***	0.077**
	(0.035)	(0.037)	(0.037)	(0.039)	(0.037)
Log (Predicted Employment in Own Industry)		Yes	Yes	Yes	Yes
Log(Other Firms Employment in Same Industry/State)			Yes		
Firm Municipality (Plant) Effects	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes		
Industry/Year Effects				Yes	Yes
State/Year Effects					Yes
Observations	250618	232604	230896	232604	232604
R-squared	0.02	0.02	0.02	0.02	0.03

Robust standard errors in parentheses, clustered at municipality level.
* significant at 10%; ** significant at 5%; *** significant at 1%

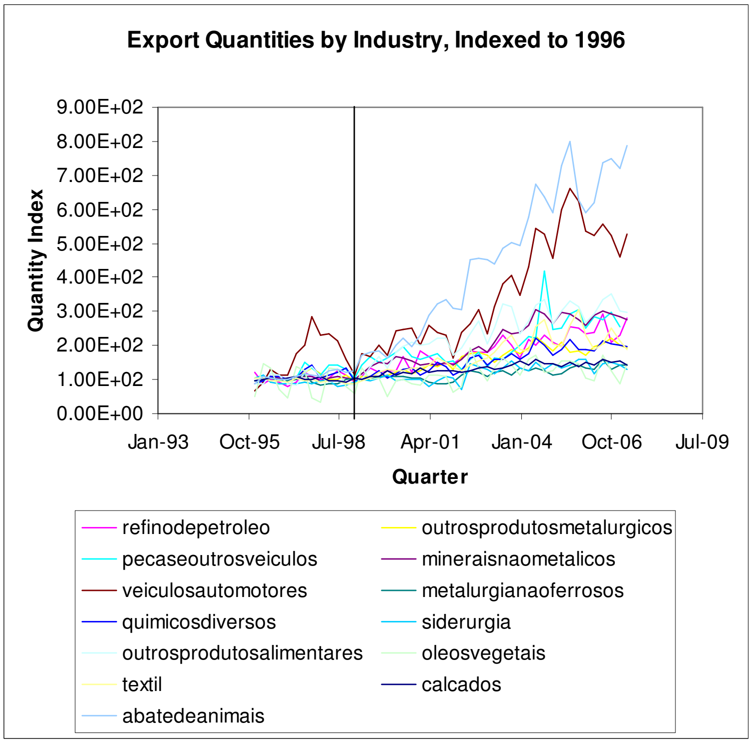

Figure 5: Exports by industry for manufacturing and other industries, excluding petroleum (export indices)