Connect and Protect:
The Role of Trade, Technology, and Labor Policies on Informality*

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February 2020
VERY PRELIMINARY AND INCOMPLETE
DO NOT CITE

Abstract: Several episodes of market-oriented reforms in developing countries have been accompanied by a significant rise in work outside of the formal economy. In addition, according to a large literature for the developed world, the rapid development of communications technologies is related to the polarization of the labor force. A growing body of literature has investigated whether these two effects on formal workers are mediated by the strength of labor enforcement. In this paper, we combine these three lines of research to consider the implications of rigid labor market policies on informality, in the aftermath of trade liberalization and technological progress. We hypothesize that strict labor policy may reinforce trends toward widening wage dispersion, job polarization, and contribute to rising informality, in part, as low-wage, low-skilled job opportunities in low-productivity formal establishments diminish. In our investigation, we employ data from the Brazilian decennial Census that provides a wealth of information on workers' demographic and employment characteristics, including job formality status. We also exploit quasi-exogenous changes in industry-level real exchange rates and advances in broadband internet technology to explore the likelihood of informality across Brazilian employers exposed to varying degrees of *de facto* labor regulations, as measured by Ministry of Labor inspections.

Keywords: International Trade; Digital Technology; Labor Regulations; Informality.
JEL: F14; F16; J46; J80.

* This work has benefitted from funding by UNU-WIDER, under the research project on "Transforming Informal Work and Livelihoods." Scott Knewitz provided excellent research assistance.

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1. Introduction

Recent market-oriented reforms, such as trade liberalization, have coincided with a substantive rise in work outside of the formal economy. In Brazil, for example, estimates suggest that approximately 30 percent of employment is informal—that is, the jobs do not pay into the tax system and the workers do not receive benefits. Much research has documented the relationship between trade policy and informality in the Brazilian context, with mixed results (Paz 2014). At the same time, the rapid development of communications technologies has radically changed the nature of work. A large body of research supports the empirical relationship between the expansion of technology and the coincident polarization of the labor force for the developed world (Acemoglu and Autor 2011). The evidence in Almeida, Corseuil, and Poole (2019) reinforces this finding for the case of the Brazilian formal economy. However, to our knowledge, the literature on the impact of technology on employment has neglected to consider technology's role in shaping the informal-formal labor market divide in developing countries. This is unfortunate because, theoretically, technology may moderate the effects of trade policy.

Technology facilitates local firms' access to new and distant markets that were previously not within reach. At the same time, it fosters local competition by increasing outsiders' access to the local market. This is similar to a reciprocal trade liberalization, as in Paz (2014), which creates formal jobs in the expanding firms (usually large and more productive firms, less likely to hire informal workers) and destroys formal and informal jobs in smaller and less productive firms (which are more likely to employ informal workers). Similarly, the technology-induced skill upgrading, uncovered by Almeida, Corseuil, and Poole (2019), improves job opportunities for skilled workers and displaces unskilled workers. Trade and technology, therefore, are predicted to reduce the number of (higher-skilled) upper-tier informal jobs and expand the number of (lower-skilled) lower-tier informal jobs.

The ultimate impact of trade and technology on formal and informal employment opportunities, however, will be mediated by the flexibility that businesses face to adjust their workforces following shocks. While labor market institutions exist to protect workers, they

may also hamper the firm's incentives to adjust the workforce by raising the costs of labor. In fact, research has shown that labor regulations constrain firm size (Almeida and Carneiro 2009; Almeida and Carneiro 2012) and firm productivity (Almeida and Poole 2017). In addition, in stark contrast to the best policy intentions, evidence in Almeida, Corseuil, and Poole (2019) points to the idea that labor market regulations differentially benefit the skilled workforce, at the expense of low-wage, low-skilled workers.

In this paper, we combine these three lines of research to consider the implications of rigid labor market policies on informality, in the aftermath of trade liberalization and technological progress. First, we investigate the impact of trade and technology on informality. Our work extends much of the existing literature to consider the interplay between trade and technology on informality. As trade can be a conduit for technological advancement and communications technology can serve to lower trade costs, we hypothesize that the two economic forces have an interactive effect on formal and informal employment.

Next, we study the role of labor policy in influencing these effects. Given the previous evidence, we hypothesize that strict labor policy may, in fact, reinforce trends toward widening wage dispersion, job polarization, and contribute to rising lower-tier informality, in part, as low-wage, low-skilled job opportunities in low-productivity formal establishments diminish. In this sense, our paper speaks to a growing public policy debate on the trade-off between economic growth and job security for workers. More flexible labor markets allow workers to reallocate to their most efficient use, enhancing the productivity gains associated with a globalizing and technologically-advancing world. The fact that rigid labor policy may unintentionally amplify the income inequality effects of these shocks, pushing workers into the informal economy, should give policymakers serious pause. Our research will offer insights for Brazil and other middle-income countries that face similar challenges in an increasingly technology-driven and integrated global economy.

The Brazilian context is suitable to the question at hand in part due to the wealth and depth of available data sources. In addition, the country underwent a dramatic unilateral trade

liberalization during the 1990s, suffered a substantive currency devaluation in 1999 allowing for increased export market access, and experienced strong growth in the provision of internet services in the early 2000s.

Our empirical strategy to identify the impact of labor market regulations on informal employment status relies on a number of data sets from Brazil exhibiting substantial variation across many different dimensions: municipal locations, industrial categories, and time. We rely on detailed individual-level data from the decennial Census. The Census covers the entire country and includes information on workers' demographics and formal or informal employment status. With information on the individual worker's industry and location of employment, we match the Census employment outcomes with industry-specific trade information and municipality-specific access to broadband internet.

Specifically, we exploit quasi-exogenous changes in trade exposure, as proxied by industry-specific real exchange rate changes, and local technological change, as exemplified by new access to broadband internet, requiring significant labor market adjustment, and explore the effects on workers' informality across Brazilian employers exposed to varying degrees of *de facto* labor regulations, as measured by Ministry of Labor inspections. The *de jure* labor regulations in Brazil, established in the 1988 Federal Constitution, are effective throughout the country. However, as the Ministry of Labor is designated with enforcing compliance with regulations, there is significant heterogeneity both within the country and over time in terms of how binding is the labor law. Since informal workers are a very heterogeneous group, we also explore these relationships across various demographic groups—age, gender, and education—in order to examine whether these policies have different impacts on lower- and upper-tier informal workers.

The rest of this paper is organized as follows. Section 2 offers a detailed overview of the main economic literatures associated with our research question linking trade, technology, labor policies, and informality. In Section 3, we present the main data sets and provide some descriptive statistics. Section 4 offers some theoretical predictions, based on the background literature, relating changes in exposure to international markets and the subnational

enforcement of labor regulations to labor market outcomes, such as informal employment status. Section 5 describes the main empirical strategy and reports the main results for the effects of international trade on informality across distinct regulatory environments. We offer conclusions and ideas for future work in the final section.

2. Background Literature

This section offers a brief overview of the background literature linking trade, technology, labor policies, and informal labor markets. We first review the literature on the impact of labor market regulations on informality. We then turn to the large literature on the role of international trade in influencing informal labor markets. Next, we evaluate the small, but growing, body of literature about the impact of technology on informal employment. Finally, we describe the limited evidence on the interactions between trade and labor policies, technology and labor policies, and trade and technology on labor market outcomes.

Our work offers several key contributions to these literatures. First, the literature on the impact of technology on informality is slim to none. Our work helps to expand the discipline's knowledge of how such important changes in automation have contributed to the informal-formal labor divide over the last several decades. Next, our work extends much of the existing literature to consider the interplay between trade and technology on informality. As trade can be a conduit for technological advancement and communications technology can serve to lower trade costs, we hypothesize that the two economic forces have an interactive effect on formal and informal employment. Finally, and most importantly, we are aware of only a few papers that study the implications of international trade on informality in the presence of heterogeneous labor market regulatory enforcement. This paper complements those structural models relying on our reduced-form empirical strategy.

2.1. Labor enforcement and informality

While there is a large literature on the implications of *de jure* regulations on the labor market[1], Bertola, et al. (2000) suggest that *de facto* regulation is as important, or even more important, in determining labor market outcomes. This may be particularly so in developing countries, where there is often significant heterogeneity concerning *de facto* regulation across localities.

Almeida and Carneiro (2009) quantify the effects of *de facto* regulation on firm outcomes within Brazil for the year 2002. Although stricter enforcement produces greater compliance with labor regulations, the authors find that higher levels of *de facto* regulation also results in lower output, smaller firms, and lower labor turnover, leading to an increase in unemployment, as the higher labor costs inhibit labor market flexibility. However, a limitation of the study is that the effect on informal firms remains unknown. In this respect, it may very well be that stricter enforcement, while reducing informal laborers amongst formal firms, contributes to a further displacement of workers. In fact, the higher unemployment rate may be associated with an increase in the size of the informal economy.

In order to assess this, in a follow-up paper, Almeida and Carneiro (2012) directly address labor market outcomes across formal and informal sectors over time as a result of labor inspections. Their model asserts that the standard view—that is, that higher enforcement results in a shift in employment toward the informal sector—neglects the fact that the value that workers place on mandated benefits is higher than the cost to employers. Therefore, given stricter *de facto* regulations, the formal sector becomes more attractive, leading to an increase in the supply of formal workers and a decrease in the supply of informal workers. Indeed, their findings suggest that stricter enforcement is associated with an increase in formal sector employment, and a decrease in employment in the informal sector.

2.2. Trade and informality

[1] See, for example, Kugler (1999), Kugler and Kugler (2009), Ahsan and Pages (2009), Petrin and Sivadasan (2013), and several other studies cited in Heckman and Pages (2004).

Theoretically, under perfect labor market flexibility, we may not see an increase in informality as a result of trade liberalization, as factors are reallocated to more productive firms and exporters. However, the empirical literature concerning trade and formality points to an ambiguous relationship as labor market flexibility is, of course, imperfect, particularly within developing countries.

In this respect, Goldberg and Pavcnik (2003) were the first to demonstrate that tariff declines in Colombia are associated with an increase in informal employment. The increases in informality were the largest in the industries which experienced the largest reductions in tariffs for the period preceding more flexible labor market reforms. The evidence for the case of Brazil is much weaker in that there is no statistical relationship between trade liberalization and informality in the Brazilian context according to Goldberg and Pavcnik (2003). The authors, therefore, assert that labor market institutions are imperative in assessing the effects of trade policy on the labor market.

It is possible that productivity rises faster than output as a result of trade liberalization. Thus, as product-market reallocations move toward more productive firms, we may see a simultaneous shift of the workforce away from these firms. Such a phenomenon is suggested by Menezes-Filho and Muendler (2011). They show that foreign import penetration and tariff reductions throughout Brazil's trade liberalization episode resulted in worker displacements that neither comparative advantage industries nor exporters immediately absorbed. In turn, the authors demonstrate that trade liberalization is associated with significantly more transitions to informal work in that country. By contrast, Bosch, et al. (2012) remark that trade liberalization accounts for a relatively small part of the dramatic increase in the informal sector in Brazil over the same time period. In fact, they find trade liberalization accounts for only around 2.5 percent of the increase in informality, while the labor policy reforms in the new Constitution account for over a third of the increased informality.

Paz (2014) develops a theoretical model of a small open economy with informal labor markets and heterogenous firms, in which the firm-level decision to employ informal

workers depends on the likelihood of enforcement, which is proportional to the firm's size, and on the magnitude of the financial penalty if the firm is found to have violated labor laws. Besides the role of firm heterogeneity on the decision to hire informal workers, this model also innovates relative to Goldberg and Pavcnik (2003) by considering the effect of exports on informality. In Paz's (2014) model, a cut the tariffs of Brazil's trade partners leads to a decline in informality, since it makes smaller firms (those that are prone to employ informal workers) to exit the market. The effect of a reduction in import tariffs increases the informality share in industries that initially had a small share, while it curbs informality in industries that had an initial large share of informal workers.

Paz (2014) relies on the Brazilian trade liberalization episode in the 1990s to test the theory. The empirics confirms that lower trade-partner tariffs reduces informality, and cuts in Brazilian import tariffs have the opposite effect. This latter result is at odds with Goldberg and Pavcnik's (2003) finding of no effects of imports on the informality share in Brazil. This is because Paz's (2014) empirical work innovates on previous empirical work by assessing the effects of Brazil's trading partner tariffs, by accounting for the endogeneity of Brazilian import tariff changes, and by controlling for state-level trends (which partially addresses changes in state-level enforcement over time).

The Paz (2014) finding that, as tariffs for Brazilian exports fall, the informal labor share also falls—as firms are able to expand output and employment—is reinforced in work by McCaig and Pavcnik (2018). They find that employment shifts from the household business (informal) sector to the formal enterprise sector in Vietnam, in the aftermath of large U.S. tariff reductions as part of the U.S.-Vietnam bilateral trade agreement.

2.3. Technology and informality

The effect of technology on overall labor demand is theoretically ambiguous. Although technology enables producers to become more efficient, reducing overall employment, it also offers the opportunity to expand output, which may, in turn, lead to an increase in employment opportunities. Thus, it follows that the research on the impact of technology on

labor offers mixed results. Even when considering the impact of technology on labor demand across different skill groups, the relationship is theoretically ambiguous, depending on the degree to which workers are substitutes or complements for technology (Acemoglu and Autor 2011).

However, this long literature on the impact of technology on labor has severely neglected the potential impact on informal labor markets. To our knowledge, there is little to no work investigating the effect of technological change on formality. One exception is Garcia-Murillo and Velez-Ospina (2014); this work finds that broadband, or internet technology, enhances the transition from the informal to the formal sector, as it gives people access to many more resources that can provide the means to finding alternative employment options. Yet, Dell'Anno and Solomon (2014) show that the level of investment in information technology may be dependent on the quality of institutions, represented by levels of enforcement. Because institutions are often weak in developing countries and, therefore, agents invest less human capital in the formal sector, the authors conclude that providing greater access to technology for the informal sector can potentially increase in informality.

2.4. Trade, enforcement, and informality

Almeida and Poole (2017) provide the first evidence of the impact of trade openness on formal employment in a developing country when firms are exposed to varying degrees of labor market regulatory enforcement. The authors find that, following trade liberalization, Brazilian plants facing stricter enforcement of the labor law increased formal employment by less than plants facing looser enforcement. In this setting, increasing the flexibility of *de jure* regulations may allow for broader access to the gains from trade, and increased formal job creation.

The work on the interaction of trade and enforcement on labor market outcomes has largely focused on formal employment, due to data constraints. However, Ulyssea and Ponczek (2018) argue that heterogeneous *de facto* regulation within Brazil is an integral cause of the variation in post-trade reform labor reallocation across regions. Specifically, the authors find

that regions with stricter enforcement of labor regulations observe no statistical increase in informal employment, but face large displacement effects. By contrast, those regions with weaker enforcement suffer no employment losses, but substantial increases in informality.

Dix-Carneiro, et al. (2019) model the structural relationship between trade liberalization, labor market regulations, and informality. They argue that import tariff movements had negligible effects on informality; as such, the focus of policymakers should be on reducing informality through greater enforcement rather than aiming to address the costs of international trade. We see these structural papers as complementary to our reduced-form framework designed to identify the causal implications of a real exchange rate depreciation on informal employment in the presence of a complete set of labor market regulations.

2.5. Technology, enforcement, and informality

To our knowledge, our work will be the first to consider the impact of technology on informal labor markets, in the presence of heterogeneous labor market regulatory enforcement. Almeida, Corseuil, and Poole (2019) study the implications of digital technologies on workers' tasks in Brazil, but only for the formal sector given data availability. The authors report that increased access to digital technologies shifts the workforce composition toward more non-routine tasks and away from routine tasks. Moreover, contrary to the best policy intentions to support vulnerable workers, their work also shows that this effect was even stronger in strictly-enforced areas of the country. This is consistent with evidence presented in Montenegro and Pages (2004), who provide support for the idea that labor market regulations reduce employment rates of the unskilled at the benefit of the skilled workforce. These results warn against the possible consequences, albeit unintended, of strict labor policies.

2.6. Trade, technology, and informality

Poole and Santos-Paulino (2018) consider the effects of trade on employment for the case of Vietnam. In their work, they posit that trade and technology have compounding effects on

labor market outcomes. Advances in access to computers are strongly associated with increases in the demand for non-routine, manual tasks. Increased exports, rather, expand employment opportunities across both routine and non-routine tasks. However, the same trade shock increases employment by less in areas of the country with better access to computing technology, providing suggestive evidence of the labor-saving nature of technology. In follow-up work, Pham, Poole, and Santos-Paulino (2020) consider how these same trade and technology shocks, as well as multinational enterprises, impact the transition from the household business sector (informal economy) to the formal enterprise sector in Vietnam.

3. Data

The data employed in this study consists of the public use microdata samples of the Brazilian Census of 2000 and 2010. These data are matched to municipality-level labor market regulatory enforcement data and to industry-level real exchange rates. The exogenous fluctuation of the industry-specific real exchange rate allows us to examine how trade openness impacts the share of informal employment, and how this effect may be modulated by the degree to which labor regulations are locally enforced.

3.1. Individual data

The Brazilian Census public microdata provides information on several worker characteristics, such as industry affiliation, earnings, hours worked in a week, job formality status, age, education, gender, marital status, race, and the Brazilian municipality and state in which the worker resides. The questions about these characteristics do not change over the two Brazilian Censuses used in our study. Our sample includes only employees—that is, we exclude self-employed workers, employers, and those not in the labor market. We also drop from our sample any observations with missing information on these key variables of interest.

Informality. In this paper, we define an informal job as an employer-employee relationship that lacks a signed labor contract (*carteira assinada*). This is the equivalent definition used in Goldberg and Pavcnik (2003). In fact, labor inspectors mostly commonly visit employers to check on the formal registration of their workers by looking for their *carteiras*. The Census questionnaires explicitly ask whether the job has a signed labor contract, and this terminology is common knowledge among employers and employees. As the data collected by the Census cannot be used in court as evidence, and this is stated before the Census interview starts, we have strong confidence in the individual's truthful responses. Additionally, informal employees are not punished in the event their employer is audited by labor inspectors, and found to have violated labor laws. Therefore, there is little incentive for the worker to provide false information regarding formal workforce registration to the Census.[2]

Table 3.1 presents some descriptive statistics on the workers in our sample in 2000 and in 2010. We can see that between 2000 and 2010 the share of informal workers fell from around 24 percent to 16 percent. Interestingly, the share of married workers also fell sharply from over two-thirds of workers to only about 40 percent. Female employment participation showed almost no change over the ten-year period (around 28 percent), as well as the share of workers living in urban areas (approximately 93 percent). The participation of blacks and Asian workers increased slightly in the manufacturing workforce, even though their participation remains very small. In terms of educational achievements, a slightly higher percentage of workers report literacy over the ten-year period. This is reinforced, as we can see a fall in the share of workers with only a middle school education, a substantial increase in the share of workers with a completed high school education, and a rise in the share of workers with a college degree.

[2] Paz (2014) employs a social security contribution compliance measure of job informality. However, as the author points out, the overlap between these two definitions of informality is above 95 percent of workers. In our context, though, such contributions are not enforced by the Ministry of Labor, but rather by Social Security inspectors. It is for this reason that we opt to rely on the *carteira assinada* definition of informality in this paper.

In unreported statistics, available by request, we also investigate how these key demographic characteristics vary according to workers' responses on whether they have a formal employment contract. The employment participation rate of blacks and Asians is similar across both formal and informal workers. On average, formal workers are older and more likely to be a male, married, and to live in urban areas. Unsurprisingly, formal workers are also more educated; for instance, they are twice as likely to hold a high school degree than informal workers, and three times as likely to be college graduates than informal workers. These patterns did not change much over the sample period, except for a reduction in the share of married workers among formally-employed workers and an increase in female employment participation in informal jobs. In our work ahead, we intend to investigate the implications of economic shocks (such as trade and technological change) on informality across these key demographic characteristics.

Industries. An important feature of the Census data is that the industry classification changes over time. The 2000 Census relies on the *Classificação Nacional de Atividades Econômicas-Domiciliar* (CNAE-Domiciliar), whereas the 2010 Census categorizes industries based on Revision 2 of CNAE-Domiciliar. Therefore, we rely on publicly-available correspondence tables from the Brazilian Census Bureau (IBGE) to report changes over time.[3] The final classification used in this project contains 47 manufacturing industries. Nuclear fuel and automotive engine refurbishing are excluded from our sample due to a lack of international trade data.

Municipalities. Another important issue is that 58 new municipalities were created in Brazil between 2000 and 2010 (Ehrl 2017). Unfortunately, this was not always a simple case of a municipality that was split into two. For example, the new municipality of Novo Santo Antônio covers territory that used to belong to São Félix do Araguaia and Cocalinho. Similarly, the new municipality of Serra Nova Dourada encompasses land that belonged to Alto Boa Vista and São Félix do Araguaia. For these special cases, we aggregate municipalities into an

[3] The concordance tables for these classifications, as well any other classification used in this paper, come from the CONCLA-IBGE website (https://concla.ibge.gov.br/).

artificially large municipality both in 2000 and 2010 in order to have comparable areas over time. This procedure results in a total of 5,438 municipalities in the two time periods.

The municipality level descriptive statistics are displayed in Table 3.2. The average share of informal workers was approximately 41 percent in 2000 and dropped to around 30 percent in 2010. The median share of informal workers in a municipality also fell considerably over the ten-year period from 28 percent to 5 percent. While the average population across cities remained roughly constant over time, the dispersion in city-size increased. Median population fell by almost one thousand people, but population increased in the largest cities. In fact, the maximum municipal population increased from 10.4 million in 2000 to 11.3 million in 2010. The smallest city also marginally increased its population from 7,950 people to 8,050 people.

3.2. Trade exposure data

During the period under analysis in this study, Brazilian import tariffs showed very small variation over time. Figure 3.1 shows the evolution of average, minimum, and maximum import tariffs applied to manufacturing goods over the sample period of 2000 to 2010. Despite the small variation in import tariffs, Brazilian manufacturing firms did experience a significant change in their exposure to international trade due to the strong variation in the real exchange rate. For example, Figure 3.2 illustrates the change in the industry-specific share of output that is exported; we observe that some industries increased export shares (like sugar, cellulose and paper, and ship building), while other industries (for instance, ceramics and vegetable oils) reduced export shares over this period. We observe similar industry-level heterogeneity in the change in import penetration, as depicted in Figure 3.3. Import penetration increased for pharmaceuticals and textiles, for example, but declined for leather processing and railroad vehicles.

Industry-specific real exchange rates. Aggregate fluctuations in the real exchange rate influence a country's competitiveness in international markets. However, the aggregate exchange rate may be less effective at capturing true changes in industry competitiveness,

induced by changes in specific bilateral exchange rates, if particular trading partners are of particular importance to particular industries. That is, movements in the dollar/*real*, peso/*real*, and euro/*real* exchange rates may have different implications for different industries, depending on the industry's trade with the United States, Argentina, and the Euro Zone, respectively.

Therefore, we construct trade-weighted, industry-specific real exchange rates based on bilateral nominal real exchange rate data from the Brazilian Central Bank, country-level consumer price index series from the International Monetary Fund, and Brazilian imports and exports from the Ministry of Foreign Trade's *Análise de Informações de Comércio Exterior* (ALICE) database. The trade data are available at the 8-digit *Nomenclatura Comum do Mercosul* (NCM) classification in the following revisions: NCM1996, NCM2002, NCM2004, and NCM2007. We concord the NCM classifications to the *CNAE-Domiciliar* industry classification available in the Census data, based on correspondence tables publicly available from IBGE.

Using these series for 141 of Brazil's trading partners, we build industry-specific real exchange rates following Goldberg (2004), as follows:

$$\text{trer}_t^k = \sum_c \left(\left(.5 * \frac{X_{t-1}^{kc}}{\sum_c X_{t-1}^{kc}} + .5 * \frac{M_{t-1}^{kc}}{\sum_c M_{t-1}^{kc}} \right) * \text{rer}_c^t \right)$$

where *t* indexes time, *k* indexes industry, and c indexes country, such that the bilateral real exchange rate, rer_c^t, denoted in units of *real* per one unit of foreign currency, is weighted by industry-specific and time-varying export shares ($\frac{X_{t-1}^{kc}}{\sum_c X_{t-1}^{kc}}$) and import shares ($\frac{M_{t-1}^{kc}}{\sum_c M_{t-1}^{kc}}$). Following Campa and Goldberg (2001), we lag the trade shares one period to avoid issues of endogeneity between trade and the exchange rate. By this measure, a decrease in the value of the index implies a real appreciation of the Brazilian *real* in trade-weighted terms for industry *k*. In some specifications, we also consider separately the export-weighted real

exchange rate, $\text{xrer}_t^k = \sum_c \left(\frac{X_{t-1}^{kc}}{\sum_c X_{t-1}^{kc}} * \text{rer}_c^t \right)$ and the import-weighted real exchange rate, $\text{mrer}_t^k = \sum_c \left(\frac{M_{t-1}^{kc}}{\sum_c M_{t-1}^{kc}} * \text{rer}_c^t \right)$.

Figure 3.4 displays a histogram of changes in the trade weighted, industry-level real exchange rate between 2000 and 2010. The majority of industries experienced negative changes in the real exchange rate—that is, an appreciation of the *real* in trade-weighted terms, though several industries also underwent trade-weighted real depreciations. Figures 3.5 and 3.6 present similar graphics for the import-weighted and export-weighted real exchange rates, respectively. We note significant industry-level heterogeneity across both figures. The export-weighted real exchange rate displayed stronger appreciations over the ten years than did the import-weighted real exchange rate.

Interestingly, the two series are not strongly correlated. The correlation between the export-weighted real exchange rate and the import-weighted real exchange rate was -0.1 in 2000 and -0.2 in 2010. The simple correlation across all industries in the change in the real exchange rates is 0.186. Therefore, in some specifications, we include the two trade-weighted real exchange rate series separately.

3.3. Enforcement data

The *de jure* labor regulations in Brazil are effective throughout the country and are rather detailed and stringent, and also strongly pro-worker. For example, changes to the federal labor laws in 1988 increased the overtime wage premium from 20 percent to 50 percent of the regular wage. Additionally, it increased one month's vacation time pay from 1 to 4/3 of a monthly wage. Moreover, terminating a formal employment relationship is very costly to Brazilian firms. The penalty on the plant for dismissing the worker without cause is around 40 percent of the total contributions to the severance fund, *Fundo de Garantia do Tempo de Serviço* (FGTS). Brazilian employers who wish to terminate worker contracts must also give a 30-day advanced notice to workers, and during this interim period, workers are granted up

to two hours per day (25 percent of a regular working day) to search for a new job. This has been shown to considerably reduce Brazilian firms' competitiveness and productivity.

The Ministry of Labor is designated with enforcing compliance with these labor regulations at the federal level, but there is significant heterogeneity both within the country and over time in the enforcement of the law.[4] We, therefore, rely on administrative data on the enforcement of labor regulations from the Brazilian Ministry of Labor. Data for the number of inspector visits are available by city and by 1-digit broad sector for the years of 2000 and 2010. The entire manufacturing industry is considered to be just one sector in this classification. In our study, we utilize data on the total number of inspector visits to a city's manufacturing establishments and the total number of inspector visits to a city's non-manufacturing establishments.

We proxy the degree of regulatory enforcement with the intensity of labor inspections at the municipality level. More specifically, our main measure of manufacturing enforcement is the logarithm of one plus the number of manufacturing inspections at the municipality level per 100,000 people living in the municipality. We also calculate a non-manufacturing enforcement measure based on non-manufacturing inspections in the city. It is important to consider the municipality size in the Brazilian context because cities like Rio de Janeiro may have a large number of inspections, but they also have very large populations. Thus, this enforcement measure will better capture the perceived probability of a visit by labor inspectors to establishments within a city.

Though our analysis is specific to the manufacturing industry, for the purposes of connecting to the international trade literature, we can also assess the degree to which inspections at non-manufacturing establishments in the city also influence manufacturing employers. On the one hand, we may expect that any labor inspector in the region will influence behavior. On the other hand, labor inspectors have limited time to inspect all establishments within a

[4] A comprehensive explanation of the enforcement of the labor regulation system and its importance in Brazil is given in Cardoso and Lage (2007).

city, and as such inspections at non-manufacturing plants may leave manufacturing industries with relatively more flexibility. This is an empirical question that we take to the data.

We next offer some descriptive statistics on the enforcement data. The share of municipalities that had at least one Ministry of Labor inspection (either manufacturing or non-manufacturing) was 63 percent in 2000; it increased by around one percentage point to 64 percent by 2010. When considering only inspections to manufacturing plants, the share of cities with at least one inspection fell from 44 percent in 2000 and to 40 percent in 2010. Table 3.2 reports average values for the number of inspections across all cities. Over the ten-year period, the average number of inspections (among the set of cities experiencing at least one inspection) fell by almost half from 302 in 2000 to 156 in 2010. Across all Brazilian municipalities, the average number of inspections dropped from 133 in 2000 to 81 in 2010. When we focus only on inspections of manufacturing establishments, a similar pattern emerges—an average of 52 inspections (per municipality with at least one inspection) to an average of 25 inspections. Across all cities, this average fell from 34 to 22 inspections over the same time period.

The number of inspections of manufacturing establishments at the municipality-level is strongly, positively correlated to the number of inspections of non-manufacturing establishments; the simple correlation is 0.870 and it did not change over time. The correlation between the ten-year change in manufacturing inspections and the ten-year change in non-manufacturing inspections, across all municipalities, is 0.838. In some specifications, we will consider how the city-specific inspections of different industries effect informality in the manufacturing sector.

Recall, our main measure of labor enforcement accounts for the city-size, in order to proxy for the probability that a given worker would be inspected. Table 3.3 also reports descriptive statistics for these measures of enforcement, for manufacturing, non-manufacturing, and all inspections. Over time, the likelihood of inspection (enforcement) fell from 4.4 inspections per 100,000 people to 4.0 inspections per 100,000 people. This decrease was even stronger

for manufacturing establishments, as the number of inspections per 100,000 inhabitants fell by around 12 percent—from 3.3 to 2.9.

Figures 3.7 and 3.8 illustrate the across-city variation in this labor market regulatory enforcement (based on total—manufacturing and non-manufacturing—inspections) for the entire country in 2000 and in 2010, respectively. The darker the shade, the higher the enforcement. These two maps display the substantial geographic variation in the intensity of enforcement, and that the within-city intensity changes over time. More precisely, most enforcement is directed to the wealthier Southern and Southeastern regions of Brazil, and this geographic difference in enforcement became more salient over time. In fact, this picture becomes even clearer in Figure 3.9, which maps city-specific differences in the change in labor market regulatory enforcement between 2000 and 2010.

A similar pattern of enforcement can be seen when we zoom in on São Paulo state, as depicted in Figure 3.10. While average inspection rates fell over the ten-year period, some municipalities experienced increases in the degree of labor market regulatory enforcement, while other municipalities faced weakening *de facto* regulations. It is exactly this across-municipality variation in changes in enforcement that we exploit in this research.

To shed some light on the sources of across-city changes in enforcement, Table 3.3 presents ordinary least squares (OLS) estimates of a regression relating changes in municipality-level enforcement of labor regulations between 2000 and 2010 on a series of lagged changes in municipal characteristics obtained from IBGE's *Cidades* database. The dependent variable is the change in enforcement between 2010 and 2000, where the municipality-level enforcement is the natural logarithm of the number of inspections plus one per 100,000 inhabitants. The specification in column (1) includes lagged changes in municipality-level GDP and economically-active population. The model in column (2) includes lagged changes in the municipality's urbanization rate, which is a proxy for transportation accessibility. The additional regressors in column (3) comprise lagged changes in city development characteristics (illiteracy rate, Theil index of inequality, share of households with access to

water, electricity, and sanitation; average life expectancy, poverty rate, and average years of schooling).

Paying particular attention to the results in column (3), we note that only the growth in the economically-active population and in the share of households with electricity are statistically-significant predictors (at the 10 percent level) of future growth in labor market regulatory enforcement. The remaining variables—including GDP growth—have no statistically-significant effect on future changes in enforcement levels. Therefore, it seems that labor inspectors reached out to cities that were developing and growing in terms of labor force participation. In the analysis that follows, we will control for these city-specific drivers of changes in enforcement as follows. Fortunately, our data allow us to include city-by-time fixed effects to account for all time-varying city attributes that may be correlated with changes in enforcement and informality.

4. Conceptual Framework

We are not aware of a single paper that considers the role of exposure to foreign markets, access to digital technologies, and heterogeneous labor market regulations on the informal economy. We argue that these interactions are integral to understanding the labor market implications of economic shocks. This is one of the central contributions of this paper.

In this section, we rely on the previous literature to posit predictions for relating changes in international trade, advances in digital technology, and informal employment status. We also present a summary of the theoretical predictions on the labor market implications of regulatory enforcement. Theory offers ambiguous predictions, and thus, these are inherently open empirical research questions.

4.1. Trade, enforcement, and informality

Our discussion in this section largely follows Paz (2014), Almeida and Carneiro (2012), and Almeida and Poole (2017).

Effect of the trade shock. A real exchange rate depreciation decreases the relative price of Brazilian goods in foreign currency terms abroad and increases the price of foreign goods in the Brazilian market. Therefore, this single price change can have several different impacts on the local labor market. First, the lower relative price of Brazilian exports offers increased foreign market access (Verhoogen 2008). Second, the higher relative price of imported goods decreases foreign competition for Brazilian firms, but also increases the costs associated with imported intermediate inputs.

If the increased access to foreign export markets allows firms to expand output and employment as was found to be true in the Mexican context in Verhoogen (2008), we should predict that the exchange rate depreciation will decrease informality in Brazil. This is consistent with the result in Paz (2014) for Brazil—decreased export market tariffs decrease the likelihood of a worker's informal status—and in McCaig and Pavcnik (2018) for Vietnam—reductions in U.S. tariffs increase transitions to the formal business sector from the household business sector.

At the same time, local firms now face weakened import competition due to the real exchange rate depreciation since foreign goods are now more costly in Brazilian *real* terms. If the protection from foreign competition allows import-competing firms to expand output and employment, we should again predict that the exchange rate depreciation will decrease informality in Brazil. Again, Paz (2014) and Menezes-Filho and Muendler (2011) find such an effect for the case of the Brazilian trade liberalization in the 1990s—in that period, Brazilian import tariff cuts increased informality.

Finally, the same real exchange rate depreciation that restricts import competition also makes imported intermediate inputs more expensive. Firms that rely on imported inputs for their final output will see production costs increase, potentially reducing output and employment demand (Goldberg, et al. 2010; Handley, et al. 2020). In fact, recent research on

the Indian trade liberalization episode demonstrates that freer trade dramatically increases firms' access to cheaper, newer, and higher quality inputs (Goldberg, et al. 2010). Moreover, the authors find that these new, higher quality intermediate inputs allow firms to expand production (and presumably employment) in the aftermath of the trade reform, despite the increases in import competition. For this reason, we predict that the exchange rate depreciation may increase informality in Brazil to the extent that firms now face higher costs, weaker quality, and fewer varieties of key intermediate inputs.

All together, the total impact of a real exchange rate devaluation will depend on which of these three effects dominates. On that, we can hypothesize the following. We know from a large literature in international trade (Bernard, Redding, and Schott 2011) that global firms are larger in terms of size and tend to be more productive on average. That said, there will be significant firm-level heterogeneity in the effects of such an exchange rate depreciation (Berman, et al. 2012). For example, exporting firms and firms that import intermediate inputs are likely to be at the top-end of the firm-size and firm-productivity distributions. Given international standards and reputations, they are also assumed to employ a smaller fraction of informal workers (Paz 2014). On the other hand, domestic firms facing import competition are more likely to be smaller and less productive, and thus to employ higher shares of informal labor.

It follows then that we might expect the weakened foreign import competition effect to dominate—that is, an exchange rate depreciation decreases informal employment in the Brazilian context. However, this is strongly an empirical question, and thus, we let the data speak in the next section. We will also estimate the effects of the real exchange rate shock separately relying on the export-weighted real exchange rate and the import-weighted real exchange rate, with the idea that we can attempt to differentiate the first effect from the latter two effects.

Effect of labor enforcement. The theoretical impact of labor market regulatory enforcement on informality, however, is not so straightforward (see Almeida and Carneiro (2012)). Plants weigh the costs and benefits of complying with strict labor regulation. They

decide whether to hire formally, informally, or formally but without fully complying with specific features of the labor code (e.g., avoiding the provision of specific mandated benefits, such as health and safety conditions, or avoiding payments to the FGTS). The expected cost of evading the law is a function of the monetary value of the penalties (fines and loss of reputation) and of the probability of being caught. The probability of being caught depends on the plant's characteristics (such as size, globalization status, and legal status) and on the degree of enforcement of regulation in the city where the plant is located.

The direction of the effect of enforcement on informality is theoretically ambiguous. On the one hand, one of the main purposes of labor market inspections is to ensure formal work registrations. By design then, an increase in enforcement should reduce informality and increase formal work registrations, if the labor inspectors are doing their jobs. In addition, the labor inspections ensure that employers comply with the mandated benefits and thus increase job quality. This should increase the supply of formal workers and decrease the supply of informal laborers. For these reasons, it is a plausible prediction that firms in areas of the country with heavier enforcement of labor laws will experience a decrease in informal employment, as formal employment becomes more attractive and formal work registrations increase.

On the other hand, stricter enforcement of the labor law raises the cost of formal workers for employers that now how to cover mandated benefits, such as maternity leave, vacation pay, and maximum working hours. As such, plants facing stricter enforcement of the labor code will have increased difficulties in adjusting labor, decreasing formal employment and increasing informal employment.

Effect of the trade shock by the stringency of labor enforcement. The extent to which a given currency shock actually changes the informal employment share will depend on the degree to which employers face labor market regulatory enforcement. Theory offers an ambiguous prediction, and thus, this is inherently an empirical question.

To summarize, a real exchange rate depreciation is predicted to decrease informality, as employment expands and workers move into the formal economy. Firms located in strongly-enforced municipalities could increase formal employment and decrease informal employment *by more* than plants located in weakly-enforced municipalities, if the first enforcement impact on informality dominates; that is, that job quality increases and workers are induced to register formally. However, the data may also show that plants located in strongly-enforced municipalities will increase formal employment and decrease informal employment *by less* than plants located in weakly-enforced municipalities, in response to the same currency depreciation, if the second enforcement impact on informality dominates; that is, that the cost to firms of employing formal workers increases and so they hire fewer formal workers to circumvent mandated benefits.

Given the evidence in Almeida and Poole (2017), as well as Almeida, Corseuil, and Poole (2019), we hypothesize that the latter effect dominates. Strict labor regulations function as "sand in the wheels" of economic growth. As such, strict labor policy may reinforce trends toward widening wage dispersion, job polarization, and contribute to rising informality, in part, as low-wage, low-skilled job opportunities in low-productivity formal establishments diminish.

4.2. Technology, enforcement, and informality

Our discussion in this section largely follows the work in Almeida, Corseuil, and Poole (2019) for the formal economy.

Effect of technology shock. We hypothesize that communication technology impacts informal labor markets through two channels. The first channel facilitates local firms' access to new and distant markets that were not previously within reach. At the same time, technology fosters competition in the local market by also increasing the access of outsiders. This is similar to the reciprocal trade liberalization studied in Paz (2014). Therefore, technology can both create jobs in the expanding firms and destroy jobs at contracting firms.

It is unclear which effect would dominate. However, we can hypothesize the following. First, if the firms that expand in response to a technology shock, are also the larger, more productive, technologically-intensive firms, which are also the firms that tend to employ a lower share of informal workers, we may not expect a large change in the informal share of the economy—if anything, a small decrease in informality. At the other end of the distribution are the small, less productive firms that rely less on information technology, and tend to employ larger shares of informal workers. In this case, a technology shock has the potential to push these firms to employ even more workers informally. However, since these firms are also likely to have lower levels of technology adoption, this effect may be attenuated.

The impact of technology on formal labor markets for skilled and unskilled workers is studied in Almeida, Corseuil, and Poole (2019). To the extent that we can offer a parallel discussion between skilled workers as more likely to be formal, and unskilled workers as more likely to be informal (as our descriptive statistics confirm), we can draw some implications for our theory from that work. That is, Almeida, Corseuil, and Poole (2019) demonstrate that access to new digital technologies in Brazil, via the expansion of internet services, differentially increased the skilled labor force in technologically-intensive industries. Hence, technology reduces informality among the higher skilled workers, but may increase informality among lower-skilled workers. We aim to assess the impact of technology on informality across workers of differing skills.

Effect of the technology shock by the stringency of labor enforcement. Almeida, Corseuil, and Poole (2019) also report that the impact of digital technology on the skill-upgrading of the workforce is reinforced in strict-enforcement areas. This finding reinforces earlier work by Montenegro and Pages (2004). The authors rationalize this idea as follows. Labor regulations increase the cost of formal labor for Brazilian employers. Given that some of these regulations are proportional to the wages that a worker receives (dismissal costs, for example), stringent enforcement of labor market regulations at the subnational level restrict necessary labor adjustments relatively more for skilled workers than for unskilled workers in the formal sector.

4.3. Trade, technology, and informality

The resulting impacts of the combined trade and technology shocks will depend on the technological intensity of the industry. For tech-intensive industries, the tech shock reinforces the trade policy effects for skilled workers and attenuates the effects for unskilled workers. For non-tech industries, the technology shock reinforces trade policy effects. At the end of the day, both shocks seem to reduce informality incidence among skilled workers (or upper tier informal workers) while the effect for unskilled workers (or lower tier informal workers) is ambiguous a priori. For these reasons, we next turn to the economic data for evidence.

5. Empirical Strategy and Results

We closely follow the estimation strategies in Paz (2014), Almeida and Poole (2017), and Almeida, Corseuil, and Poole (2019) in this section.

The basic framework estimates the effects of an exogenous real exchange rate devaluation and increased digital technology adoption on the share of informal workers in a city-industry pair. It relies on substantial variation across three different dimensions: municipalities, industries, and time. Furthermore, we exploit the fact that Brazilian employers are exposed to varying degrees of *de facto* labor regulations, as measured by the number of Ministry of Labor inspections per 100,000 inhabitants of the city, and analyze how the effects of trade and technology on informality depend on the enforcement of labor regulations.

5.1. Impact of trade

We begin by replicating and extending the approach in Paz (2014) to estimate the effect of trade openness on the share of informal workers in a city-industry. We consider changes in the Brazilian *real*'s real exchange rate across industries and over time as the main exogenous

shock to trade openness. Therefore, the effect of exposure to trade is identified using across-industry differences in real exchange rate changes over time. The main estimating equation is as follows:

$$INFORMAL_{jt} = \beta_1 RER_{jt} + \varphi_j + \delta_t + \varepsilon_{jt} \quad (1)$$

where j indexes the 47 manufacturing *CNAE-Domicilar* industries and t indexes time. We relate the share of informal workers ($INFORMAL_{jt}$) to the time-varying, industry-specific trade-weighted real exchange rate (RER_{jt}), which serves as an exogenous shock to trade openness. We also include industry fixed effects (φ_j) to capture time-invariant factors, such as the industry's unobserved, underlying productivity or technology, which may influence the industry's size and informality, and year dummies (δ_t) to control for the average effect on informal employment of Brazil's many policy reforms over this time period.

β_1, our main coefficient of interest, reports the effect of the exchange rate shock on informal labor markets. As we remark in Section 4.1, a single relative price change has several possible effects on informality, and thus, the sign on β_1 is theoretically ambiguous. However, following the literature (e.g., Revenga (1992) and Verhoogen (2008)), we hypothesize that $\beta_1 < 0$, as an exchange rate depreciation (increase in RER_{jt}) decreases informality—that is, the impact of reduced import competition and increased export market access outweighs the impact of higher-priced and lower-quality imported intermediate inputs.

Table 5.1 estimates equation (1), where the dependent variable is the city-industry share of informal workers, by ordinary least squares with standard errors clustered at the industry level. Counter to the initial hypothesis, the point estimate in column (1) suggests that a depreciation of the trade-weighted real exchange rate (an increase in RER_{jt} by our measure) increases the informal share, though this result is statistically insignificant. In columns (2) and (3), we include the import-weighted real exchange rate and the export-weighted real exchange rate, respectively, in order to attempt to decompose the various mechanisms through which a single relative price change may affect informal employment. In column (4),

we include both trade-weighted real exchange rates, considering that the correlations in Section 3.2 suggest that there is independent variation in the two variables. Interestingly, the point estimates are also both positive, yet statistically insignificant.

We note that the magnitude of the point estimate is smaller for the import-weighted real exchange rate than for the export-weighted real exchange rate, counter to our initial discussion of theory. One possibility is that those firms poised to export are the exact same firms that are globally engaged in terms of importing intermediate inputs, and hence, this explains the larger, positive impact on informality of the export-weighted real exchange rate depreciation. In fact, work by Bernard, Redding, and Schott (2011) notes exactly this for the case of the United States—that is, the largest exporters are also importers. Similarly, Handley, Kamal, and Monarch (2020) demonstrate that the U.S. import tariff hikes of 2018-2019 actually decreased U.S. exports due to the supply-chain linkages. In our setting, it is suggestive that the real exchange rate depreciation, which increases the costs of imported intermediate inputs, harm export-oriented industries, thus raising the level of informal employment.

5.2. Impact of enforcement

Equation (1), however, considers only the industry-time shock of the real exchange rate devaluation. Brazil's large informal sector suggests significant evasion of Ministry of Labor regulations and we know from a long literature that labor market regulations and regulatory enforcement influence the degree of informality. We, therefore, alter equation (1) as follows:

$$INFORMAL_{jmt} = \beta_1 RER_{jt} + \beta_2 ENF_{mt} + \varphi_m + \varphi_j + \delta_t + \varepsilon_{jmt} \quad (2)$$

where all the notation is as in equation (1) and m now indexes the city (*munícipio*). ENF_{mt} represents time-varying, municipality-level enforcement of labor regulations, as captured by Ministry of Labor inspections. Recall, our measure of regulatory (manufacturing) enforcement is the logarithm of one plus the number of (manufacturing) inspections at the

municipality level per 100,000 people living in the municipality. As we note in Section 4.1, the effect of enforcement on informality is theoretically ambiguous (Almeida and Carneiro 2012). For example, by design, an increase in enforcement should help authorities to decrease informality ($\beta_2 < 0$), though because enforcement increases the cost of formal workers for firms, it may also push more workers into informality ($\beta_2 > 0$).

Given the potential cross-sectional endogeneity in enforcement—that is, that more developed areas of the country have more resources for enforcement, or areas that are likely violators of the labor law will see higher levels of enforcement—we also incorporate municipality fixed effects (φ_m) into equation (2) to account for such time-invariant, city-specific differences. With the city fixed effects, the main coefficient of interest is identified from city-specific changes in enforcement over time, which are far more exogenous than levels of enforcement. In fact, as we show in Section 3.3, changes in enforcement are associated to few city-specific measures of development—lagged changes in the economically-active population and lagged changes in the share of households with access to electricity.

Table 5.2 reports results from the estimation of equation (2) by ordinary least squares where the main enforcement variable is calculated based on city-specific inspections in manufacturing. Indeed, while the trade-related variables are qualitatively similar to the estimates in Table 5.1, we note that increased enforcement of labor market regulations is strongly and negatively associated with informality. Cities experiencing increases in enforcement report declines in the share of informal workers.

5.3. Impact of trade with heterogeneous labor enforcement

The implications of a real exchange rate depreciation for informal employment depend on the degree to which employers are exposed to labor market regulatory enforcement. We hypothesize that two identical industries will respond differently to changes in the real exchange rate depending on the *de facto* regulations they face. For this reason, we adapt equation (2) as follows:

$$INFORMAL_{jmt} = \gamma_1 RER_{jt} * ENF_{mt} + \beta_1 RER_{jt} + \beta_2 ENF_{mt} + \varphi_m + \varphi_j + \delta_t + \varepsilon_{jmt} \quad (3)$$

where all of the notation is as previously stated in equation (2). γ_1, our main coefficient of interest, captures the differential impact of the exchange rate shock on industries in strictly-enforced municipalities relative to weakly-enforced municipalities. In response to an exchange rate depreciation, employers may employ more informal workers as the cost of imported intermediate inputs rises ($\beta_1 > 0$). However, industries facing heavy inspections may be differentially restricted from adjusting labor ($\gamma_1 > 0$)—as the cost of a formal worker increases, increasing informality by more than weakly-enforced industries—or may experience smaller increases in informality ($\gamma_1 < 0$), as formal work registrations increase with improvements in job quality.

Table 5.3 reports coefficients from the estimation of equation (3) with the exogenous, industry-specific real exchange rate shock interacted with the city-specific enforcement changes. The evidence suggests that the positive (though insignificant) impacts of trade openness on informality in Tables 5.1 and 5.2 were fully driven by the impact in strictly-enforced municipalities. In fact, focusing on column (2), we note that a depreciation of the import-weighted real exchange rate decreases informality in weakly-enforced areas of the country (albeit insignificantly). This is consistent with our earlier theoretical discussions—that is, when import-competing firms face weakened import competition they can expand formal employment. However, in areas of the country with strict regulatory enforcement, that same real depreciation differentially increases informality. In other words, though firms may wish to expand into formal employment in response to the decreased import penetration, they also face higher costs of formal workers and as such, undergo a smaller shift toward formality. These effects are robust when we also consider the export-weighted real exchange rate shock simultaneously in the final column. This evidence points to the potential for unintended consequences of strict labor policies, restricting the possibilities for employers to respond to economic shocks. As such, flexible labor market policies may in fact

protect workers and help the transition to the formal economy in the aftermath of employment shocks.

However, as we mention earlier, even changes in enforcement are subject to concerns about endogeneity. For this reason, in Table 5.4, we enhance equation (3) to include interactive city-by-year fixed effects. With these controls, we can no longer identify the level effect of enforcement. Importantly, the main coefficient on the interaction term of the import-weighted real exchange rate change and enforcement is still positive and significant. Moreover, this holds even when including the export-weighted real exchange rate shock simultaneously.

To push this idea even further, to mitigate concerns that even the trade shock is not entirely exogenous, in Table 5.5 we also include interactive industry-by-year fixed effects, to account for all industry-specific changes over time. Since this includes the real exchange rate shocks, we cannot separately identify the coefficient on the trade variables. The interaction terms are identified from the across-municipality variation in enforcement changes and the across-industry variation in the real exchange rate shocks. The main coefficients of interest remain similar in magnitude, positive, and statistically significant. A depreciation in the import-weighted real exchange rate has the capacity to decrease employment in the informal economy, as low-productivity, import-competing firms face less foreign competition and expand output. In strictly-enforced municipalities, however, firms are restricting from adjusting their labor forces as the cost of formal employment increases. As such, an equal exchange rate shock differentially increases informal employment in industries located in these areas.

Heterogeneity in enforcement type. In the analysis until now, we have assumed that only inspections aimed at manufacturing firms will influence labor markets for manufacturing industries. In Table 5.6, we utilize all of the inspections data, in order to assess the degree to which inspections at non-manufacturing establishments in the city may also influence labor adjustment at manufacturing employers. Though the across-city correlation in enforcement in manufacturing industries and non-manufacturing industries is positive

and quite large, it is not obvious how inspections at non-manufacturing plants will affect manufacturing firms. On the one hand, it could be that any labor inspector in the region will influence behavior—that is, it is merely the threat of heightened enforcement that matters, not the actual degree of enforcement. On the other hand, labor inspectors have limited time to inspect all establishments within a city. As such, inspections at non-manufacturing plants may actually leave manufacturing industries with relatively more flexibility (weakened enforcement).

Interestingly, the evidence in Table 5.6 is suggestive of the latter possibility. That is, the direct inspections of manufacturing establishments in the city differentially increase informality, as we show in Table 5.5 (see column (2)). Note that the magnitude of the coefficient is now larger in size. But, enforcement of the non-manufacturing plants in the same city report a differential negative influence on manufacturing sector informality in the city. To be specific, a depreciation in the import-weighted real exchange rate allows import-competing firms to expand and reduce the share of informal workers. Yet, given labor inspectors' limited time and capacity to inspect all firms in a city, manufacturing firms in cities with strictly-enforced non-manufacturing industries are able to be even more flexible in their adjustment. This highlights the possibility that it is the inspections that matter and not merely the threat of inspections.

6. Conclusions and Future Work

Populist, protectionist policies are gaining influence in global politics, in large part because of the belief that globalization harms local labor market conditions. Meanwhile, the digital revolution has spread fear about robots and artificial intelligence replacing high-quality jobs and workers. Policymakers often position and propose labor market policies, such as firing restrictions and severance payments, to protect workers, vulnerable to such negative employment shocks. In this paper, we investigate the idea that policies designed to connect developing country firms with developed country markets—via access to export markets and supply of digital technologies—can promote higher-quality employment in less-

developed countries, as workers shift from informal to formal employment. Moreover, flexible labor market policies may in fact protect workers and help the transition to the formal economy in the aftermath of employment shocks.

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Figure 3.1: Simple Average Import Tariff, 2000–2010

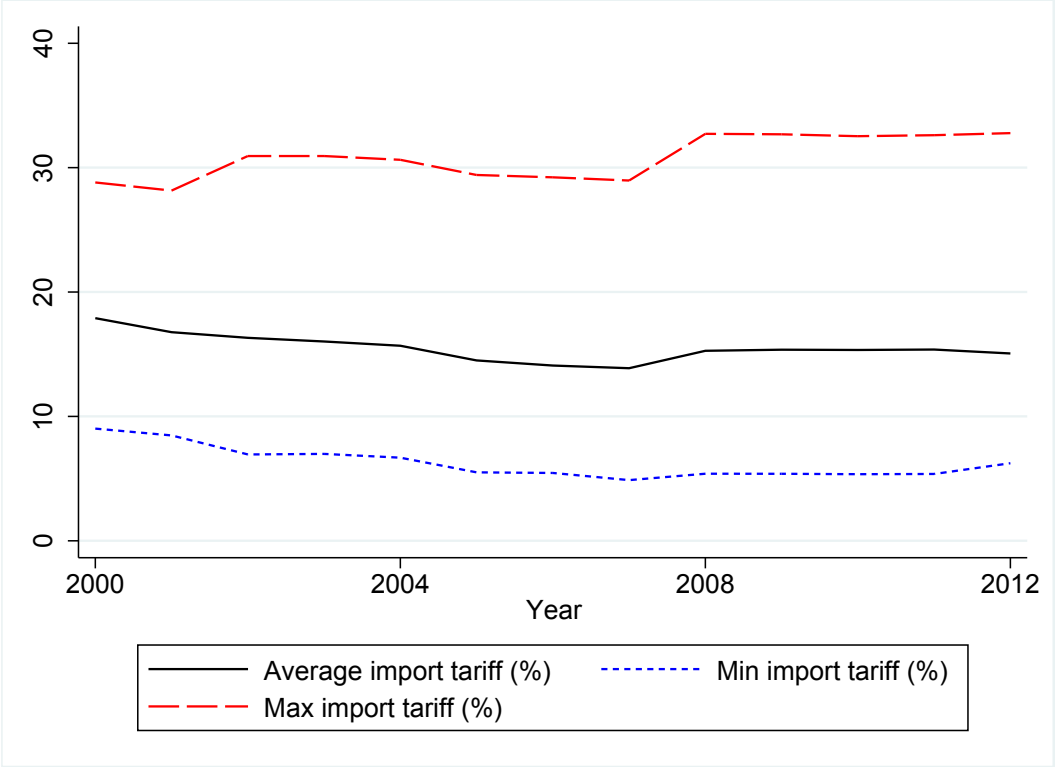

Figure 3.2: Change in Industry-Specific Export Shares, 2000-2010

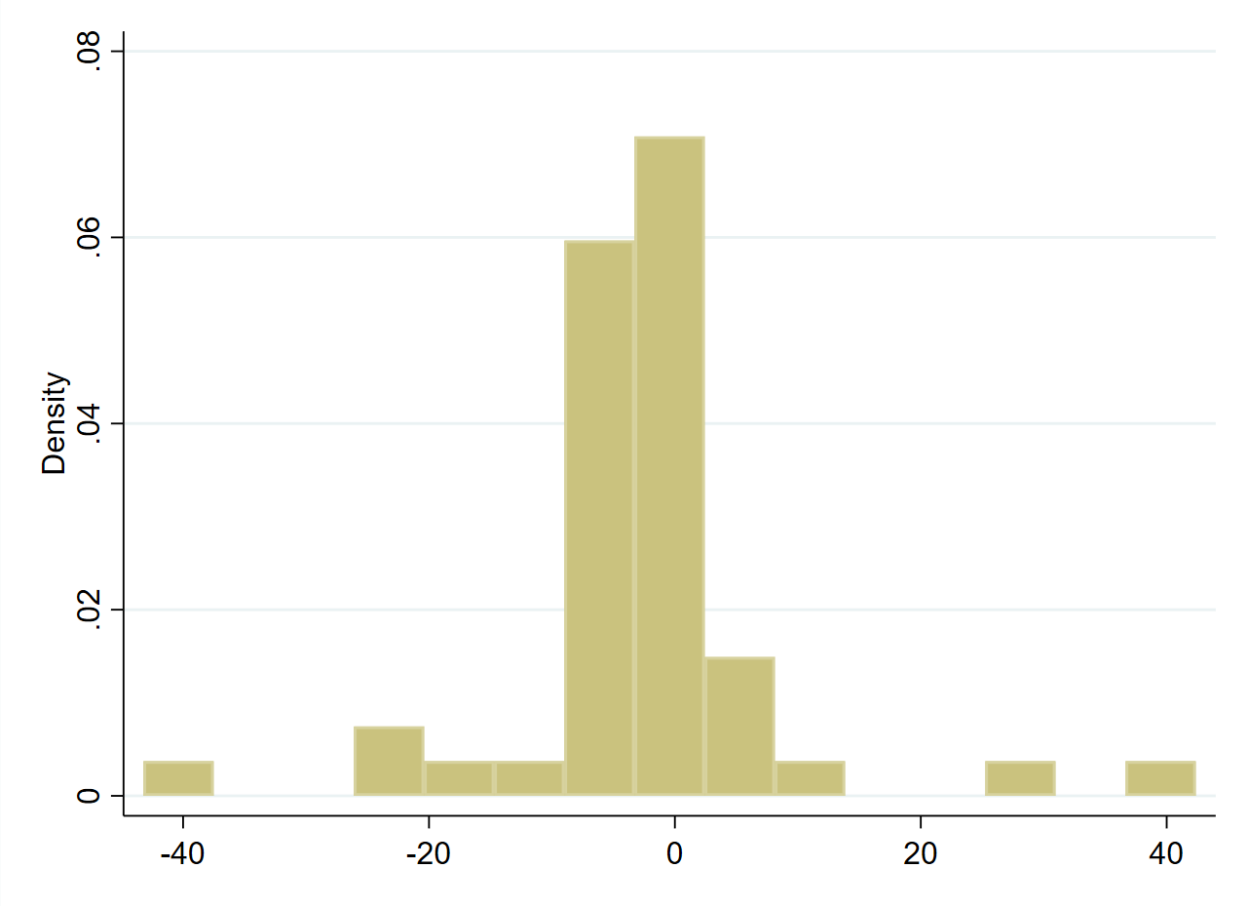

Figure 3.3: Change in Industry-Specific Import Penetration, 2000-2010

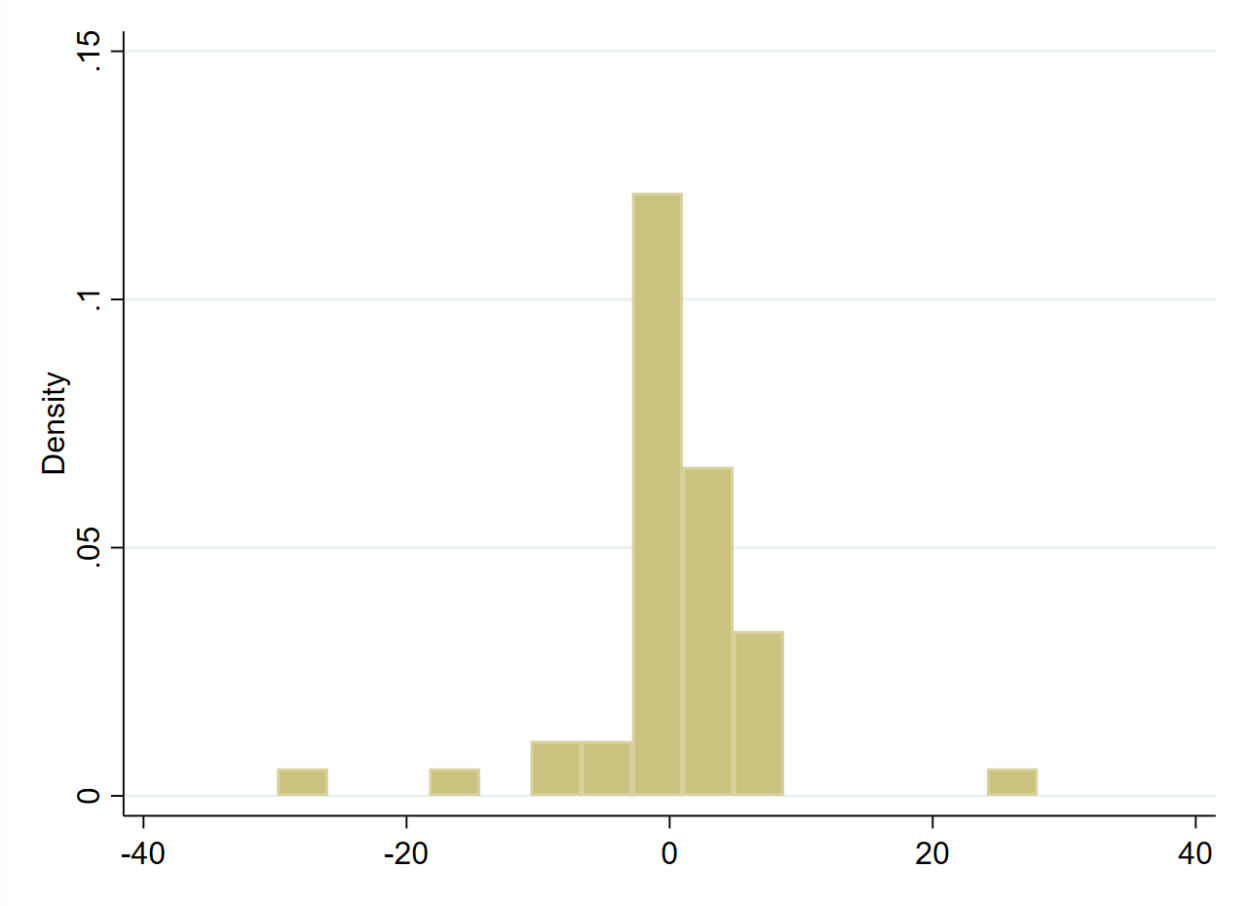

Figure 3.4:

Change in Industry-Specific Trade-Weighted Real Exchange Rate, 2000-2010

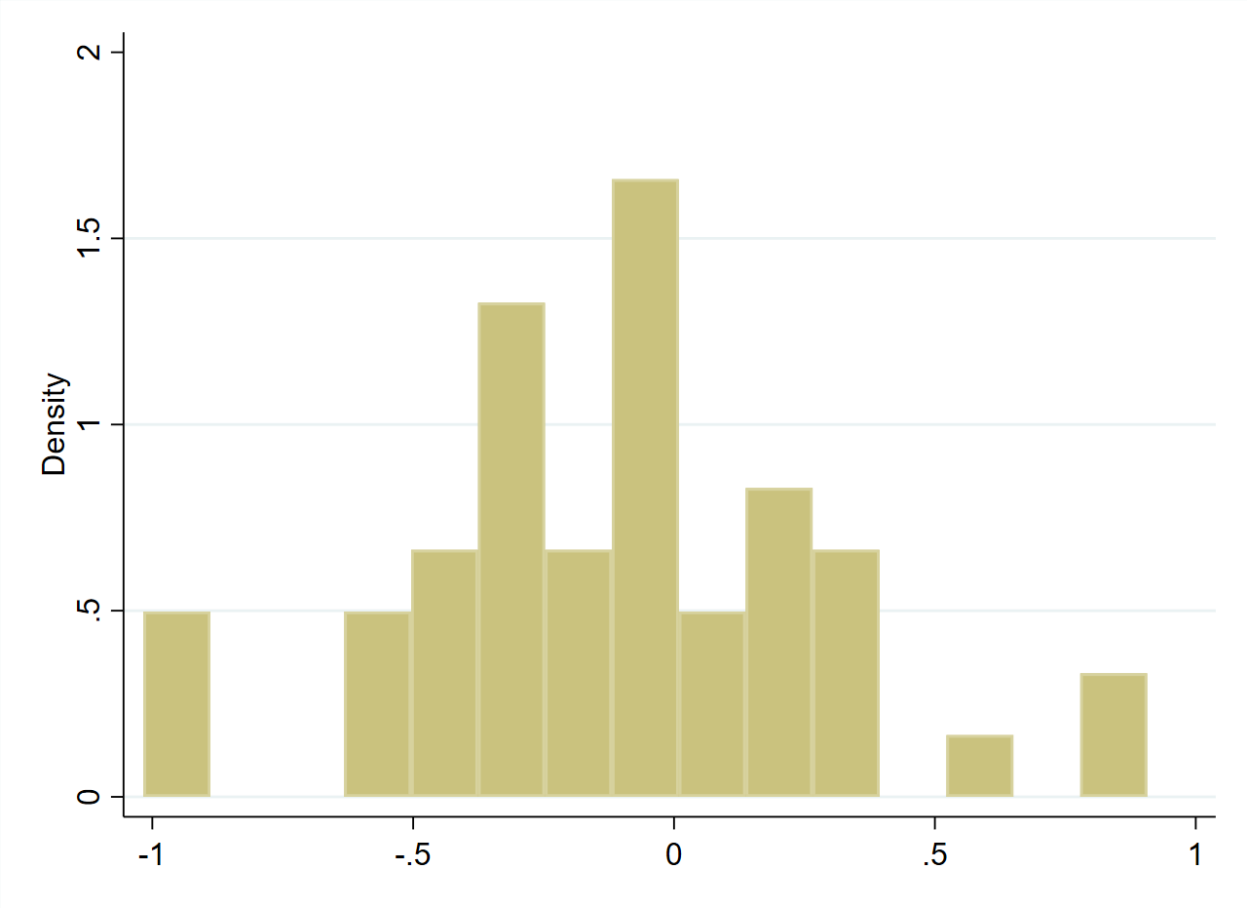

Figure 3.5:

Change in Industry-Specific Import-Weighted Real Exchange Rate, 2000-2010

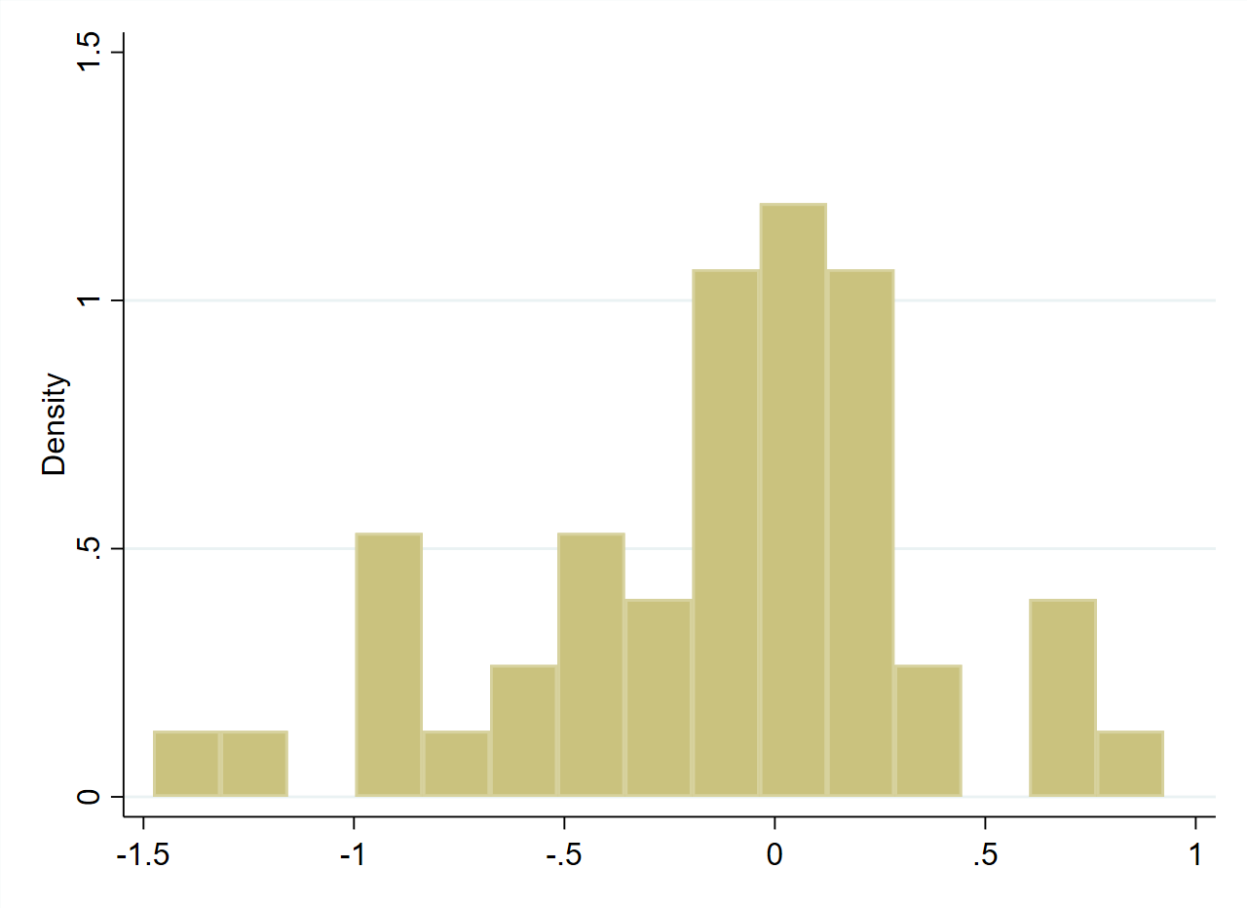

Figure 3.6:

Change in Industry-Specific Export-Weighted Real Exchange Rate, 2000-2010

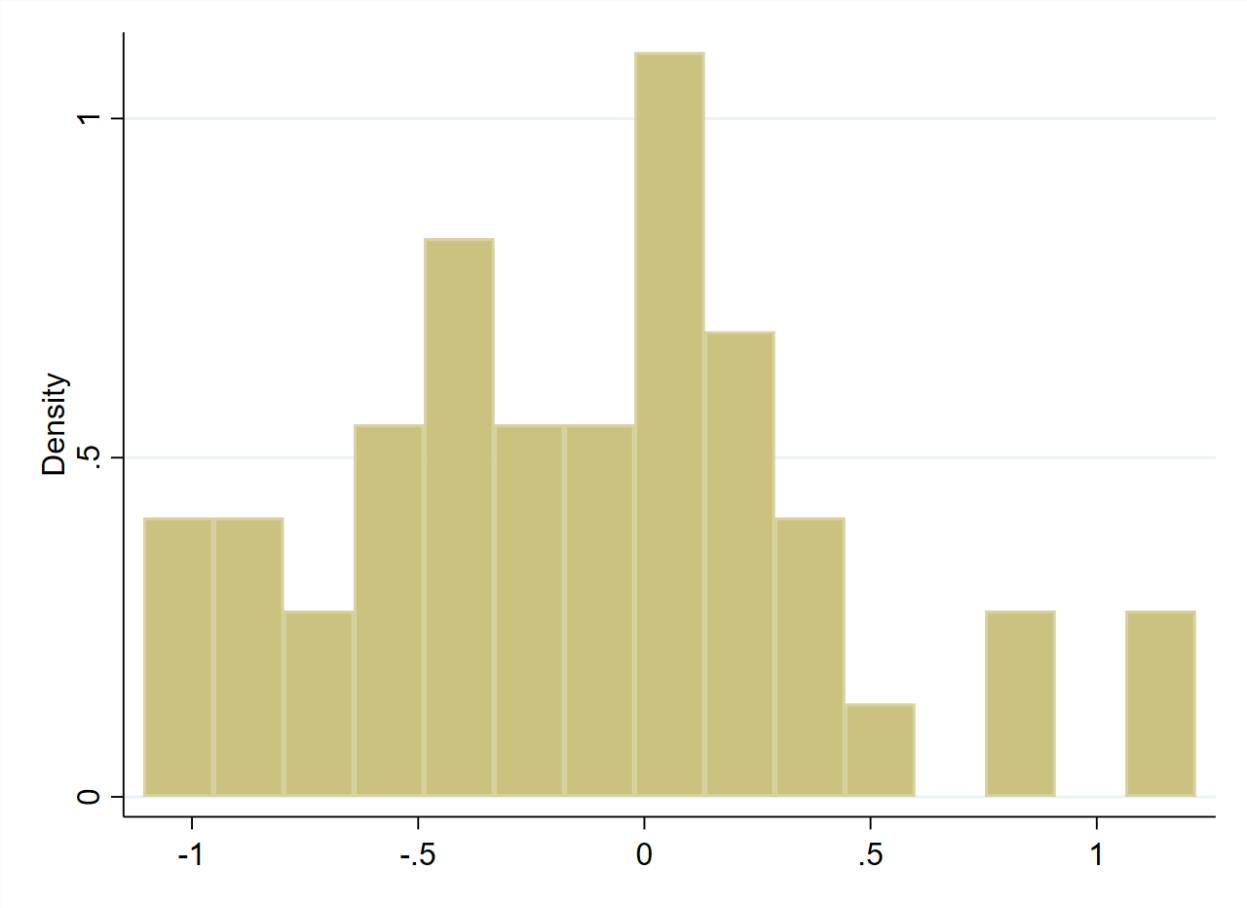

Figure 3.7: Municipality-level Labor Enforcement, 2000

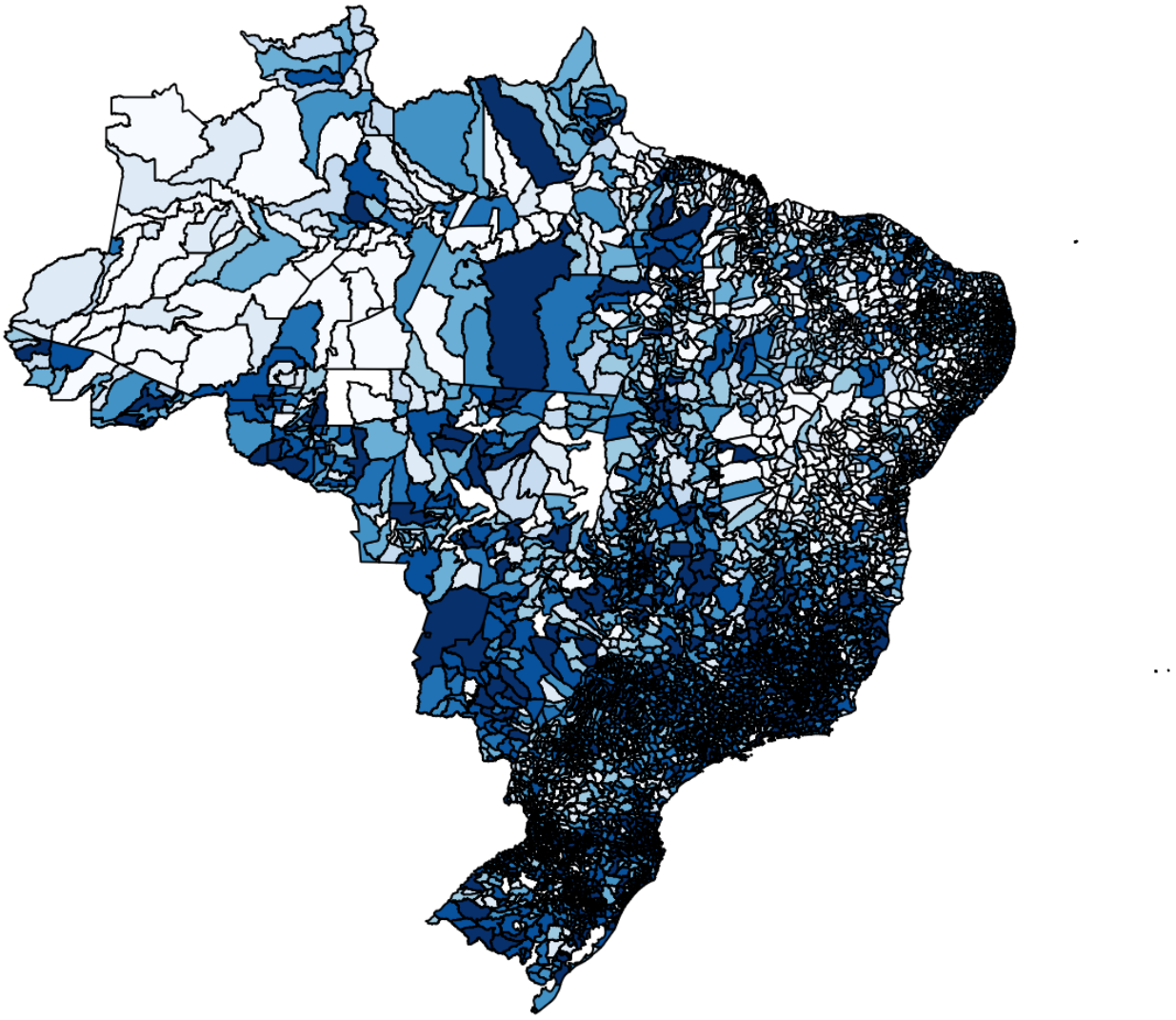

Figure 3.8: Municipality-level Labor Enforcement, 2010

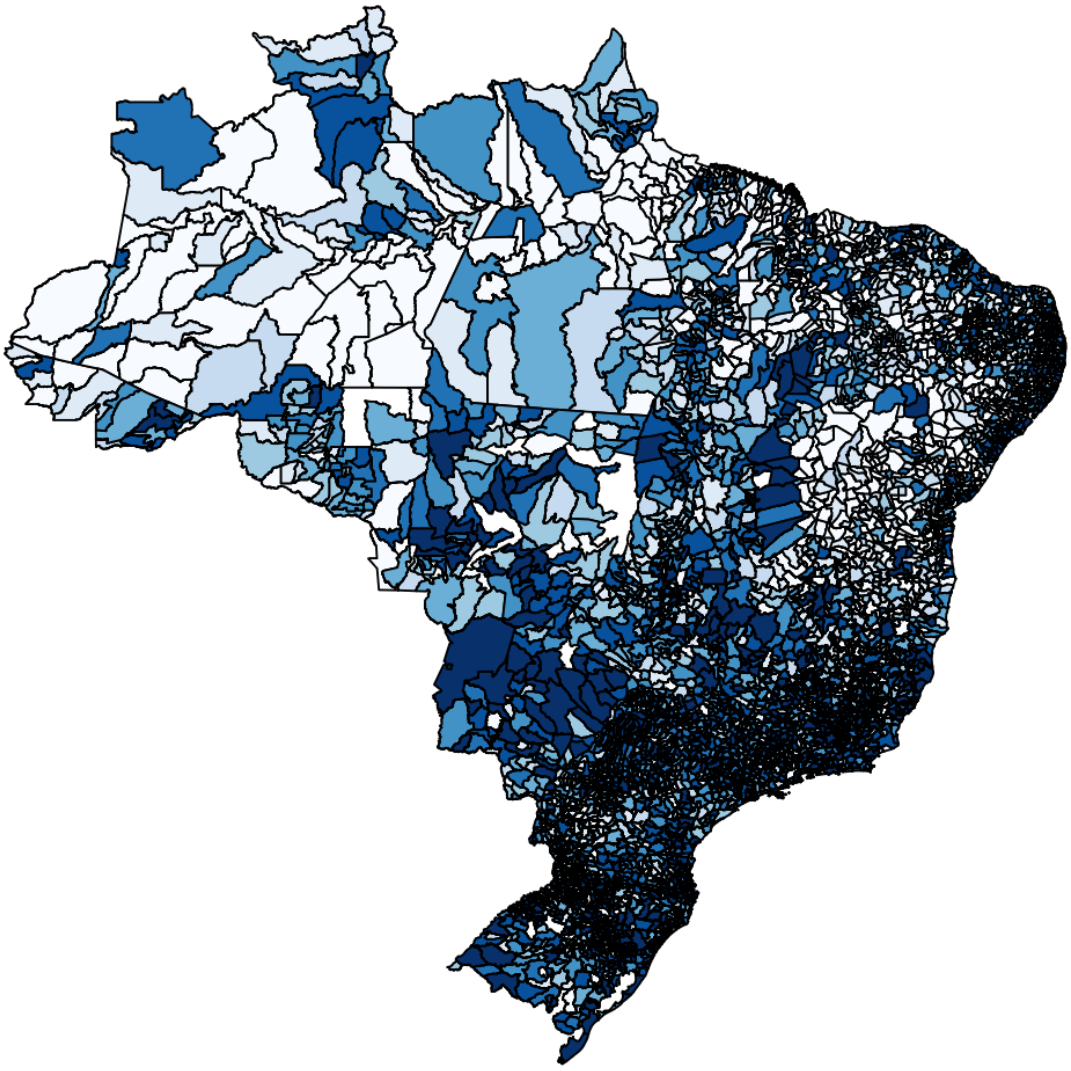

Figure 3.9: Municipality-level Changes in Labor Enforcement, 2000-2010

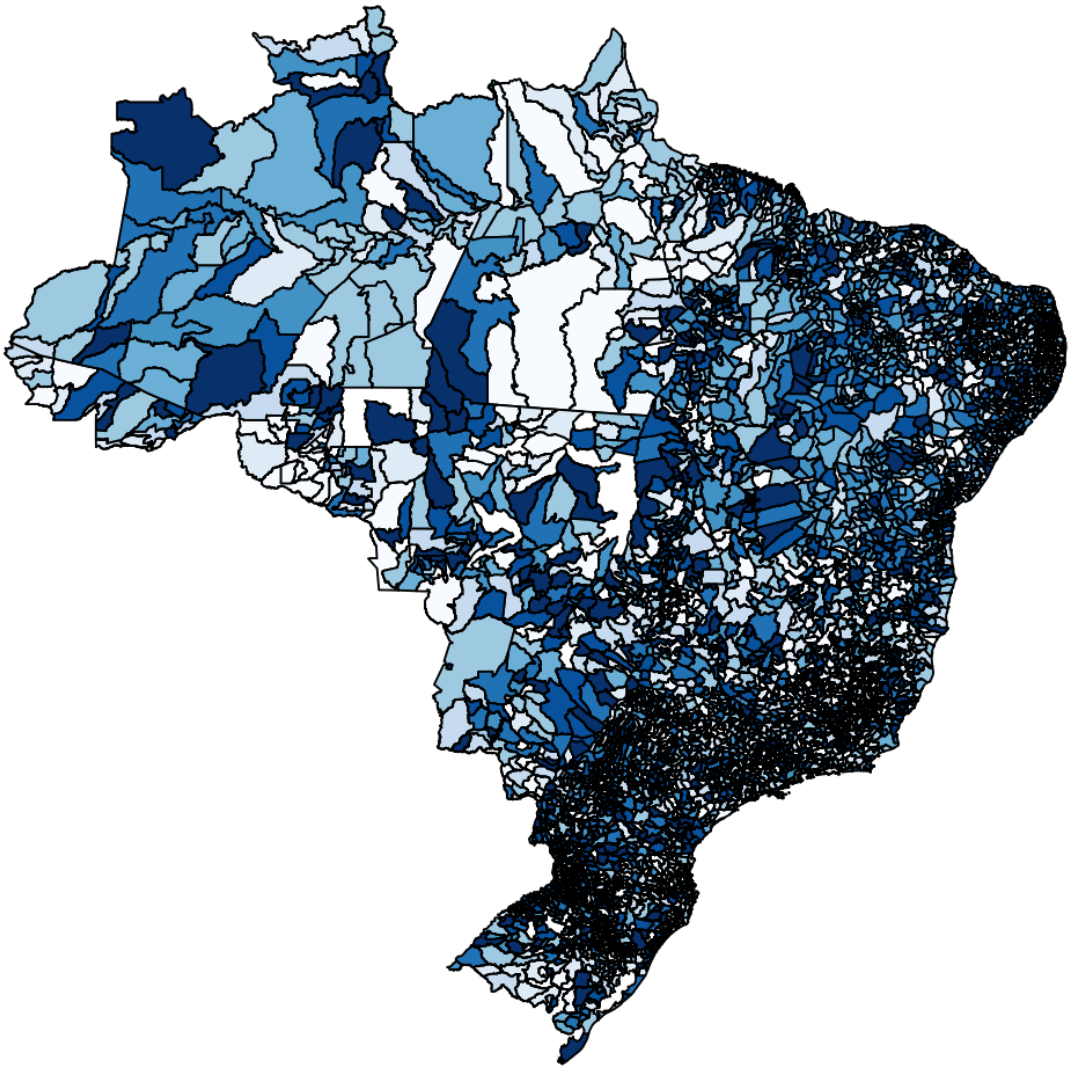

Figure 3.10:

Municipality-level Changes in Labor Enforcement, São Paulo state, 2000-2010.

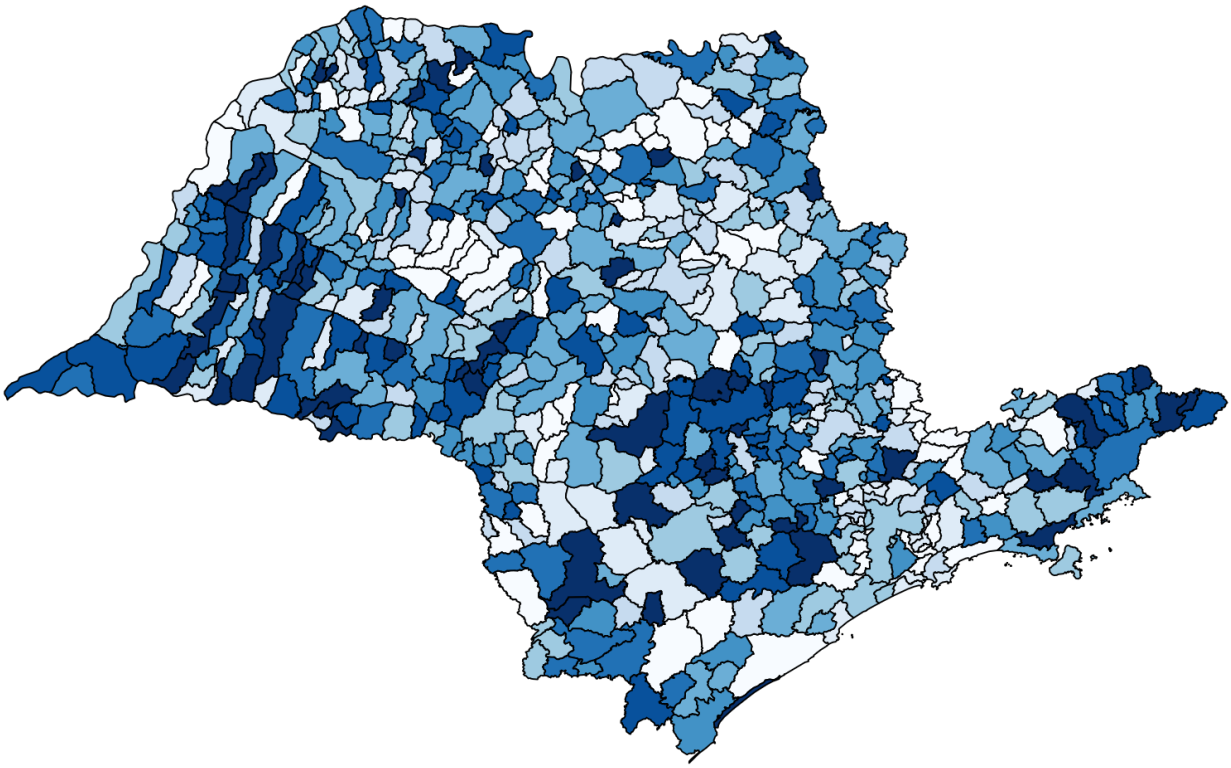

Table 3.1: Descriptive Statistics, 2000-2010

2000	Observations	Mean	SD	Min	Median	Max
Informal share	6,489,937	0.239	0.427	0.000	0.000	1.000
Age	6,489,937	31.554	10.540	15.000	30.000	65.000
Married	6,489,937	0.675	0.468	0.000	1.000	1.000
Urban	6,489,937	0.933	0.250	0.000	1.000	1.000
Female	6,489,937	0.277	0.447	0.000	0.000	1.000
Black	6,489,937	0.060	0.238	0.000	0.000	1.000
Asian	6,489,937	0.004	0.066	0.000	0.000	1.000
Literate	6,489,937	0.963	0.190	0.000	1.000	1.000
Middle school	6,489,937	0.297	0.457	0.000	0.000	1.000
High school	6,489,937	0.234	0.423	0.000	0.000	1.000
College	6,489,937	0.046	0.209	0.000	0.000	1.000

2010	Observations	Mean	SD	Min	Median	Max
Informal share	6,596,242	0.155	0.362	0.000	0.000	1.000
Age	6,596,242	33.347	11.026	15.000	31.000	65.000
Married	6,596,242	0.407	0.491	0.000	0.000	1.000
Urban	6,596,242	0.934	0.248	0.000	1.000	1.000
Female	6,596,242	0.281	0.449	0.000	0.000	1.000
Black	6,596,242	0.078	0.269	0.000	0.000	1.000
Asian	6,596,242	0.009	0.093	0.000	0.000	1.000
Literate	6,596,242	0.972	0.164	0.000	1.000	1.000
Middle school	6,596,242	0.228	0.419	0.000	0.000	1.000
High school	6,596,242	0.378	0.485	0.000	0.000	1.000
College	6,596,242	0.066	0.248	0.000	0.000	1.000

Sources: Brazilian Decennial Census.
Note: Household survey weights are used.

Table 3.2: Municipality-Industry Descriptive Statistics, 2000-2010

2000	Obs	Mean	SD	Min	Median	Max
Informal	57224	41.355	41.261	0.000	27.997	100.000
Non-college informal	56752	41.657	41.310	0.000	28.721	100.000
College informal	6675	13.859	31.034	0.000	0.000	100.000
manuf_inspections	57224	52.279	292.768	0.000	4.000	7803.000
nonmanuf_inspections	57224	249.802	1483.625	0.000	12.000	27307.000
all_inspections	57224	302.081	1748.966	0.000	19.000	32074.000
manuf_enforcement	57224	3.335	1.081	0.024	3.383	7.723
nonmanuf_enforcement	57224	4.126	1.266	0.268	4.218	7.208
all_enforcement	57224	4.427	1.307	0.268	4.636	7.736
Population in 100,000	57224	0.847	3.85	0.0795	2.042	104
Trer	57224	1.237	0.310	0.461	1.257	2.449
Mrer	57224	1.116	0.516	0.245	1.142	2.912
Xrer	57224	1.358	0.532	0.230	1.258	2.607

2010	Obs	Mean	SD	Min	Median	Max
Informal	65287	30.494	39.497	0.000	5.299	100.000
Non-college informal	64149	30.920	39.670	0.000	5.851	100.000
College informal	11620	8.968	26.272	0.000	0.000	100.000
manuf_inspections	65287	25.216	118.897	0.000	2.000	3030.000
nonmanuf_inspections	65287	130.742	738.433	0.000	6.000	13760.000
all_inspections	65287	155.959	844.052	0.000	9.000	16790.000
manuf_enforcement	65287	2.927	1.004	-0.238	2.950	6.432
nonmanuf_enforcement	65287	3.752	1.150	0.074	3.785	7.082
all_enforcement	65287	4.017	1.175	0.074	4.097	7.122
Population in 100,000	65287	0.846	3.93	0.0805	0.196	113
Trer	65287	1.134	0.267	0.470	1.154	1.817
Mrer	65287	1.095	0.444	0.252	1.124	2.048
Xrer	65287	1.173	0.439	0.290	1.108	2.172

Source: Brazilian Decennial Census 2000-2010.

Table 3.3: Correlates of Changes in Labor Enforcement, 2000-2010

	(1)	(2)	(3)
Dep. Variable: ΔEnforcement$_{m,2010-2000}$	Size	Access	Development
ΔLog(GDP)$_{m,\ 2000-1996}$	-3.527	-3.680	-4.985
	(3.025)	(3.023)	(3.162)
ΔLog(Econ. active population)$_{m,\ 2000-1991}$	0.078**	0.060*	0.062*
	(0.032)	(0.032)	(0.032)
ΔUrbanization rate$_{m,\ 2000-1991}$		65.779	51.827
		(44.996)	(44.017)
ΔIlliteracy rate$_{m,\ 2000-1991}$			-0.118
			(1.187)
ΔTheil index$_{m,\ 2000-1991}$			-27.509
			(38.296)
ΔHousehold with water rate$_{m,\ 2000-1991}$			-0.409
			(0.343)
ΔHousehold with electricity rate$_{m,\ 2000-1991}$			0.604*
			(0.326)
ΔHousehold with sanitation rate$_{m,\ 2000-1991}$			0.076
			(0.193)
ΔLife expectancy $_{m,\ 2000-1991}$			3.005
			(1.949)
ΔPoverty rate $_{m,\ 2000-1991}$			0.088
			(0.477)
ΔYears of schooling $_{m,\ 2000-1991}$			2.723
			(3.182)
Number of Observations	4,973	4,973	4,973

Note: This table reports coefficients from a city-level ordinary least squares regression in first-differences, where the dependent variable is the change in enforcement between 2000 and 2010. Enforcement is measured as the logarithm of the total number of inspections in the city (plus one) per 100,000 inhabitants of the municipality. In column (1), we relate changes in enforcement to lagged changes in city size characteristics (GDP and economically active population). Column (2) also includes lagged changes in city access characteristics (urbanization rate), while column (3) also includes lagged changes in city development characteristics (illiteracy rate, Theil index of inequality, share of households with access to water, electricity, and sanitation, average life expectancy, poverty rate, and average years of schooling). *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level. Robust standard errors are reported in parentheses.

Table 5.1: Trade and Informality

Dep. Variable: Informal Share$_{jmt}$	(1)	(2)	(3)	(4)
Trade-weighted RER$_{jt}$	1.685			
	(2.212)			
Import-weighted RER$_{jt}$		0.182		0.201
		(1.397)		(1.408)
Export-weighted RER$_{jt}$			1.570	1.573
			(1.644)	(1.640)
Number of Obs.	122,511	122,511	122,511	122,511
Industry Fixed Effects	YES	YES	YES	YES
Year Dummies	YES	YES	YES	YES

Sources: Brazilian Decennial Census, Ministry of Labor administrative data on inspections, 2000-2010.

Note: This table reports coefficients from the ordinary least squares estimation of equation (1) in the paper, where the dependent variable is the city-industry share of informal workers. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level. Robust standard errors, clustered at the industry level, are reported in parentheses.

Table 5.2: Trade, Enforcement, and Informality

Dep. Variable: Informal Share$_{jmt}$	(1)	(2)	(3)	(4)
Enforcement$_{mt}$	-1.197***	-1.193***	-1.190***	-1.192***
	(0.218)	(0.216)	(0.218)	(0.217)
Trade-weighted RER$_{jt}$	1.271			
	(1.692)			
Import-weighted RER$_{jt}$		0.126		0.140
		(1.191)		(1.214)
Export-weighted RER$_{jt}$			1.197	1.199
			(1.507)	(1.497)
Number of Obs.	122,511	122,511	122,511	122,511
City Fixed Effects	YES	YES	YES	YES
Industry Fixed Effects	YES	YES	YES	YES
Year Dummies	YES	YES	YES	YES

Sources: Brazilian Decennial Census, Ministry of Labor administrative data on inspections, 2000-2010.

Note: This table reports coefficients from the ordinary least squares estimation of equation (2) in the paper, where the dependent variable is the city-industry share of informal workers. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level. Robust standard errors, clustered at the industry level, are reported in parentheses.

Table 5.3: Trade, Enforcement, and Informality

Dep. Variable: Informal Share$_{jmt}$	(1)	(2)	(3)	(4)
TRER$_{jt}$ * Enforcement$_{mt}$	0.377			
	(0.882)			
MRER$_{jt}$ * Enforcement$_{mt}$		1.158*		1.008*
		(0.607)		(0.546)
XRER$_{jt}$ * Enforcement$_{mt}$			-0.846	-0.588
			(0.699)	(0.636)
Enforcement$_{mt}$	-1.647	-2.464***	-0.105	-1.544
	(1.100)	(0.734)	(0.942)	(0.945)
Trade-weighted RER$_{jt}$	0.044			
	(3.551)			
Import-weighted RER$_{jt}$		-3.583		-3.099
		(2.453)		(2.356)
Export-weighted RER$_{jt}$			4.052	3.224
			(2.863)	(2.736)
Number of Obs.	122,511	122,511	122,511	122,511
City Fixed Effects	YES	YES	YES	YES
Industry Fixed Effects	YES	YES	YES	YES
Year Dummies	YES	YES	YES	YES

Sources: Brazilian Decennial Census, Ministry of Labor administrative data on inspections, 2000-2010.

Note: This table reports coefficients from the ordinary least squares estimation of equation (3) in the paper, where the dependent variable is the city-industry share of informal workers. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level. Robust standard errors, clustered at the industry level, are reported in parentheses.

Table 5.4: Trade, Enforcement, and Informality

Dep. Variable: Informal Share$_{jmt}$	(1)	(2)	(3)	(4)
TRER$_{jt}$ * Enforcement$_{mt}$	0.708			
	(0.899)			
MRER$_{jt}$ * Enforcement$_{mt}$		1.212*		1.115**
		(0.622)		(0.546)
XRER$_{jt}$ * Enforcement$_{mt}$			-0.689	-0.393
			(0.742)	(0.676)
Trade-weighted RER$_{jt}$	-0.606			
	(3.551)			
Import-weighted RER$_{jt}$		-3.521		-3.208
		(2.610)		(2.472)
Export-weighted RER$_{jt}$			3.698	2.748
			(2.927)	(2.776)
Number of Obs.	122,511	122,511	122,511	122,511
City-Year Fixed Effects	YES	YES	YES	YES
Industry Fixed Effects	YES	YES	YES	YES

Sources: Brazilian Decennial Census, Ministry of Labor administrative data on inspections, 2000-2010.

Note: This table reports coefficients from a variation on equation (3) in the paper, where the dependent variable is the city-industry share of informal workers. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level. Robust standard errors, clustered at the industry level, are reported in parentheses.

Table 5.5: Trade, Enforcement, and Informality

Dep. Variable: Informal Share$_{jmt}$	(1)	(2)	(3)	(4)
TRER$_{jt}$ * Enforcement$_{mt}$	0.142			
	(0.848)			
MRER$_{jt}$ * Enforcement$_{mt}$		1.102*		0.901*
		(0.569)		(0.495)
XRER$_{jt}$ * Enforcement$_{mt}$			-0.974	-0.733
			(0.687)	(0.623)
Number of Obs.	122,511	122,511	122,511	122,511
City-Year Fixed Effects	YES	YES	YES	YES
Industry-Year Fixed Effects	YES	YES	YES	YES

Sources: Brazilian Decennial Census, Ministry of Labor administrative data on inspections, 2000-2010.

Note: This table reports coefficients from a variation on equation (3) in the paper, where the dependent variable is the city-industry share of informal workers. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level. Robust standard errors, clustered at the industry level, are reported in parentheses.

Table 5.6: Trade, Enforcement, and Informality

Dep. Variable: Informal Share$_{jmt}$	(1)	(2)	(3)	(4)
TRER$_{jt}$ * Man. Enforcement$_{mt}$	0.025			
	(1.012)			
MRER$_{jt}$ * Man. Enforcement$_{mt}$		1.569***		1.243**
		(0.531)		(0.488)
XRER$_{jt}$ * Man. Enforcement$_{mt}$			-1.536**	-1.202**
			(0.585)	(0.566)
TRER$_{jt}$ * Non-man. Enforcement$_{mt}$	0.190			
	(0.698)			
MRER$_{jt}$ * Non-man. Enforcement$_{mt}$		-0.766**		-0.561
		(0.374)		(0.355)
XRER$_{jt}$ * Non-man. Enforcement$_{mt}$			0.911*	0.758
			(0.472)	(0.493)
Number of Obs.	122,511	122,511	122,511	122,511
City-Year Fixed Effects	YES	YES	YES	YES
Industry-Year Fixed Effects	YES	YES	YES	YES

Sources: Brazilian Decennial Census, Ministry of Labor administrative data on inspections, 2000-2010.

Note: This table reports coefficients from a variation on equation (3) in the paper, where the dependent variable is the city-industry share of informal workers. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level. Robust standard errors, clustered at the industry level, are reported in parentheses.