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Margins of labor market adjustment to trade☆

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ABSTRACT

We use both longitudinal administrative data and cross-sectional household survey data to study the margins of labor market adjustment following Brazil's early 1990s trade liberalization. We document how workers and regional labor markets adjust to trade-induced changes in local labor demand, examining various adjustment margins, including earnings and wage changes; interregional migration; shifts between tradable and nontradable employment; and shifts between formal employment, informal employment, and non-employment. Our results provide insight into the regional labor market effects of trade, and have important implications for policies that address informal employment and that assist trade-displaced workers.

1. Introduction

Since at least 1941, when Stolper and Samuelson (1941) published their seminal paper, economists have known that trade is likely to create winners and losers. A voluminous empirical literature then followed, investigating the differences in trade's effects on workers with different skills or employed in different industries. However, starting in the late 2000s, a number of authors documented substantial differences in the effects of trade and import competition on workers in geographic regions with different patterns of industrial specialization. Examples of this recent literature include Topalova (2007) and Kovak (2013), who investigated the regional effects of trade liberalization in India and Brazil respectively, and Autor et al. (2013), who documented the effects of increased Chinese imports on U.S. local labor markets.[1] A robust conclusion from this literature is that trade's costs and benefits are unevenly distributed geographically, not just across industries or skills.

Given the substantial effects of trade liberalization across local labor markets, it is important to understand how workers and regional labor markets adjusted to these changes in local labor demand. Documenting these adjustments is essential to understanding the processes behind trade-displaced workers' labor market outcomes. In this paper, we examine various potential adjustment margins including earnings and wage changes; interregional migration; shifts between tradable and

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[1] Other papers using a similar approach include Costa et al. (2016), Dix-Carneiro and Kovak (2017), Edmonds et al. (2010), Hakobyan and McLaren (2016), Hasan et al. (2006), Hasan et al. (2012), Kondo (2018), McCaig (2011), Topalova (2010), and many others.

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nontradable employment; and shifts between formal employment, informal employment, and non-employment.[2] We compare outcomes for workers and regional labor markets facing larger and smaller tariff reductions, finding a rich pattern of labor market adjustment over time.

We make extensive use of longitudinal administrative data (RAIS) covering the Brazilian formal labor market between 1986 and 2010. These data cover the universe of formally employed workers and allow us to follow them over time and across firms, sectors, and regions. However, the RAIS data do not cover workers outside formal employment. To study the effects of liberalization on non-employment or informal employment, which are quite common in the Brazilian context, we use repeated cross-section data from decennial Demographic Censuses from 1970 to 2010. These data are representative at fine geographic levels and provide information on employment status, including informality, but do not allow one to follow individual workers over time.

Our empirical strategy exploits the fact that regions with different industry mixes are differently affected by Brazil's early 1990s trade liberalization. We find that workers initially employed in regions facing larger tariff declines (i) spend less and less time formally employed relative to workers in regions facing smaller tariff declines; (ii) are more likely to transition into nontradable sector employment, particularly in low-paying service industries, but these transitions do not make up for employment losses in the tradable sector; (iii) face similar losses when initially employed in tradable or nontradable sectors; and (iv) do not respond to depressed local labor market conditions by migrating to more favorably affected regions. We also show that harder-hit locations experience relative increases in non-employment and in informal employment in the medium run (1991 to 2000). However, in the long run (1991 to 2010) non-employment does not respond, and informal employment strongly increases. These results suggest that the informal sector eventually absorbs a significant portion of formerly trade-displaced workers who spent years non-employed following liberalization.

This paper relates to three literatures investigating the labor market effects of trade. First, we contribute to a recent but fast growing literature on the regional effects of trade, including Topalova (2007), Autor et al. (2013), Kovak (2013), and Hakobyan and McLaren (2016). While these papers focus on the regional effects at a particular time horizon, here we observe how the local labor market effects of liberalization evolve over time, both for individual workers and for regional economies. Second, our paper relates to a recent literature on worker-level effects of trade using longitudinal administrative datasets such as Menezes-Filho and Muendler (2011), Autor et al. (2014), Dauth et al. (2014), Keller and Utar (2016), and Utar (2018). Our paper differs from much of this prior literature by studying i) regional rather than industry shocks, ii) a discrete shock, allowing us to measure dynamic responses to liberalization, and iii) transitions into the nontradable sector and informal employment, which are salient features of the Brazilian context.[3] Finally, our paper relates to the literature on trade and informality.[4] We find substantial effects of trade policy on informality, with regions facing larger tariff reductions exhibiting larger increases in the informal share of working age population, particularly in the long run. These large effects contrast with a number of other papers studying Brazilian liberalization, which find minimal evidence for effects on informality. For example, industry-level studies such as Goldberg and Pavcnik (2003) and Bosch et al. (2012) found no significant effects of tariff reductions on informality within the relevant industries. Our regional approach broadens the scope of these industry-level analyses by capturing transitions into formal status even when they accompany transitions across industries in the same region. Menezes-Filho and Muendler (2011) observe yearly employment transitions for individual workers initially employed in manufacturing. While we lack worker panel data covering the informal sector, our regional analysis suggests that transitions into the formal sector often involve long periods of non-employment, which in many cases would be unobservable at a yearly frequency. Thus, the differences in findings can largely be reconciled by differences in research design, unit of analysis, and time horizons.

Our findings are also closely related to those in our prior work, which used a regional research design to document steady declines in relative formal sector earnings and employment growth in regions facing larger tariff reductions (Dix-Carneiro and Kovak, 2017). In that paper, we present evidence that the surprising growth in these effects results from dynamics in labor demand driven by a combination of slow capital reallocation and agglomeration economies. The present paper makes two additional contributions to our understanding of the margins of labor market adjustment following Brazilian liberalization. First, we employ a *worker-level* research design to examine whether and to what extent individual workers in the formal sector adjust to liberalization-induced changes in labor demand by changing sectors or moving across regions. Second, we use Census data to examine effects on the labor market outside the formal sector, closely examining how liberalization affected informality and non-employment. These results complement those in the prior literature by providing a rich characterization of various margins of labor market adjustment to liberalization both for individual workers and regional labor markets.

These results have important implications regarding the regional labor market effects of trade. We show that labor market outcomes for formally employed workers initially located in regions more exposed to foreign competition steadily deteriorate over time relative to those in less exposed regions. These growing effects contrast with standard spatial equilibrium models (e.g. Blanchard and Katz (1992) and Bound and Holzer (2000)) and the empirical findings of Jacobson et al. (1993), in which workers' labor market outcomes eventually partially recover. Additionally, we show that non-employment strongly increases in harder-hit locations in the years immediately following liberalization, but that employment in these locations recovers in the longer run. This employment recovery is entirely accounted for by an increase in informal employment in harder-hit locations. In other words, after going through long periods of non-employment, trade-displaced formal-sector workers appear to eventually settle for informal employment. Given these findings, it is possible that policies discouraging informal employment may amplify the response of non-employment following a trade policy shock. We encourage future research investigating how labor market policies and institutions mediate the effects of liberalization.

Even though Brazil went through a major trade liberalization episode in the 1990s, it still remains a relatively protected economy, with import tariffs across sectors averaging 10.4%.[5] Therefore, understanding how Brazilian labor markets adjusted to trade liberalization is useful to inform policy makers planning another wave of trade liberalization. In addition, although the Brazilian context differs in a variety of ways from that of higher income countries, our findings yield a number of insights that likely apply across contexts. We find that the labor market effects of liberalization fall not just upon workers in tradable industries, but also in non-tradable sectors. Indeed, non-tradable sectors experience falling labor demand due to local equilibrium effects, and absorb many displaced workers from tradable sectors. This cross-sector integration implies that policies such as Trade Adjustment Assistance in the U.S., targeting only

[2] Formal employment refers to jobs visible to the government and in which employers must comply with labor market regulations. Informal employment refers to self-employment or to jobs that are invisible to the government and in which employers do not necessarily comply with labor market regulations. Informal sector jobs are widely perceived as low-quality jobs (LaPorta and Schleifer, 2008; Bacchetta et al., 2009; Fajnzylber et al., 2011; LaPorta and Schleifer, 2014). In the Brazilian context, employers may not contribute to social security or comply with minimum wage requirements and do not incur firing costs, potentially leading to increased job insecurity. Also, workers displaced from informal jobs are not eligible for unemployment insurance.

[3] A notable exception is Menezes-Filho and Muendler (2011). Although they do not consider regional shocks, they do study the same liberalization episode in Brazil and examine worker transitions into non-manufacturing and informality.

[4] See, for example, Goldberg and Pavcnik (2003), Menezes-Filho and Muendler (2011), Bosch et al. (2012), McCaig and Pavcnik (2018), Paz (2014), and Cruces et al. (forthcoming).

[5] Authors' calculations using 2010 UNCTAD TRAINS data and a similar level of aggregation as in Fig. 1. The 25th percentile of the distribution of 2010 import tariffs is 5.3% and the 75th percentile is 13.9%, with some sectors facing tariffs over 30% (clothing and footwear).

trade-exposed industries, omit large numbers of workers whose employment and earnings prospects were indirectly affected by liberalization. Broader policies that cover all displaced workers or target depressed regions may better capture those directly and indirectly affected by tariff changes. We also show that displaced tradable sector workers who eventually find formal employment primarily transition into low-paying service industries. This pattern parallels the recent experiences in the U.S. and Western Europe, in which workers displaced from tradable sectors tend to find reemployment in low-wage service jobs (Goos and Manning, 2007; Autor and Dorn, 2013; Goos et al., 2014). We also find that in harder hit locations jobs shifted from the formal to the informal sector, which are widely perceived as (on average) lower-quality jobs due to the lack of enforcement of labor market regulations, increased job insecurity and the inability to benefit from unemployment insurance. Still, the informal sector seems to have worked as a cushion to trade-displaced workers' labor market outcomes. These results suggest a direction for future work in high-income countries, as self-employment and other more flexible work arrangements have become more common (for example, with the rise of the gig economy). As with Brazilian informality, these alternatives may provide a source of alternative employment for workers facing import competition. A full welfare analysis on the role of the informal sector in smoothing the labor market outcomes of trade-displaced workers is also a fruitful research avenue.[6]

Our paper is structured as follows. Section 2 describes the history and institutional context of Brazil's early 1990s trade liberalization. Section 3 describes the data sources used throughout the paper. Section 4 explains why trade liberalization had heterogeneous effects across regions and shows how we measure trade-induced local labor demand shocks. Section 5 investigates the effects of liberalization on worker-level labor market outcomes using longitudinal data from RAIS. Section 6 complements this analysis by investigating the effects of liberalization on the structure of local labor markets, with an emphasis on how regional formal employment, informal employment, and non-employment responded to the trade shocks. Section 7 concludes.

2. Trade liberalization in Brazil

Brazil's early 1990s trade liberalization provides an excellent setting in which to study the labor market effects of changes in trade policy. The unilateral trade liberalization involved large declines in average trade barriers and featured substantial variation in tariff cuts across industries. As we will argue below, this variation was plausibly exogenous to counterfactual industry performance, making it possible to estimate causal effects of liberalization. As a result, many papers have examined the labor market effects of trade liberalization in the Brazilian context.[7]

In the late 1980s and early 1990s, Brazil ended nearly one hundred years of extremely high trade barriers imposed as part of an import substituting industrialization policy.[8] In 1987, nominal tariffs were high, but the degree of protection actually experienced by a given industry often deviated substantially from the nominal tariff rate due to i) a variety of non-tariff barriers such as suspended import licenses for many goods and ii) a system of "special customs regimes" that lowered or removed tariffs for many transactions (Kume et al., 2003).[9] In 1988 and 1989, in an effort to increase transparency in trade policy, the government reduced tariff redundancy by cutting nominal tariffs and eliminating certain special regimes and trade-related taxes, but there was no effect on the level of protection faced by Brazilian producers (Kume, 1990).

Liberalization effectively began in March 1990, when the newly elected administration of President Collor suddenly and unexpectedly abolished the list of suspended import licenses and removed nearly all of the remaining special customs regimes (Kume et al., 2003). These policies were replaced by a set of import tariffs providing the same protective structure, as measured by the gap between prices internal and external to Brazil, in a process known as tariffication (*tarificação*) (de Carvalho Jr, 1992). In some industries, this process required modest tariff increases to account for the lost protection from abolishing import bans.[10] Although these changes did not substantially affect the protective structure, they left tariffs as the main instrument of trade policy, such that tariff levels in 1990 and later provide an accurate measure of protection.

The main phase of trade liberalization occurred between 1990 and 1995, with a gradual reduction in import tariffs culminating with the introduction of Mercosur. Tariffs fell from an average of 30.5% to 12.8%, and remained relatively stable thereafter.[11] Along with this large average decline came substantial heterogeneity in tariff cuts across industries, with some industries such as agriculture and mining facing small tariff changes, and others such as apparel and rubber facing declines of more than 30 percentage points. We measure liberalization using long-differences in the log of one plus the tariff rate from 1990 to 1995, shown in Fig. 1. During this time period, tariffs accurately measure the degree of protection faced by Brazilian producers, and tariff reductions from 1990 to 1995 reflect the full extent of liberalization faced by each industry. We do not rely on the timing of tariff cuts between 1990 and 1995, because this timing was chosen to maintain support for the liberalization plan, cutting tariffs on intermediate inputs earlier and consumer goods later (Kume et al., 2003).

As discussed below, along with regional differences in industry mix, the cross-industry variation in tariff cuts provides the identifying variation in our analysis. Following the argument in Goldberg and Pavcnik (2005), we note that the tariff cuts were nearly perfectly correlated with the pre-liberalization tariff levels (correlation coefficient $= -0.90$). These initial tariff levels reflected a protective structure initially imposed in 1957 (Kume et al., 2003), decades before liberalization. This feature left little scope for political economy concerns that might otherwise have driven systematic endogeneity of tariff cuts to counterfactual industry performance.

To check for any remaining spurious correlation between tariff cuts and other steadily evolving industry factors, we regress pre-liberalization (1980–1991) changes in industry employment and average monthly earnings on the 1990–1995 tariff reductions, with detailed results reported in Appendix B.1. We attempted a variety of alternative specifications and emphasize that the results should be interpreted with care, as they include only 20 tradable-industry observations. Most specifications exhibit no statistically significant relationship, but heteroskedasticity-weighted specifications place heavy weight on agriculture and find a positive relationship. Agriculture was initially the least protected industry, and it experienced approximately no tariff reduction. It also had declining wages and employment before liberalization, driving the positive relationship with tariff reductions. Consistent with earlier work, when omitting agriculture, tariff cuts are unrelated to pre-liberalization earnings trends (Krishna et al., 2011). Given these varying results, we include controls for pre-liberalization trends in all of the analyses presented below, to account

[6] Trade-induced shifts into informality potentially have many competing effects on welfare. First, the availability of a large informal sector as a fallback sector may improve worker welfare, especially if their primary alternative is unemployment. However, a reallocation of resources to small and less productive informal firms or firms with low tax compliance may reduce aggregate welfare.

[7] Examples include Arbache et al. (2004); Dix-Carneiro and Kovak (2017); Goldberg and Pavcnik (2003); Gonzaga et al. (2006); Kovak (2013); Krishna et al. (2014); Menezes-Filho and Muendler (2011); Pavcnik et al. (2004); Paz (2014); Schor (2004); and Soares and Hirata (2016) among many others.

[8] Although Brazil was a founding signatory of the General Agreement on Tariffs and Trade (GATT) in 1947, it maintained high trade barriers through an exemption in Article XVIII Section B, granted to developing countries facing balance of payments problems (Abreu, 2004). Hence, trade policy changes during the period under study were unilateral.

[9] These policies were imposed quite extensively. In January 1987, 38% of individual tariff lines were subject to suspended import licenses, which effectively banned imports of the goods in question (Authors' calculations from *Bulletin International des Douanes* no.6 v.11 supplement 2). In 1987, 74% of imports were subject to a special customs regime (de Carvalho Jr, 1992).

[10] Appendix Fig. A1 shows the time series of tariffs. Note the tariff increases in 1990 for the auto and electronic equipment industries.

[11] Simple averages of tariff rates across *Nível 50* industries, as reported in Kume et al. (2003). See Appendix A.1 for details on tariff data.

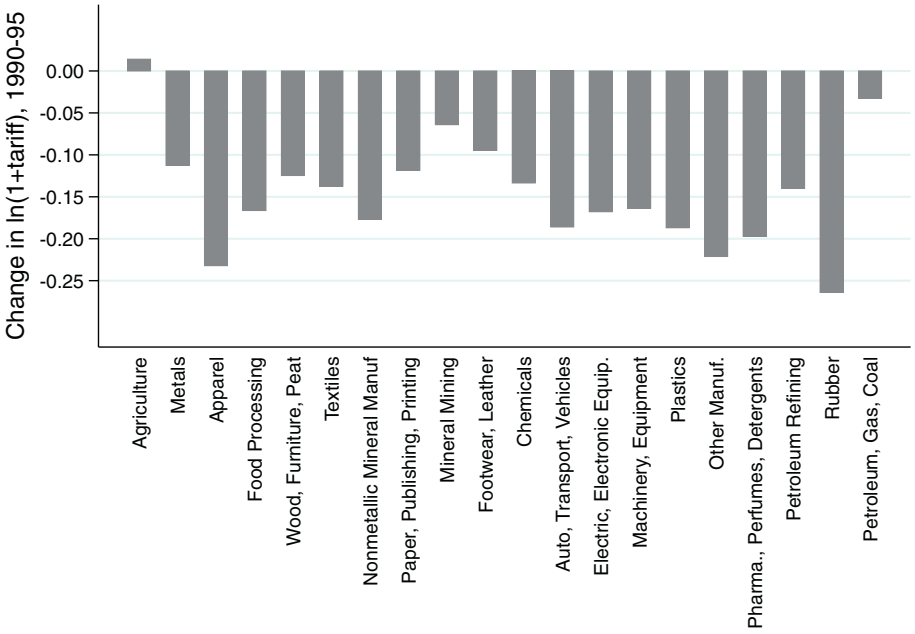


Fig. 1. Tariff Changes. Tariff data from Kume et al. (2003), aggregated to allow consistent industry definitions across data sources. See Appendix Table A1 for details of the industry classification. Industries sorted based on 1991 national employment (largest on the left, and smallest on the right).

for any potential spurious correlation. Consistent with the notion that the tariff changes were exogenous in practice, these pre-liberalization controls have little influence on the vast majority of our results.

3. Data

Our main data source for individual labor market outcomes is the *Relação Anual de Informações Sociais* (RAIS), spanning the period from 1986 to 2010. This is an administrative dataset assembled yearly by the Brazilian Ministry of Labor, providing a high quality census of the Brazilian formal labor market (De Negri et al., 2001; Saboia and Tolipan, 1985). Accurate information in RAIS is required for workers to receive payments from several government benefits programs, and firms face fines for failure to report, so both agents have an incentive to provide accurate information. RAIS includes nearly all formally employed workers, meaning those with a signed work card (*carteira assinada*), providing them access to the benefits and labor protections afforded by the legal employment system. It omits interns, domestic workers, and other minor employment categories, along with those without signed work cards, including the self-employed. These data have recently been used by Dix-Carneiro (2014), Helpman et al. (2017), Krishna et al. (2014), Lopes de Melo (2018), and Menezes-Filho and Muendler (2011), though these papers utilize shorter panels. The data consist of job records including worker and establishment identifiers, allowing us to track workers and establishments over time. We utilize the establishment's geographic location (municipality) and industry; worker-level information including gender, age, and education (9 categories); and job-level information such as the date of accession, date of separation, tenure, occupation, and average monthly earnings.

These data have various advantages relative to previous work on the effects of trade on local labor markets. First, because we study a discrete policy shock, we can use the RAIS data to infer the dynamics of adjustment to trade liberalization, in contrast to studies of steadily evolving shocks such as Chinese trade, as emphasized by Autor et al. (2014). Second, RAIS is a census rather than a sample, so it is representative of the formal labor market at fine geographic levels.[12] Third, the panel dimension of the data allows us to track workers over time as they potentially transition between jobs, sectors, and regions.

As is typically the case in administrative employment datasets, the limitation of RAIS is a lack of information on workers who are not formally employed. When a worker does not appear in the database in a given month, we can conclude that they are not formally employed at that time. However, we cannot tell whether the worker is out of the labor force, unemployed, informally employed, or self-employed. This is important in the Brazilian context, with informality rates often exceeding 50% of all employed workers during our sample period.[13] When we need information on individuals who are not formally employed, or information before 1986, we supplement the analysis using the decennial Brazilian Demographic Census, covering 1970–2010. While these data do not permit following individuals over time, they allow us to study the effects of liberalization on the regional employment structure by covering the entire population, including the informally employed, unemployed, and those outside the labor force.[14] We classify as informally employed workers without a signed work card, paralleling the formality definition in RAIS and following much of the literature on Brazilian informality.[15] Because the Census is a household survey and workers face no penalties for reporting informal status, this measure accurately reflects informality.

4. Regional tariff reductions

Our empirical analyses compare the evolution of labor market outcomes for workers and regions facing large tariff declines to those facing smaller tariff declines. Intuitively, regions experience larger declines in labor demand when their most important industries face larger liberalization-induced price declines (Topalova, 2007). Kovak (2013) presents a specific-factors model of regional economies capturing this intuition, in which the regional labor demand shock resulting from liberalization is

[12] The National Household Survey (*Pesquisa Nacional por Amostra de Domicílios* - PNAD) would be a natural alternative data source for a yearly analysis, but it only provides geographic information at the state level, does not allow one to follow individual workers over time, and provides a much smaller sample.

[13] See Appendix B.2 for descriptive statistics on informal employment.

[14] See Appendix A.3 for more detail on the Demographic Census data.

[15] The work-card based definition of formality is standard in papers using household survey data to study Brazilian informality, including Goldberg and Pavcnik (2003), Menezes-Filho and Muendler (2011), Bosch et al. (2012), Paz (2014), and many others.

$$\sum_i \beta_{ri}\hat{P}_i, \qquad \text{where} \qquad \beta_{ri} \equiv \frac{\lambda_{ri}\frac{1}{\varphi_i}}{\sum_j \lambda_{rj}\frac{1}{\varphi_j}}. \tag{1}$$

Hats represent proportional changes, r indexes regions, i and j index tradable-sector industries, φ_i is the cost share of non-labor factors, and λ_{ri} is the share of regional labor initially allocated to tradable industry i. $\hat{P}_i$ is the liberalization-induced price change facing industry i, and (1) is a weighted average of these price changes across tradable industries, with more weight on industries capturing larger shares of initial regional employment.[16] Thus, although all regions face the same vector of liberalization-induced price changes, differences in the regional industry mix generate regional variation in labor demand shocks.

We operationalize this shock measure by defining the "regional tariff reduction" (RTR), which utilizes only liberalization-induced variation in prices, replacing $\hat{P}_i$ with the change in log of one plus the tariff rate.

$$RTR_r = -\sum_i \beta_{ri} d\ \ln(1+\tau_i) \tag{2}$$

τ_i is the tariff rate in industry i, and d represents the long difference from 1990 to 1995, the period of Brazilian trade liberalization. We calculate tariff reductions using data from Kume et al. (2003), λ_{ri} using the 1991 Census, and φ_i using 1990 National Accounts data from IBGE.[17] Together, these allow us to calculate the weights, β_{ri}. Note that RTR_r is more positive in regions facing larger tariff *reductions*, which simplifies the interpretation of our results, since nearly all regions faced tariff declines during liberalization.

Fig. 2 maps the spatial variation in RTR_r. We define a set of consistently identifiable regions based on the "microregion" definition of the Brazilian Statistical Agency (IBGE), which groups together economically integrated contiguous municipalities with similar geographic and productive characteristics (IBGE, 2002).[18] Regions facing larger tariff reductions are presented as lighter and yellower, while regions facing smaller cuts are shown as darker and bluer. The region at the 10th percentile faced a tariff reduction of 0.2 percentage points, as measured by (2), while the region at the 90th percentile faced a 10.7 percentage point decline. Hence, in interpreting the regression estimates below, we compare regions whose values of RTR_r differ by 10 percentage points, closely approximating the 90–10 gap of 10.5 percentage points. Note that there is substantial variation in the tariff shocks even among local labor markets within the same state. As we include state fixed effects in our analyses to control for state-level policy differences such as minimum wages, these within-state differences provide the identifying variation in our study.[19]

5. Worker-level analysis

5.1. Worker-level empirical specification

We utilize the panel dimension of the RAIS data to follow individual workers over time, tracking the evolution of labor market outcomes for workers initially employed in regions facing larger tariff reductions vs. those initially in regions facing smaller tariff cuts. Our main analysis focuses on a panel of workers who were initially employed in the tradable sector in December 1989, just before trade liberalization began. In particular, we restrict attention to workers aged 25–44 in December 1989 (who remain of working age through 2010) and whose highest paying job was in the tradable sector. For computational tractability, we take a 15% sample of individuals meeting these criteria in regions with more than 2000 tradable sector workers in 1989 and include all relevant workers from smaller regions, weighting appropriately in subsequent analyses. This process yields 585,078 individuals in our main tradable sector sample. In Section 5.6, we also consider an alternate population of workers initially employed in the nontradable sector, in order to investigate the transmission of the trade shock into this indirectly affected sector. All other restrictions and sampling procedures are the same, yielding a sample of 973,703 nontradable sector workers. Table 1 provides summary statistics for the tradable sector and nontradable sector samples.

We use the following specification to compare the evolution of labor market outcomes for workers initially employed in regions facing larger vs. smaller tariff reductions.

$$y_{irt} = \theta_t RTR_r + \alpha_{st} + X_{ir,1989}\Phi_t + \epsilon_{irt}, \tag{3}$$

where i indexes individuals, t indexes years following the start of liberalization ($t \in [1990 - 2010]$), and r is the worker's initial region of employment in December 1989. Note that a worker's initial region r is fixed throughout the analysis, even if they are employed elsewhere in later years. y_{irt} represents various worker-level post-liberalization outcomes, which we define below. $X_{ir,\,1989}$ is a rich set of worker-level controls including demographics (9 education category indicators, gender, age, age-squared), initial job characteristics for the highest-paying job in December 1989 (84 occupation category indicators, 14 tradable industry indicators, 12 nontradable industry indicators, tenure at the plant), initial employer characteristics (log employment, exporting indicator, log exports, importing indicator, log imports), and initial region characteristics (pre-liberalization (1986–89) earnings growth and formal employment growth, and pre-liberalization growth in the outcome of interest).[20] This specification compares subsequent labor market outcomes for two otherwise observationally equivalent workers who in 1989 happened to live in regions facing different local trade shocks. Since RTR_r does not vary over time, always reflecting tariff reductions from 1990 to 1995, the estimates of θ_t trace out the effects of regional tariff reductions on the worker's outcome y_{irt} as of year t. We estimate (3) separately for each year $t \in [1990, 2010]$, allowing the regression coefficients (θ_t, Φ_t) and state fixed effects (α_{st}) to differ across years. Throughout the RAIS analyses, it is important to keep in mind that we can only observe worker outcomes in the formal labor market; we do not observe informally employed or non-employed workers in the RAIS data, and when a worker leaves formal employment we are unable to observe whether they are informally employed or non-employed. To address this coverage issue, Section 6 presents regional analyses using

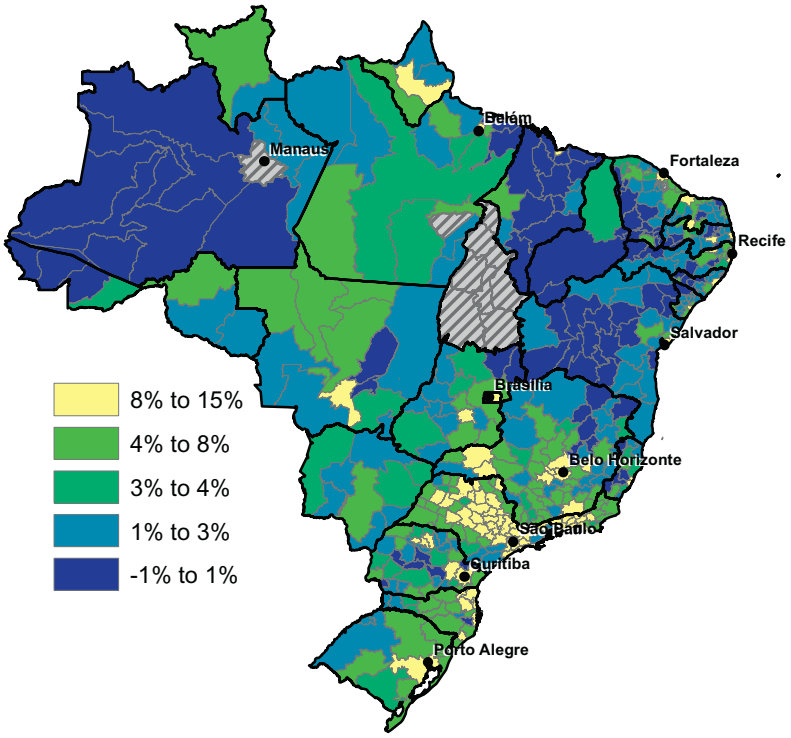
[16] Following Kovak (2013), we drop the nontradable sector in the calculation of local trade-induced shocks, based on the assumption that nontradable prices move with tradable prices. In Dix-Carneiro and Kovak (2017), we confirm this assumption using a measure of local nontradables prices.

[17] See Appendix A.4 for more detail on the construction of (2). We use the Census to calculate λ_{ri} because it allows for a more detailed industry definition than what is available in RAIS (see Appendix A.1) and because the Census allows us to calculate weights that are representative of overall employment, rather than just formal employment.

[18] We consistently identify 475 regions for analyses falling within 1986–2010 and 405 markets for analyses using data from 1980 and earlier. Our geographic classification is a slightly aggregated version of the one in Kovak (2013), accounting for additional boundary changes during the longer sample period. The analysis omits 11 microregions, shown with a cross-hatched pattern Fig. 2. These include i) Manaus, which was part of a Free Trade Area and hence not subject to tariff cuts during liberalization; ii) the microregions that constitute the state of Tocantins, which was created in 1988 and hence not consistently identifiable throughout our sample period; and iii) a few other municipalities that are omitted from RAIS in the 1980s. The inclusion or exclusion of these regions when possible has no substantive effect on the results.

[19] A regression of RTR_r on state fixed effects yields an R^2 of 0.36; i.e. 64% of the variation in RTR_r is not explained by state effects. Our main conclusions are unaffected by the inclusion or exclusion of state fixed effects.

[20] Firm-level imports and exports for 1990 come from customs data assembled by the *Secretaria de Comércio Exterior* (SECEX). The pre-liberalization outcome controls are calculated as follows. We draw a sample of workers in December 1986, paralleling the main sample, and estimate a version of (3) replacing RTR_r with region indicators. These first step region indicator coefficients enter as controls in Eq. (3). Note that when examining accumulated earnings, we are unable to normalize by pre-1986 earnings, so we instead include the pre-liberalization control related to months formally employed. For migration-related outcomes, we additionally control for the 1986–1991 probability of out-migration, obtained from the Census.



	percentile				
mean	10	25	50	75	90
0.044	0.002	0.012	0.031	0.066	0.107

Fig. 2. Regional Tariff Reductions. Local labor markets reflect microregions defined by IBGE, aggregated slightly to account for border changes between 1986 and 2010. Regions are colored based on the regional tariff reduction measure, RTR_r, defined in (2). Regions facing larger tariff reductions are presented as lighter and yellower, while regions facing smaller cuts are shown as darker and bluer. Dark lines represent state borders, gray lines represent consistent microregion borders, and cross-hatched migroregions are omitted from the analysis. These microregions were either i) part of a Free Trade Area ii) part of the state of Tocantins and not consistently identifiable over time, or iii) not included in the RAIS sample before 1990.

Census data, which cover all individuals irrespective of employment status.

5.2. Employment

We begin by examining how the regional tariff reduction in a worker's initial region affected their subsequent formal employment status. We calculate the cumulative average number of months formally employed per year from 1990 to year t.

$$\frac{1}{t-1989}\sum_{s=1990}^{t} Months_{is}, \tag{4}$$

where $Months_{is}$ is the number of months individual i was formally employed in year s.[21] Note that $Months_{is}$ includes formal employment in any location, even if the individual moves away from their initial region following liberalization. Fig. 3 reports the effects of liberalization on this dependent variable, using specification (3). Each point in the figure represents the regression coefficient θ_t for the relevant year. The negative estimates imply that workers initially employed in harder hit regions experience relative declines in employment in the formal sector. As shown in Fig. 3, the point estimate for 2010 is −4.7, implying that a worker whose initial region faced a 10 percentage point larger tariff decline (approximately the 90–10 gap in RTR_r) on average worked in the formal sector for 9.9 fewer total months between 1990 and 2010. This is a large effect, as it represents 8% of the average number of total months worked in the formal sector during our 21-year time period (125 months) for workers in our sample (see Table 1).[22] In contrast to conventional wisdom, negatively-affected workers' average employment outcomes do not recover during the 15 years following liberalization. In fact, the effects *grow* over time, implying steady relative declines in formal employment for workers initially employed in regions facing larger tariff reductions.

This pattern of growing individual-level formal employment effects is similar to our earlier findings, which used a region-level rather than worker-level research design (Dix-Carneiro and Kovak, 2017). In that paper, we present evidence that the surprising growing effects of liberalization on earnings result from dynamics in labor demand that gradually amplify the short-run effect of the shock. These dynamics are driven by a combination of slow capital reallocation and agglomeration economies. In that context, a liberalization-induced decline in labor demand lowers wages and employment rates on impact. Then, through depreciation and reinvestment elsewhere, capital slowly reallocates away from the region, reducing regional workers' marginal product and further reducing earnings and employment. Agglomeration economies amplify this effect, reducing marginal products as regional economic activity contracts. In Dix-Carneiro and Kovak (2017), we present qualitative and quantitative empirical evidence supporting this mechanism.

[21] RAIS reports the month of accession and separation (if any) for each job, so that we can observe formal employment at the monthly level.

[22] The employment measure in (4) is cumulative, in the sense that it calculates average months employed from 1990 to subsequent year t. Appendix B.3 presents an alternative non-cumulative measure, the fraction of year t in which the worker was formally employed, with similarly growing effects over time.

Table 1
Individual analysis summary statistics.

	Tradable sector sample		Nontradable sector sample	
	mean	std. dev.	mean	std. dev.
Education				
Illiterate	0.02	0.13	0.01	0.11
4th grade incomplete	0.13	0.33	0.10	0.30
4th grade complete	0.25	0.43	0.18	0.38
8th grade incomplete	0.19	0.39	0.14	0.34
8th grade complete	0.15	0.35	0.14	0.35
High School incomplete	0.05	0.21	0.06	0.23
High School complete	0.13	0.34	0.21	0.41
College incomplete	0.02	0.15	0.04	0.19
College complete	0.07	0.26	0.13	0.33
Female	0.24	0.43	0.32	0.46
Age	32.8	5.4	32.8	5.5
December 1989 Earnings (in 2010 R$)	1,906	2,447	1,837	2,669
1989 Yearly Earnings (in 2010 R$)	19,170	23,822	18,683	26,002
Average Annualized Earnings 1986–1989 (in 2010 R$)	18,997	21,058	18,065	21,596
Months formally employed per year				
1990	10.2	3.5	9.9	3.8
1990–1995	8.2	3.8	8.2	3.9
1990–2000	7.1	3.7	7.2	3.9
1990–2005	6.4	3.7	6.6	3.9
1990–2010	6.0	3.7	6.1	3.9
Migration				
Employed in a different region in 1994 than in 1989	0.09	0.29	0.11	0.31
Employed in a different region in 2000 than in 1989	0.10	0.31	0.12	0.32
Observations	585,078		973,703	

RAIS data. Weighted to account for 15% sample of individuals in regions with more than 2000 traded sector workers in 1989 and 100% sample in other regions. All monetary values reported in 2010 R$. In Dec 31, 2010, a US dollar was worth 1.66 Brazilian Reais.

In Section 5.4 below, we document the robustness of these growing employment effects to alternative specification choices and to controlling for a variety of post-liberalization economic shocks. Appendix B.4 demonstrates that these large and growing effects on formal employment apply to a variety of worker subsamples, including workers who were initially highly connected to the formal labor market (employed for at least 36 or 42 out of 48 months during 1986–1989), to both more educated workers (high school degree or more) and less educated workers (less than high school), and to younger (initially age 25–34) and older (age 35–44) workers.

Along with the transitions out of formal employment documented in Fig. 3, workers also adjust between tradable and nontradable sector employment. Recall that all of the workers in our main sample were initially employed in the tradable sector just prior to liberalization. In Fig. 4, we examine the average number of months formally employed per year, as in (4), but separate months into those worked in tradable and nontradable sector employment. As expected, formal employment losses were concentrated in the tradable sector, which makes sense given that trade liberalization directly affected the tradable sector and the workers in our sample were initially employed in tradable industries. In contrast, nontradable employment offsets a fraction of the employment losses in the tradable sector, indicating that some tradable sector workers facing larger regional tariff reductions transitioned into nontradable employment. These reallocations into the nontradable sector allowed some workers initially in negatively affected regions to spend more time formally employed.[23] However, they were not large enough to offset the substantial losses in the tradable sector, such that overall months formally employed (in either sector) still decline in the hardest-hit locations, as seen in Fig. 3.

Table 2 adds further detail to this analysis, splitting the tradable sector into agriculture/mining and manufacturing and splitting the nontradable sector into low-paying services, high-paying services, and construction. The results show that tradable-sector workers facing larger regional tariff reductions experience formal employment losses primarily in tradable industries, but also see more modest relative declines in formal employment in high-paying services in the long run. Essentially all of the growth in nontradable sector employment shown in Fig. 4 occurs in low-paying service industries. These patterns following Brazilian trade liberalization parallel recent experiences in the U.S. and Western European countries, in which workers displaced from tradable sectors tend to find reemployment in low-wage service jobs (Goos and Manning, 2007; Autor and Dorn, 2013; Goos et al., 2014; Keller and Utar, 2016).

5.3. Earnings

Together with changes along the employment margin, workers' formal earnings may have responded to liberalization-induced changes in labor demand as well. It is important to keep in mind that *formal* earnings effects are likely to be upper bounds on the *overall* earnings effects, since workers losing formal earnings may partially offset these losses through earnings in the informal sector. Although informal earnings are unobserved in the RAIS worker panel, in Section 6.2 we use Census data to document substantial shifts into informality in regions facing larger tariff reductions.

Following Autor et al. (2014), we calculate a worker's average yearly earnings from 1990 to each subsequent year t as a multiple of the worker's average pre-liberalization (1986–89) yearly earnings:

$$\frac{\frac{1}{t-1989}\sum_{s=1990}^{t} Earnings_{is}}{Mean\,Earnings_{i,1986-89}}, \tag{5}$$

$$\text{where } Mean\,Earnings_{i,1986-89} \equiv \frac{\sum_{s=1986}^{1989} Earnings_{is}}{\sum_{s=1986}^{1989} Months_{is}} \times 12$$

The numerator is the worker's average post-liberalization formal earnings from 1990 to t, and the denominator is the worker's average pre-liberalization formal earnings from 1986 to 1989.[24] Note that formal earnings may decline due to lower wages or due to fewer months or fewer hours worked in the formal sector. We use this measure because it accounts for worker heterogeneity in initial earnings while still being well defined for workers with zero earnings after 1989, avoiding sample selection issues. We then regress this earnings measure for each year t on the regional tariff reduction (RTR_r) and the extensive set of controls described above. Fig. 5 shows the results. The point estimate in 2010 is −0.85, implying that over the course of 21 years, a worker whose initial region faced a 10 percentage point larger tariff decline lost 1.8 times their yearly pre-liberalization formal earnings, in relative terms.[25] On average, individuals in our sample accumulated 13.7 times their initial formal-sector earnings during the 21 years from 1990 to 2010, so a loss of 1.8 times initial earnings represents a loss of 13% relative to the average. Note that this is larger than the parallel employment loss of 8% referenced in Section 5.2, indicating that earnings conditional on employment also fell for workers initially employed in harder-hit locations.

[23] This result parallels that of Menezes-Filho and Muendler (2011), who show that manufacturing workers whose industry faced a larger tariff decline were more likely to switch into formal employment in a non-manufacturing industry.

[24] Employers' report workers' individual average monthly earnings during employed months in a given year. We construct individual yearly earnings by multiplying average monthly earnings by the number of months employed in the year and then summing across employers.

[25] Note that the earnings measure in (5) is cumulative, in the sense that it averages earnings between 1990 and subsequent year t. Appendix B.3 presents an alternative non-cumulative measure, earnings in year t as a multiple of average pre-liberalization earnings, with similarly growing effects over time.

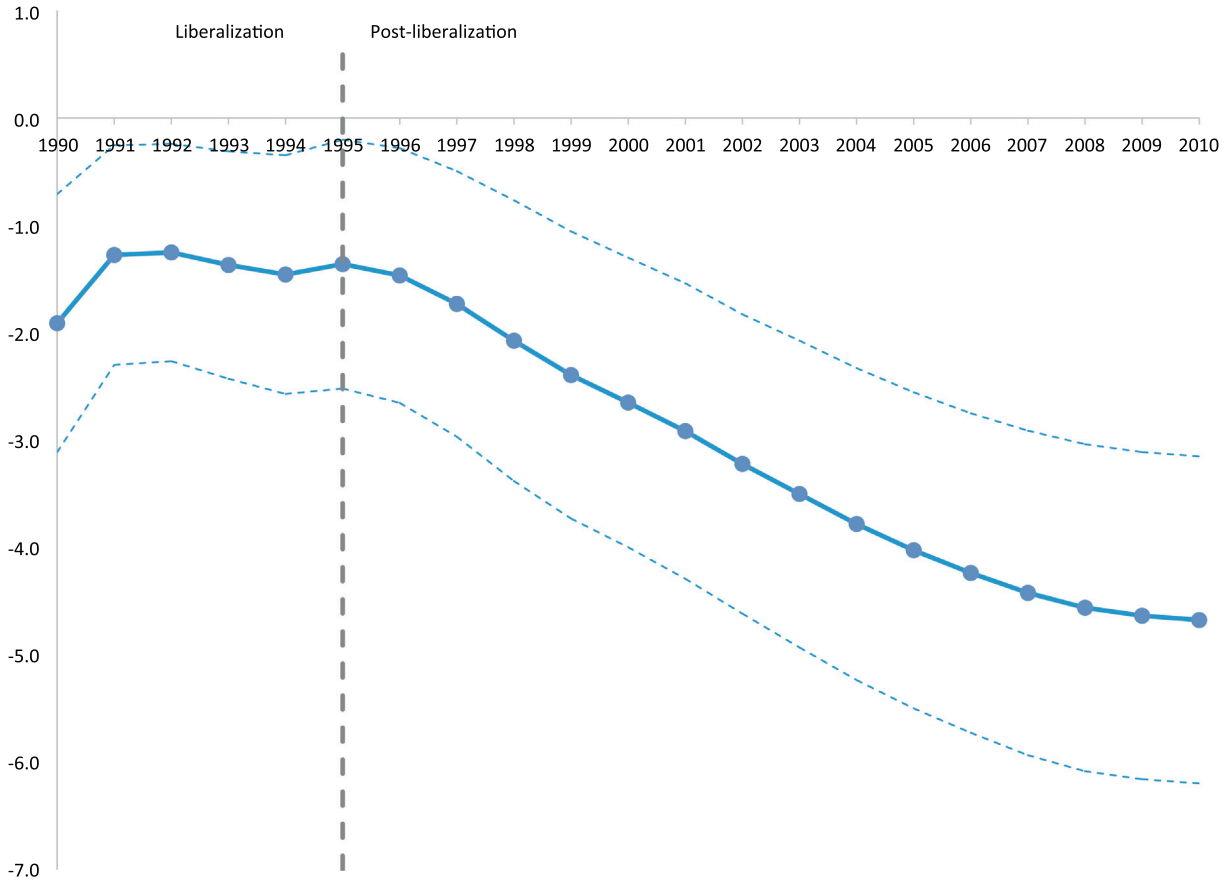


Fig. 3. Cumulative Average Months Formally Employed Per Year - Tradable Worker Sample - 1990-2010. Each point reflects an individual regression coefficient, $\hat{\theta}_t$, following (3), where the dependent variable is the average months formally employed per year from 1990 to the year listed on the x-axis. The independent variable is the regional tariff reduction (RTR_r), defined in (2). Note that RTR_r always reflects tariff reductions from 1990 to 1995. The regressions include state fixed effects and extensive controls for worker, initial job, initial employer, and initial region characteristics (see text for details). Negative estimates imply that workers initially in regions facing larger tariff reductions spend a smaller average share of the relevant years formally employed than workers in other regions. The vertical bar indicates that liberalization began in 1990 and was complete by 1995. Dashed lines show 95% confidence intervals. Standard errors adjusted for 106 mesoregion clusters.

As with employment, these formal earnings results correspond closely to the regional analysis in Dix-Carneiro and Kovak (2017).[26]

5.4. Robustness

We have implemented a variety of robustness tests demonstrating that the formal employment effects in Fig. 3 and the formal earnings effects in Fig. 5 are robust to alternative measurement and specification choices and to controlling for salient economic shocks occurring after liberalization. A detailed discussion appears in Appendix B.5, and we summarize the findings here.

We first calculate alternative regional tariff reductions using effective rates of protection, which account for tariff changes on industry output and industry inputs. We also estimate (3) omitting fixed effects for the worker's initial industry and/or their initial occupation. These alternative specifications thus capture the direct effects of liberalization on industries and occupations at the national level and are a bit larger than those controlling for industry and occupation fixed effects. In both cases, we continue to observe growing effects over time, and predicted effects on employment and wages are very similar to those in the main analysis.

Many salient economic shocks hit the Brazilian economy in the years following trade liberalization, and we introduce controls to ensure that these subsequent shocks are not driving our results. We control for regional tariff reductions occurring after liberalization, exchange rate movements, and the wave of privatization in the early 2000s. To rule out the possibility that government development policies targeting the North, Northwest, and Center-West regions confound our results (Resende, 2013), we present specifications omitting these regions. We also present a variety of robustness tests related to agriculture and commodities. We IMF commodity price data to control directly for changes in commodity prices, which is particularly important given the commodity-intensive nature of Brazilian output and the substantial increase in commodity prices beginning in 2004. To rule out a broad array of concerns related to agriculture and mining, we present specifications omitting regions with agriculture and mining's share of employment above the median value or above the 25th percentile. We also omit regions in the Cerrado region, which experienced huge increases in agricultural output due to new crop varieties and mechanized farming techniques (Economist, 2010;

[26] Fig. 3 in Dix-Carneiro and Kovak (2017) shows that by 2010 a region facing a 10 percentage point larger tariff reduction experienced a 15.9% larger decline in formal earnings. Appendix Fig. B4 shows that tradable-sector workers initially in the same region experienced a 3.9% larger decline in the probability of working in the formal sector by 2010. Combining these estimates, we can calculate the expected decline in individual yearly earnings as a share of initial yearly earnings.

$$\frac{E^{2010}P^{2010}-E^{1990}P^{1990}}{E^{1990}P^{1990}} = \frac{E^{2010}P^{2010}}{E^{1990}P^{1990}} - 1 = (1-0.159)(1-0.039) - 1 = -0.192$$

where E is average earnings and P is the probability of formal employment in the given year. We compare this predicted average decline in individual yearly earnings of 19.2% to the parallel estimate of 16.4% in Appendix Fig. B5. These magnitudes are quite similar in spite of the fact that Fig. 3 in Dix-Carneiro and Kovak (2017) includes all formal workers, while Figs B4 and B5 include only workers initially employed in the formal tradable sector.

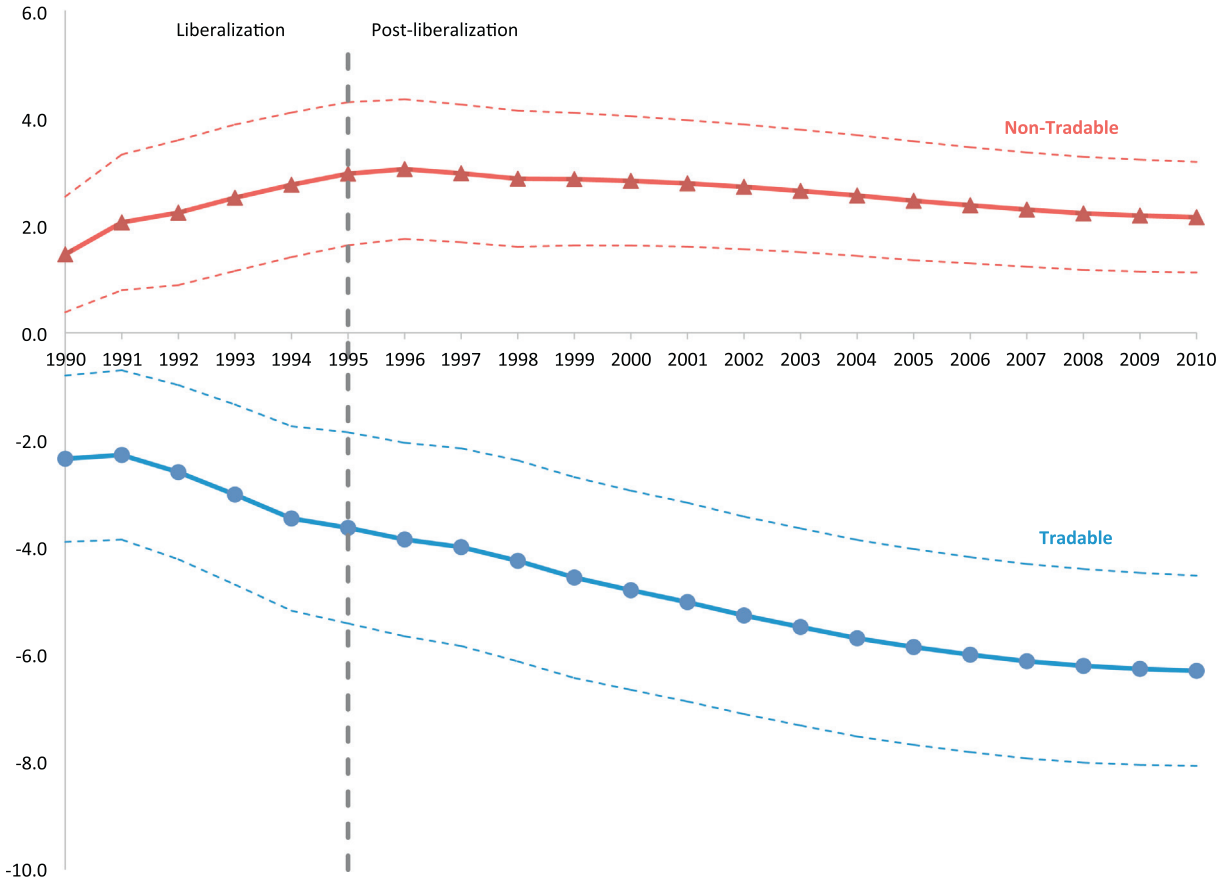


Fig. 4. Average Months Formally Employed in Tradable or Nontradable Sectors Per Year - Tradable Worker Sample - 1990-2010. Each point reflects an individual regression coefficient, $\hat{\theta}_t$, following (3), where the dependent variable is the average months formally employed in the relevant sector per year from 1990 to the year listed on the x-axis. The independent variable is the regional tariff reduction (RTR_r), defined in (2). Note that RTR_r always reflects tariff reductions from 1990 to 1995. The regressions include state fixed effects and extensive controls for worker, initial job, initial employer, and initial region characteristics (see text for details). Negative (positive) estimates imply that workers initially in regions facing larger tariff reductions spend a smaller (larger) average share of the relevant years formally employed in the relevant sector than workers in other regions. The vertical bar indicates that liberalization began in 1990 and was complete by 1995. Dashed lines show 95% confidence intervals. Standard errors adjusted for 106 mesoregion clusters.

Table 2
Average Months Formally Employed in Detailed Sectors Per Year - Tradable Worker Sample - 1990-2010.

Cumulative average months formally employed	1990–1995	1990–2000	1990–2005	1990–2010
Per year	(1)	(2)	(3)	(4)
Panel A: agriculture and mining				
Regional tariff reduction (RTR)	−1.237***	−1.741***	−2.152***	−2.392***
	(0.401)	(0.411)	(0.411)	(0.412)
Panel B: manufacturing				
Regional tariff reduction (RTR)	−2.451***	−3.098***	−3.739***	−3.939***
	(0.810)	(0.763)	(0.737)	(0.723)
Panel C: low-paying services				
Regional tariff reduction (RTR)	2.711***	2.882***	2.822***	2.736***
	(0.590)	(0.563)	(0.545)	(0.511)
Panel D: high-paying services				
Regional tariff reduction (RTR)	−0.019	−0.223	−0.506***	−0.714***
	(0.137)	(0.169)	(0.182)	(0.182)
Panel E: construction				
Regional tariff reduction (RTR)	0.298**	0.190	0.154	0.137
	(0.145)	(0.170)	(0.168)	(0.165)
State fixed effects (26)	✓	✓	✓	✓

Regression coefficients, $\hat{\theta}_t$, follow (3). The dependent variable is the average months formally employed per year from 1990 to the year listed in the column heading in the subsector listed in the panel heading. Services are classified as high-paying or low-paying based on industry earnings premia in a Mincer-style wage regression controlling flexibly for age, gender, education, and region. High-paying service industries include public utilities, public administration, education, finance, medicine, and transportation and communications. The independent variable is the regional tariff reduction (RTR_r), defined in (2). Note that RTR_r always reflects tariff reductions from 1990 to 1995. The regressions include state fixed effects and extensive controls for worker, initial job, initial employer, and initial region characteristics (see text for details). Negative estimates imply that workers initially in regions facing larger tariff reductions spend a smaller average share of the relevant years formally employed in the relevant subsector than workers in other regions. Standard errors adjusted for 106 mesoregion clusters.

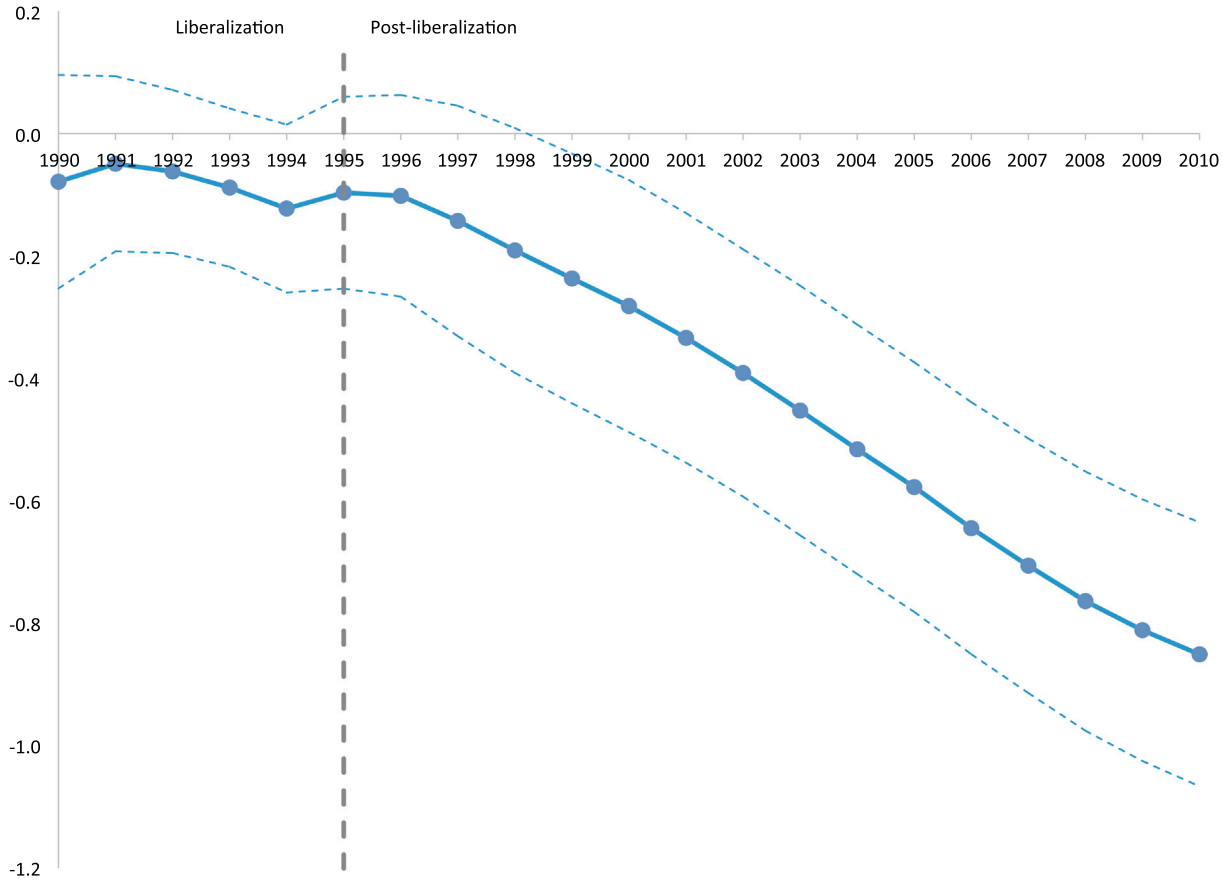


Fig. 5. Cumulative Average Earnings - Tradable Worker Sample - 1990-2010. Each point reflects an individual regression coefficient, $\hat{\theta}_t$, following (3), where the dependent variable is the average yearly earnings from 1990 to the year listed on the x-axis, expressed as a multiple of the worker's pre-liberalization (1986–89) average yearly earnings. The independent variable is the regional tariff reduction (RTR_r), defined in (2). Note that RTR_r always reflects tariff reductions from 1990 to 1995. The regressions include state fixed effects and extensive controls for worker, initial job, initial employer, and initial region characteristics (see text for details). Negative estimates imply that workers initially in regions facing larger tariff reductions experience earnings reductions compared to workers in other regions. The vertical bar indicates that liberalization began in 1990 and was complete by 1995. Dashed lines show 95% confidence intervals. Standard errors adjusted for 106 mesoregion clusters.

Bustos et al., 2016). Finally, we use data from the Brazilian Agricultural Census to omit regions with above median growth in the value or area under cultivation for the crops experiencing substantial technical change (corn, cotton, and soy) and regions with above median growth in agricultural machines (tractors, planters, harvesters, or plows).

In all cases, when controlling for these post-liberalization shocks we continue to find large and growing effects of liberalization on local formal employment and formal earnings. This robustness applies to the main tradable-sector sample and the nontradable-sector sample discussed below in Section 5.6. Together, these results imply that our findings are robust to alternative measurement and specification choices and that the growing effects we observe over time are not driven by subsequent shocks to the Brazilian economy. Rather, they reflect growing effects of liberalization over time.

5.5. Migration

Workers whose initial regions faced larger tariff reductions may have chosen to migrate to more positively affected labor markets. In earlier work, we used cross-sectional information from the Census to document that regional working-age population does not respond to RTR_r, suggesting that workers did not systematically move away from harder-hit regions (Dix-Carneiro and Kovak, 2017). Here, we are able to utilize the panel dimension of the RAIS data to follow individual workers over time to see whether those initially employed in regions facing larger tariff reductions were more likely to obtain formal employment elsewhere. Note that if migrants leave the formal sector, they leave the RAIS sample, and their migration will not be observed. To lessen potential bias due to differential attrition from formal employment, we calculate the share of formally employed months spent away from the initial region:

$$\frac{MonthsAway_{it}}{Months_{it}}. \tag{6}$$

This measure mitigates selection concerns by conditioning on formal employment and because the vast majority of individuals in our sample spend at least one month in the formal sector between 1990 and 2009.

Fig. 6 reports the relationship between (6) and RTR_r for the tradable worker panel (similar results for the nontradable panel appear in Appendix Fig. B10). The estimates are small and not nearly statistically significantly different from zero. The negative point estimates suggest that, if anything, workers initially employed in regions facing larger tariff declines were *less* likely to migrate to a formal job elsewhere than workers initially employed in more favorably affected regions, although the lack of statistical significance rules out any strong conclusions along these lines. More generally, the only way that this analysis would miss a substantial migration response would be if migrating workers are systematically more likely to switch from formal employment to informal employment upon migration. While this is possible ex-ante, the lack of working-age population response documented in Dix-Carneiro and

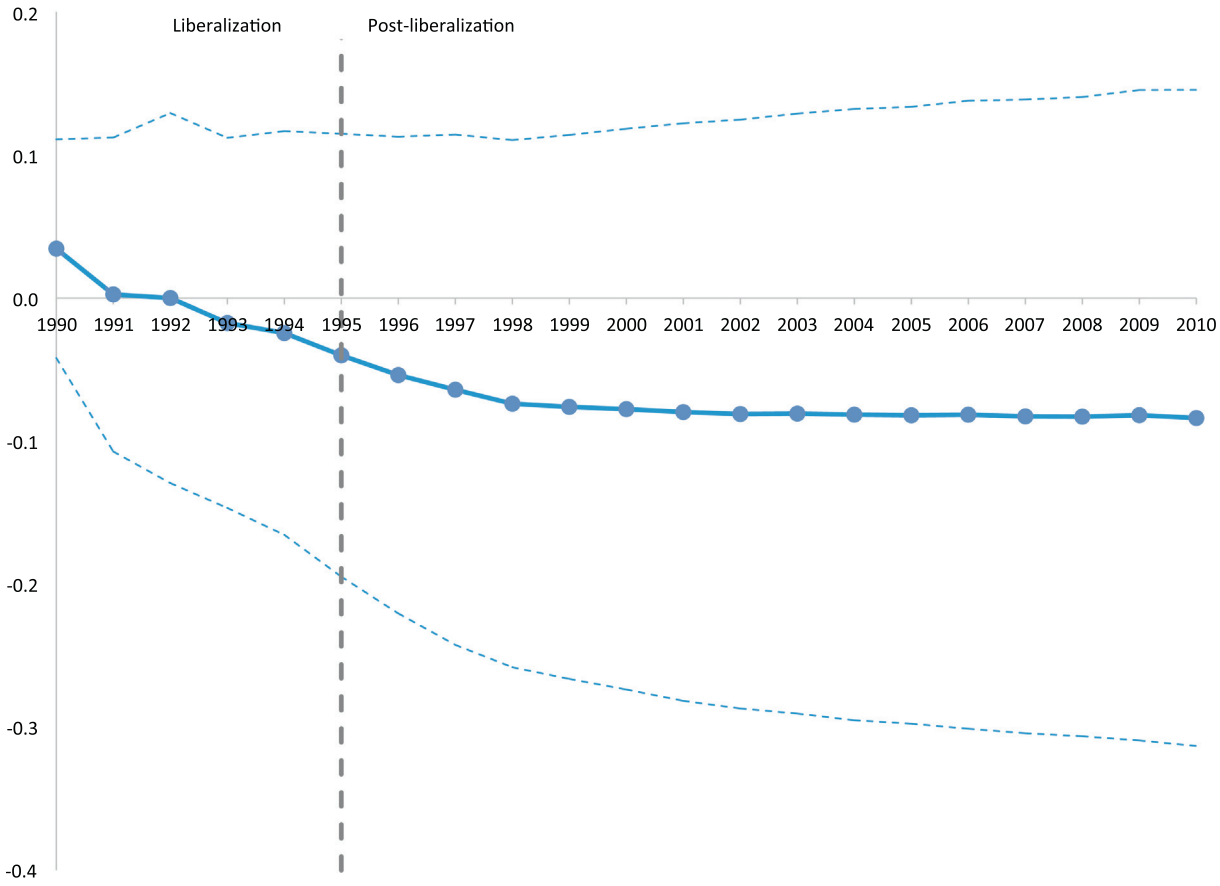


Fig. 6. Fraction of Formally Employed Months in a New Region - Tradable Worker Sample - 1990-2010. Each point reflects an individual regression coefficient, $\hat{\theta}_t$, following (3), where the dependent variable is the fraction of formally employed months in the year listed on the x-axis spent outside the initial region. The independent variable is the regional tariff reduction (RTR_r), defined in (2). Note that RTR_r always reflects tariff reductions from 1990 to 1995. The regressions include state fixed effects and extensive controls for worker, initial job, initial employer, and initial region characteristics (see text for details). Negative estimates imply that workers initially in regions facing larger tariff reductions spend a smaller share of their formal employment outside the initial region than did workers in other regions. The vertical bar indicates that liberalization began in 1990 and was complete by 1995. Dashed lines show 95% confidence intervals. Standard errors adjusted for 106 mesoregion clusters.

Kovak (2017) rules out this possibility. Hence, we find no evidence for systematic migration responses to liberalization-induced labor demand shocks.

5.6. Nontradable sector workers

Recall that the empirical results discussed so far in this section apply to workers who initially worked in tradable industries prior to liberalization, i.e. those in industries directly affected by the tariff shock. We also implemented all of these analyses using an alternate group of workers who were initially employed in the nontradable sector (as of December 1989). Our objective is to see whether workers outside tradable sectors are insulated from the local effects trade liberalization, or whether the tradable and nontradable labor markets are sufficiently integrated that regional trade shocks affect both sectors' workers similarly. This integration may occur through changes in consumer demand for local nontradables or because workers compete for jobs in both the tradable and nontradable sectors.

For all outcomes, workers initially employed in the nontradable sector experience similar effects of liberalization to those of initially tradable sector workers, though generally with somewhat smaller magnitudes. For example, Fig. B6 in Appendix B.3 reports the effects of regional tariff reductions on the average number of months formally employed per year from 1990 to year t, as in (4). The effects are large and grow over time, indicating that nontradable sector workers initially employed in regions facing larger tariff reductions spend less and less time formally employed compared to workers initially employed in more favorably affected regions. The long-run (2010) point estimate for the nontradable sector is −2.7, which implies that a worker whose initial region faced a 10 percentage point larger tariff decline on average worked in the formal sector for 5.7 fewer total months between 1990 and 2010, compared to an unconditional average of 129 months worked in the formal sector for the nontradable sector sample. This large effect implies that the tradable and nontradable sectors were sufficiently integrated that the direct effects of liberalization in the tradable sector spill over into the nontradable sector. However, the nontradable sector effect is 43% smaller than that in the tradable sector (Fig. 3), indicating that workers in the nontradable sector were somewhat insulated from the direct employment effects of liberalization.

The integration of nontradable and tradable sector labor markets is further reinforced by Fig. 7, which breaks the employment analysis of Fig. B6 into months spent in tradable and nontradable employment. The results are quite different from those for tradable sector workers in Fig. 4. The biggest formal employment losses for workers initially employed in the *nontradable* sector occur in the *tradable* sector. Only in the last years of our sample do nontradable sector employment losses become significantly different from zero, while tradable sector losses are large and significant throughout the post-liberalization period. This means that in favorably affected markets, nontradable sector workers regularly transition to tradable employment, but that these workers spend less and less time employed in tradable sectors

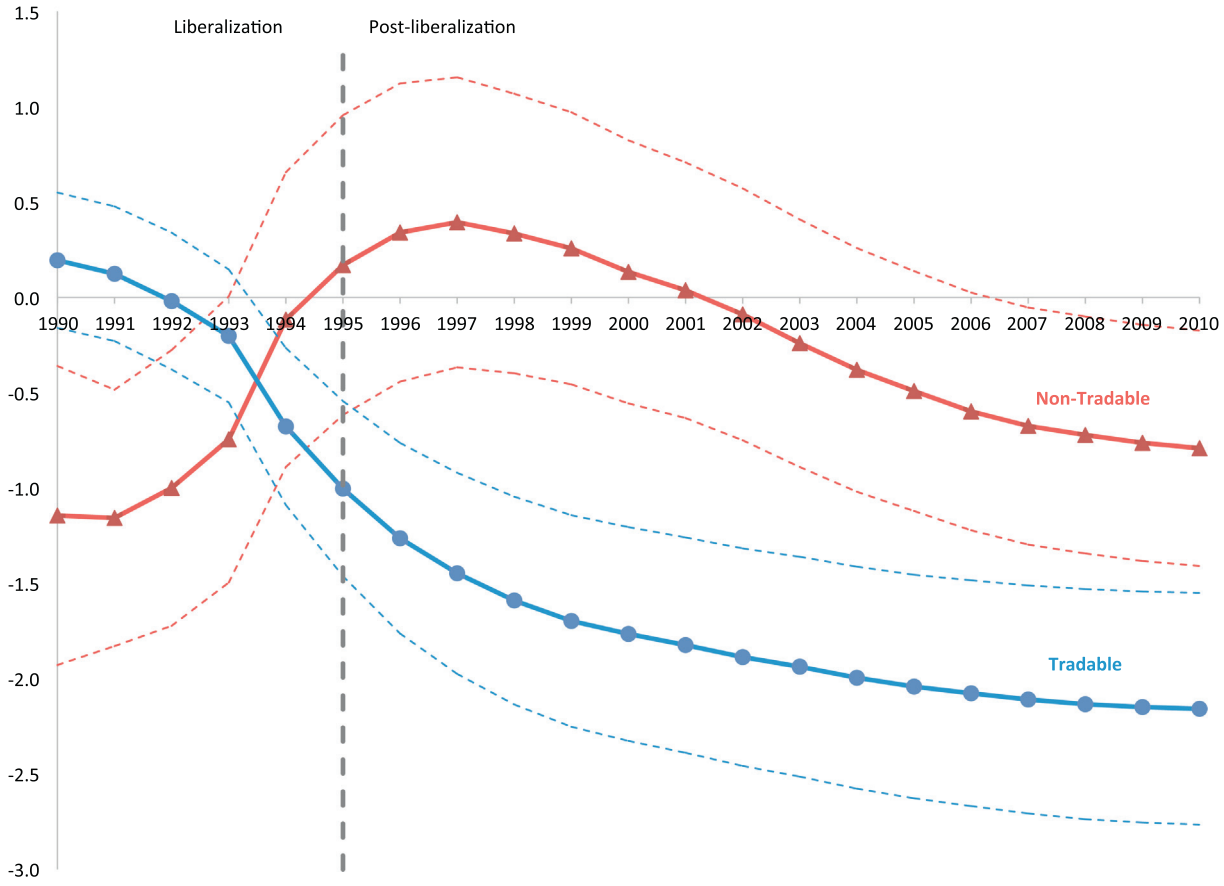


Fig. 7. Average Months Formally Employed in Tradable or Nontradable Sectors Per Year - Nontradable Worker Sample - 1990-2010. Each point reflects an individual regression coefficient, $\hat{\theta}_t$, following (3), where the dependent variable is the average months formally employed in the relevant sector per year from 1990 to the year listed on the x-axis. The independent variable is the regional tariff reduction (RTR_r), defined in (2). Note that RTR_r always reflects tariff reductions from 1990 to 1995. The regressions include state fixed effects and extensive controls for worker, initial job, initial employer, and initial region characteristics (see text for details). Negative (positive) estimates imply that workers initially in regions facing larger tariff reductions spend a smaller (larger) average share of the relevant years formally employed in the relevant sector than workers in other regions. The vertical bar indicates that liberalization began in 1990 and was complete by 1995. Dashed lines show 95% confidence intervals. Standard errors adjusted for 111 mesoregion clusters.

in markets facing larger tariff declines, driving much the overall formal employment losses faced by nontradable sector workers. Table 3 provides additional sectoral detail, finding that nontradable sector workers in harder-hit regions are more likely to transition into low-paying services and construction. However, in the long run, these increases in low-paying services are swamped by decreases in high-paying service employment, leading to the eventual relative decline in nontradable employment seen in Fig. 7.

The other outcomes considered above also exhibit similar patterns in the nontradable and tradable sectors. Appendix B.3 presents results for migration, earnings, and alternative employment measures, and Appendix B.5 documents the robustness of the nontradable-sample results to alternative specifications and controls for post-liberalization shocks, using the same specifications summarized in Section 5.4.

5.7. Summary of worker-level analysis

The results in this section document substantial and growing effects of trade liberalization on workers' formal employment and earnings for 15 years following the end of liberalization. Labor market outcomes of workers initially employed in harder-hit places steadily deteriorate over time and never recover. Adversely affected workers spend less time formally employed and exhibit declining formal earnings compared to workers initially employed in other regions. These findings at the individual level are similar to the region-level results of Dix-Carneiro and Kovak (2017), who find large and growing effects on regional formal employment and earnings.

We also found evidence of various adjustment margins within formal employment. Workers initially in the tradable sector are more likely to transition into nontradable employment when facing more negative shocks. However, these sectoral transitions are too small on average to compensate for losses in the tradable sector. We find minimal effect of regional shocks on inter-regional worker mobility. Although this finding is similar to earlier work, it remains surprising that workers do not migrate in the face of substantially depressed relative labor market conditions in harder-hit regions. Rather, on average, worker adjustment appears to operate along other margins within a given region.

Finally, the evidence strongly supports the conclusion that formal tradable and nontradable sectors are strongly integrated. Workers initially employed in the nontradable sector experienced similar employment and earnings effects to those initially employed in the tradable sector, though with smaller magnitude. Employment losses for initially tradable sector workers were partly offset by transitions into nontradable employment. More strikingly, employment losses for initially nontradable sector workers occurred primarily through reduced subsequent transitions into tradable employment, highlighting the close integration of the two sectors.

6. Regional analysis

In the preceding analyses, we focused on outcomes for formally employed workers. The formal sector is of particular interest for a

Table 3
Average months formally employed in detailed sectors per year - nontradable worker sample - 1990-2010.

Cumulative average months formally employed	1990–1995	1990–2000	1990–2005	1990–2010
Per year	(1)	(2)	(3)	(4)
Panel A: agriculture and mining				
Regional tariff reduction (RTR)	−1.037***	−1.355***	−1.396***	−1.414***
	(0.139)	(0.182)	(0.187)	(0.187)
Panel B: manufacturing				
Regional tariff reduction (RTR)	0.025	−0.419**	−0.653***	−0.751***
	(0.173)	(0.193)	(0.190)	(0.191)
Panel C: low-paying services				
Regional tariff reduction (RTR)	0.455	1.093***	1.181***	1.226***
	(0.364)	(0.281)	(0.242)	(0.217)
Panel D: high-paying services				
Regional tariff reduction (RTR)	−1.190***	−1.918***	−2.544***	−2.834***
	(0.354)	(0.341)	(0.357)	(0.359)
Panel E: construction				
Regional tariff reduction (RTR)	1.143***	1.110***	0.967***	0.879***
	(0.145)	(0.138)	(0.120)	(0.113)
State fixed effects (26)	✓	✓	✓	✓

Regression coefficients, $\hat{\theta}_t$, follow (3). The dependent variable is the average months formally employed per year from 1990 to the year listed in the column heading in the subsector listed in the panel heading. Services are classified as high-paying or low-paying based on industry earnings premia in a Mincer-style wage regression controlling flexibly for age, gender, education, and region. High-paying service industries include public utilities, public administration, education, finance, medicine, and transportation and communications. The independent variable is the regional tariff reduction (RTR_r), defined in (2). Note that RTR_r always reflects tariff reductions from 1990 to 1995. The regressions include state fixed effects and extensive controls for worker, initial job, initial employer, and initial region characteristics (see text for details). Negative estimates imply that workers initially in regions facing larger tariff reductions spend a smaller average share of the relevant years formally employed in the relevant subsector than workers in other regions. Standard errors adjusted for 111 mesoregion clusters.

variety of reasons. It is more capital intensive, dynamic, and productive than the informal sector, and formal jobs are generally seen as being of much higher quality than informal jobs (LaPorta and Schleifer, 2008; Bacchetta et al., 2009; Fajnzylber et al., 2011; LaPorta and Schleifer, 2014). Formal employment gives workers access to all of the benefits and labor protections afforded them by the legal employment system, while informal jobs generally provide minimal benefits and fail to comply with various labor regulations. Jobs in the informal sector are widely perceived as (on average) lower quality jobs as employers may avoid compliance with labor market regulations, and workers may experience increased job insecurity but are not eligible to unemployment insurance. Hence, transitions out of formal employment may involve important declines in worker wellbeing even if displaced workers later find informal employment.

In this section we seek to better understand what happens to workers in harder-hit regions once they leave the formal sector. Although the longitudinal data in RAIS do not provide information on workers outside the formal sector, we turn to Census data, which allow us to examine the roles of informal employment and non-employment in regional labor market adjustment.[27] Recall that the Census reports whether a worker has a signed work card, giving them access to the worker rights and protections afforded them by formal employment. Workers without a signed work card are informally employed.[28] Trade policy's effects on informality are also of independent interest, as evidenced by a large and growing academic literature.[29] Import competition may increase pressure on firms to cut costs by neglecting to comply with labor regulations, and informal jobs are often characterized as providing fewer opportunities for training and advancement and generally less favorable working conditions (Goldberg and Pavcnik, 2007; Bacchetta et al., 2009). Together, these concerns have made informality a prominent issue in public debates over globalization in the developing world (Bacchetta et al., 2009).

6.1. Regional empirical specification

While the RAIS data allow us to follow workers over time, they do not allow us to observe the worker's status outside formal employment. In order to study margins of labor market adjustment involving informal employment or non-employment, we utilize decennial Census data and an empirical approach that examines outcomes at the region level rather than the worker level.[30] In particular, we estimate specifications of the following form,

$$y_{rt} - y_{r,1991} = \theta_t RTR_r + \alpha_{st} + \gamma_t \Delta y_{r,\text{pre}} + \varepsilon_{rt}. \quad (7)$$

We estimate this specification separately for each post-liberalization Census year $t \in \{2000, 2010\}$. y_{rt} is a labor market outcome in region r and year t, RTR_r is the regional tariff reduction defined in (2), α_{st} are state fixed effects (allowed to vary by year), and $\Delta y_{r,\text{pre}}$ is a pre-liberalization change in the outcome (either 1980–1991 or 1970–1980). We use 1991 as the base year for outcome changes because that is the closest Census year to the beginning of liberalization. Since RTR_r does not vary over time, always reflecting tariff reductions from 1990 to 1995, the estimates of θ_t trace out the effects of regional tariff reductions on the regional outcome y_r as of year t. Table 4 presents summary statistics on the regional outcomes examined in the following analyses.[31]

6.2. Regional labor market structure

We have already documented that workers initially employed in regions facing larger tariff reductions spend less and less time formally employed than otherwise similar workers initially in more favorably affected regions. Yet from the RAIS data alone, one can not observe whether these displaced formal workers find informal employment or become non-employed. To shed light on this question, we use the regional empirical strategy just described to examine the effects of

[27] We focus on non-employment, which includes both unemployment and out of the labor force. This approach allows us to avoid changing labor force definitions over time and captures transitions into unemployment and out of the labor force, both of which may be affected by trade reform.

[28] See footnote 15 for papers using the same definition of informality.

[29] See Goldberg and Pavcnik (2007) and Paz (2014) for literature reviews with relevant citations.

[30] In order to maintain consistent regional definitions across Censuses from 1970 to 2010, the analysis in this section partitions Brazil into 405 regions.

[31] Table 4 reports unweighted means and standard deviations across time-consistent microregions. Note that these may differ from similar figures at the national level because of variation in regional populations. See Appendix B.2 for national informality rates etc. Also, Appendix B.8 presents a version of Table 4 with separate panels for regions facing larger and smaller regional tariff reductions, confirming the qualitative patterns we document in our main analyses.

Table 4
Regional analysis summary statistics.

	1991		2000		2010	
	mean	std. dev.	mean	std. dev.	mean	std. dev.
Shares of working-age population						
Not-employed	0.397	0.046	0.399	0.059	0.355	0.076
Informal	0.418	0.090	0.435	0.082	0.370	0.077
Informal employee	0.225	0.062	0.221	0.045	0.216	0.061
Self-employed	0.193	0.081	0.214	0.084	0.154	0.040
Shares of employment						
Formal tradable	0.111	0.094	0.102	0.074	0.121	0.082
Formal nontradable	0.191	0.092	0.172	0.085	0.292	0.101
Informal tradable	0.394	0.203	0.323	0.176	0.259	0.153
Informal nontradable	0.304	0.078	0.403	0.078	0.328	0.056
Average informal earnings (in 2010 R$)	731	396	941	435	890	379
Average overall earnings (in 2010 R$)	708	337	890	363	938	326
Observations	405		405		405	

Decennial Census data. Reports unweighted means and standard deviations across time-consistent microregions. Note that these may differ from similar figures at the national level because of variation in regional populations. See Appendix B.2 for national informality rates etc. All monetary values reported in 2010 R$. In Dec 31, 2010, a US dollar was worth 1.66 Brazilian Reais.

liberalization on the regional shares of working-age (18–64) individuals that are not employed or are informally employed. To ensure that our results are not driven by changes in the regional composition of workers, we control for worker demographics and education, following an approach similar to that of Goldberg and Pavcnik (2003). Separately for each Census year t and each employment category $c \in \{\text{non - employed}, \text{informal}, \text{informal employee}, \text{self - employed}\}$, we estimate regressions of the following form.

$$\mathbf{1}(category_{irt} = c) = \mu_{rt}^{c} + X_{it}\beta_{t}^{c} + e_{irt}^{c}, \tag{8}$$

The dependent variable is an indicator for the employment status of individual i in region r in year t, μ_{rt}^{c} are region fixed effects (allowed to vary across years), and X_{it} is a set of worker controls including 5 age bins, gender indicator, and indicators for individual years of education. The regional fixed effect estimates, $\hat{\mu}_{rt}^{c}$, then capture the share of working-age individuals in the region who have the relevant employment status, purged of variation related to these observable worker characteristics. We use these adjusted employment status shares as dependent variables in regional analyses following (7). Note that this research design explains differences across regions in the growth of informal or non-employed shares of the regional working-age population, rather than aggregate national trends in these shares.[32]

The results appear in Table 5. Columns (1)–(3) examine changes from 1991 to 2000, while columns (4)–(6) examine changes from 1991 to 2010. We control for pre-liberalization share changes for 1980–1991, 1970–1980, and both. Information on formality is unavailable in 1970, so 1970–1980 pre-trends always refer to the non-employed share. All columns include state fixed effects. Panel A shows that regions facing larger tariff declines experience relative increases in the share of the working age population that is not employed. The estimate of 0.301 in column (3) implies that by 2000 a region facing a 10 percentage point larger regional tariff reduction exhibited a 3.01 percentage point larger increase in the non-employed share. This is a large difference, accounting for 7.6% of the baseline average non-employment rate across regions of 0.397 (Table 4). Panel B shows that harder hit regions also experience relative increases in the share of working-age population that is informally employed, although this effect on informal employment is somewhat smaller than the effect on nonemployment in Panel A. By 2010, however, the situation is different. The informal effect increases by even more, while the non-employed effect is small and statistically indistinguishable from zero. Column (6) of Panel B implies that by 2010 a region facing a 10 percentage point larger regional tariff reduction exhibited a 5.28 percentage point larger increase in the informally employed share of the working age population. In the absence of substantial interregional migration, as documented above, these results suggest that many workers whose regions faced larger tariff declines were non-employed in the years just following liberalization, but that many of these individuals later found employment in the informal sector.

Appendix B.6.2 reinforces this interpretation by presenting similar findings for a consistent birth cohort across 1991, 2000, and 2010, ensuring that the results are not driven by compositional change in the working-age population. Hence, transitions to informal employment often occurred following a lengthy spell of non-employment.[33] Table B14 in Appendix B.6.1 splits informal employment into informal employee and self-employed status, finding suggestive evidence that the long-run informality effects reflect workers with few traditional employment options pursuing self-employment[34]. Appendix B.6.2 shows that the results in Table 5 are robust to the many controls and subsamples described above in Section 5.4, and Appendix B.6.3 shows that the results are quite consistent across education levels. Finally, we also emphasize that the effects estimated in Table 5 capture *relative* effects of trade liberalization across regions facing larger and smaller tariff reductions, not aggregate national effects.[35]

The substantial effect of liberalization on local informal employment in Table 5 may appear to contradict other results in the literature studying the response of Brazilian informality to trade policy changes. The apparent conflict is resolved by noting differences in methodology and observed adjustment patterns. For example, Goldberg and Pavcnik (2003) do not find an effect of trade policy on informality, a finding corroborated by Bosch et al. (2012). These papers restrict attention to manufacturing sectors and relate changes in within-industry informality to changes in industry-specific tariffs. This industry-level approach does not capture any informality responses that occur through intersectoral shifts and omits non-manufacturing sectors entirely. As shown in Appendix B.2, during the 1990s, informal shares increased in manufacturing industries, which faced larger tariff cuts, and informal shares declined in agriculture and mining, which faced more positive tariff changes.[36] Our region-level approach captures these shifts between formal and informal employment that occur across industries, including those outside manufacturing.

Menezes-Filho and Muendler (2011) employ an alternative research design, utilizing worker panel data from the *Pesquisa Mensal de Emprego* (PME) to examine yearly employment transitions for individual workers initially employed in manufacturing. This approach has the substantial benefit of observing worker-level transitions between formal employment, informal employment, and non-employment rather than relying on repeated cross-sections, as we do here. However, it is limited in geographic coverage (6 metropolitan areas), and by observing transitions only at the yearly frequency. They find no significant relationship between tariff reductions and the likelihood of transitioning

[32] See Appendix B.2 for information on national informality rates.

[33] Table 1 of Meghir et al. (2015) supports this interpretation, showing very frequent transitions of unemployed workers to informal employment. Transitions from unemployment to informal employment are 4 to 5 times more frequent than transitions from unemployment to formal employment.

[34] These results are merely suggestive, as the distinction between self-employment and informal employment is often unclear in the Brazilian context.

[35] This point applies to analyses at the region or industry levels, including Goldberg and Pavcnik (2003), Menezes-Filho and Muendler (2011), and Bosch et al. (2012). See Appendix B.2 for aggregate trends in informality at the national level.

[36] Appendix Fig. B1 provides a breakdown of informality changes by more detailed industry.

Table 5
Employment category shares of regional working-age population - 2000, 2010.

	1991–2000			1991–2010		
Change in share:	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: not-employed						
Regional tariff reduction *(RTR)*	0.301***	0.306***	0.301***	−0.024	−0.029	−0.023
	(0.043)	(0.040)	(0.043)	(0.057)	(0.055)	(0.058)
Not-employed share pre-trend (80–91)	0.036		0.028	−0.074		−0.035
	(0.045)		(0.057)	(0.057)		(0.071)
Not-employed share pre-trend (70–80)		−0.031	−0.012		0.084*	0.060
		(0.044)	(0.055)		(0.049)	(0.060)
State fixed effects (26)	✓	✓	✓	✓	✓	✓
R-squared	0.479	0.479	0.479	0.584	0.585	0.585
Panel B: informal						
Regional tariff reduction *(RTR)*	0.170***	0.192***	0.213***	0.486***	0.463***	0.528***
	(0.050)	(0.043)	(0.053)	(0.066)	(0.067)	(0.077)
Informal share pre-trend (80–91)	0.015		−0.044	−0.079		−0.136**
	(0.042)		(0.047)	(0.060)		(0.068)
Not-employed share pre-trend (70–80)		0.076	0.112*		−0.000	0.110*
		(0.048)	(0.058)		(0.057)	(0.058)
State fixed effects (26)	✓	✓	✓	✓	✓	✓
R-squared	0.328	0.334	0.336	0.564	0.559	0.567

Decennial Census data. Positive (negative) coefficient estimates for the regional tariff reduction (*RTR*) imply larger increases (decreases) in the relevant employment category share in regions facing larger tariff reductions. The informal share in Panel B covers both informal employees and the self-employed, shown separately in Table B14 in Appendix B.6.1. Changes in employment shares are calculated controlling for regional worker composition (see text for details). Pre-trends computed for 1980–1991 and 1970–1980 periods. Due to a lack of information on informality in the 1970 Census, the 1980–1970 pre-trends always refer to the non-employed share. 405 microregion observations. Standard errors (in parentheses) adjusted for 90 mesoregion clusters. Weighted by the inverse of the squared standard error of the estimated change in the relevant employment share. *** Significant at the 1%, ** 5%, * 10% level.

into informal employment, but do find that output tariff declines lead to increased transitions into non-employment. These findings are consistent with our results if, as suggested by Table 5, many displaced formal sector workers spend more than a year in non-employment before eventually obtaining informal employment. Our findings more closely parallel those of McCaig and Pavcnik (2018), who find substantial shifts from household (informal) to enterprise (formal) employment in Vietnam in response to the U.S.-Vietnam Bilateral Trade Agreement.[37]

To complete the picture of liberalization's effects on regional labor market structure, we examine changes in the shares of regional employment falling in the following four categories: formal tradable, formal nontradable, informal tradable, and informal nontradable. This analysis allows us to understand the role of shifts across sectors vs. changes in informality within sectors. The results appear in Panels A-D of Table 6.[38] Formal tradable employment is clearly the category hardest hit when facing larger regional tariff reductions. The offsetting growth in informal employment that we saw in Panel B of Table 5 does not reflect a shift toward nontradables, but occurs primarily within the tradable sector, as shown in Panel C. Putting these results in context, in Fig. 4 we found that formal tradable sector workers were more likely to transition into formal nontradable sector employment when the initial region faced a more negative labor demand shock. Yet here we generally find small negative or insignificant coefficients for the regional formal nontradable employment share, indicating that this portion of the labor market does not expand to absorb the tradable sector workers transitioning into nontradable employment.[39] What, then, happened to workers initially in the formal nontradable sector? Recall from Fig. 7 that the biggest employment losses for formal workers initially in the nontradable sector occurred in the tradable sector. This means that formal nontradable workers often transition to formal tradable employment, but these transitions occur much less frequently in markets facing larger tariff declines. It is likely that these formal nontradable sector workers who are no longer able to find formal tradable or nontradable employment drive a large portion of the growth in informal tradable employment seen in Table 6.

6.3. Regional earnings

Given that many formally employed workers in regions facing larger tariff declines transitioned to informal employment, we now examine the effects of liberalization on regional informal and overall earnings (including both formal and informal workers). In Dix-Carneiro and Kovak (2017), we show that regions facing larger tariff reductions experience declining formal sector earnings compared to other regions and that this difference grows steadily over time following liberalization. We expect similar results for informal and overall regional earnings because the previous section documented large shifts between regional formal and informal employment and because there is substantial overlap in the industry composition of the formal and informal sectors (Appendix B.2). As in the employment share analysis, we control for changes in the composition of the regional workforce by estimating regressions of the following form.

$$\ln(earn_{irt}) = \mu_{rt} + X_{it}\beta_t + e_{irt} \tag{9}$$

The dependent variable is log earnings for worker i in region r in year t, μ_{rt} are region fixed effects (allowed to vary across years), and X_{it} is the same set of worker controls used in (8). The regional fixed effect estimates, $\hat{\mu}_{rt}$, which we refer to as regional earnings premia, then capture average log earnings in the region, purged of variation related to observable worker characteristics.[40]

[37] Paz (2014) and Cruces et al. (forthcoming) provide two other recent examples that find significant effects of tariff changes on informality using different methodologies.

[38] Note that although these categories partition all employed workers, the coefficients do not precisely sum to zero because of differences in weighting and pre-trends across outcomes.

[39] The lack of increase in nontradable employment in harder hit regions provides insight into the mechanisms integrating the tradable and nontradable sectors. Figs 4 and 7 provide direct evidence of transmission through labor market adjustment, in which workers shift labor supply from tradable to nontradable sectors. However, Table 6 also shows that formal nontradable sector employment, if anything, slightly shrinks in harder-hit regions. This is not consistent with shifts in labor supply alone, which would raise nontradable sector employment and lower worker earnings. Thus, there must also be a decline in the demand for regional nontradable output, so earnings decline but nontradable employment does not expand.

[40] Note that we do not control for industry fixed effects in (9), paralleling the employment category analysis in (8). This choice allows us to capture both the direct effects of tariff reductions in a worker's industry and the indirect effects, operating through regional equilibrium (Hakobyan and McLaren, 2016; Acemoglu et al., 2016). Differences from the similar informal and overall earnings results in Dix-Carneiro and Kovak (2017) result primarily from the exclusion of these industry fixed effects. See Appendix Table B24 for results controlling for industry fixed effects when calculating regional earnings premia.

Table 6
Employment category × sector shares of regional employment and regional earnings premia - 2000, 2010.

	1991–2000	1991–2010
	(1)	(2)
Change in employment share		
Panel A: Formal tradable share		
Regional tariff reduction *(RTR)*	−0.408***	−0.503***
	(0.041)	(0.051)
Panel B: Formal nontradable share		
Regional tariff reduction *(RTR)*	−0.063	−0.042
	(0.063)	(0.094)
Panel C: Informal tradable share		
Regional tariff reduction *(RTR)*	0.604***	0.882***
	(0.046)	(0.081)
Panel D: Informal nontradable share		
Regional tariff reduction *(RTR)*	0.051	0.013
	(0.045)	(0.081)
Dependent variable pre-trend (80–91)	✓	✓
Not-employed share pre-trend (70–80)	✓	✓
State fixed effects (26)	✓	✓
Change in log earnings premia		
Panel E: informal earnings		
Regional Tariff Reduction *(RTR)*	−0.433***	−0.021
	(0.156)	(0.234)
Panel F: Overall earnings		
Regional Tariff Reduction *(RTR)*	−0.495***	−0.535**
	(0.136)	(0.206)
Dependent variable pre-trend (80–91)	✓	✓
Overall earnings pre-trend (70–80)	✓	✓
State fixed effects (26)	✓	✓

Decennial Census data. Positive (negative) coefficient estimates for the regional tariff reduction (*RTR*) imply larger increases (decreases) in the relevant employment × sector category share or earnings in regions facing larger tariff reductions. Changes in employment × sector shares and regional earnings premia are calculated controlling for regional worker composition (see text for details). Pre-trends computed for 1980–1991 and 1970–1980 periods. Due to a lack of information on informality in the 1970 Census, the 1980–1970 pre-trends refer to the non-employed share (in panels A-D) or overall earnings including both formal and informal workers (in panels E and F). 405 microregion observations. Standard errors (in parentheses) adjusted for 90 mesoregion clusters. Weighted by the inverse of the squared standard error of the estimated change in the relevant employment × sector share or earnings premium. *** Significant at the 1%, ** 5%, * 10% level.

Panels E and F of Table 6 report the results of estimating the relationship between regional earnings premia and regional tariff reductions, as in (7). Panel E restricts attention to informal workers, i.e. those without a signed work card, including both informal employees and the self-employed. The estimate in column (1) shows that by 2000, informal earnings declined substantially in regions facing larger tariff reductions, compared to those in other regions; a region facing a 10 percentage point larger tariff decline experienced a 4.33 percentage point larger proportional decline in earnings among informal workers. In contrast, by 2010, these effects have largely disappeared, as seen in the much smaller and statistically insignificant point estimate.

This reduction in magnitude of the informal earnings effect is in sharp contrast to the effects of regional tariff reductions on formal sector earnings, which grow substantially over time. The contrast is somewhat puzzling; we expected informal wages to fall along with formal sector wages. The industry distributions of formal and informal output are similar (Ulyssea (2018) and Appendix B.2), so we expect similar declines in labor demand in both sectors. Also, displaced formal sector workers flood into informal employment (Fig. 3 and Table 5), which we expect to lower informal workers' wages. Appendix B.7.1 subjects the results in Panels E and F of Table 6 to the many robustness tests discussed in Section 5.4, and finds that this surprising pattern of informal earnings effects is somewhat less robust than the other results presented thus far. As an example, when omitting regions most reliant upon agriculture and mining employment, we find the expected pattern of increasing magnitude informal earnings effects over time (Table B23 Panels I and J). That said, for the vast majority of robustness tests, the pattern seen in Table 6 remains.[41]

Because we do not have panel data on the informal sector, we can not strictly rule out selection on worker unobservables. However, in Appendix B.7.1, we present suggestive evidence against this mechanism by documenting consistent informal earnings results when sequentially including more detailed and flexible worker controls when calculating regional informal earnings premia. If selection on unobservables accompanies selection on observables, then we would observe changes as we control for more detailed information on worker observables. The absence of such changes partly mitigates concerns about selection on unobservables.[42] Additionally, we examine the effect of liberalization on overall wages. Under the assumption that the quality of the regional workforce remains constant, this analysis nets out the potential confounding influence of worker selection by combining formal and informal workers together. If the informal earnings results were driven by worker selection alone, we should find growing effects of liberalization on overall regional earnings, but Panel F of Table 6 shows that this is not the case. It finds roughly constant earnings effects over time, with substantial effects in both 2000 and 2010. This pattern is consistent with continuously declining formal sector earnings and recovery in informal earnings (net of composition). Understanding the mechanism behind this result is an important avenue for future work.

Together these results show that declining labor demand in regions facing larger tariff declines led many workers to shift into informal employment or lose employment all together. In the long-run, many of these non-employed workers become self-employed to ensure they have some earnings. Although we cannot make strict welfare claims without more detailed information on workers and jobs in the informal sector, it is quite likely that the observed increases in non-employment and informality both imply substantial declines in workers' labor market outcomes given the apparently undesirable nature of many informal jobs in comparison to formal jobs. Nonetheless, the long-run shifts into informal employment suggest that the informal sector provides an alternative for trade-displaced workers who might have remained unemployed in the absence of an informal option or a more flexible formal labor market.

7. Conclusion

This paper examines various potential margins of labor market adjustment following a large trade liberalization in Brazil. Using both longitudinal administrative data and cross-sectional household survey data, we document a rich pattern of adjustment both at the worker and regional levels. A worker's initial region of employment is very important in determining their subsequent labor market outcomes. Workers initially employed in regions facing larger tariff declines spend less and less time formally employed and earn less and less in the formal sector than a worker initially employed in a more favorably affected region. Consistent with the importance of geographic location, we find no evidence for inter-regional mobility in response to these sharp differences across labor markets, implying that any worker adjustment occurs primarily within region. These worker-level findings complement our previous region-level analyses of the formal labor

[41] See Appendix B.7.1 for versions of Panels E and F of Table 6 with more detailed worker controls when calculating regional earnings premia, following a consistent birth cohort across years, and examining hourly wages rather than monthly earnings. Table B29 in Appendix B.7.1 also examines the effects of regional tariff reductions on *real* earnings, using a local price deflator following Moretti (2013).

[42] See Altonji et al. (2005) for a more formal version of this kind of argument.

market (Dix-Carneiro and Kovak, 2017), and reinforce the central role of local labor markets in determining workers' outcomes during a period of structural change.

Although changes in trade policy are directly incident upon workers in tradable industries, we find substantial effects in the nontradable sector, implying close integration of the two sectors at the regional level. Consistent with this interpretation, in regions facing larger tariff declines, workers are more likely to transition from the tradable sector to the nontradable sector, although these reallocations are not large enough to offset employment declines in the formal tradable sector. This close integration across sectors raises concerns about policies providing targeted compensation for workers in industries experiencing increased import competition, such as Trade Adjustment Assistance in the U.S. When regional labor markets are reasonably integrated across sectors, even workers whose industry did not directly face a trade shock experience the labor market effects of that shock. Policies with industry targeting will fail to address declining earnings and employment rates for for these indirectly affected workers, suggesting potential value in broader policies that cover all displaced workers or target entire regions that are most affected by trade shocks.

Studies of import competition in the U.S. find relative declines in employment and shifts out of the labor force for workers facing larger trade shocks (Autor et al., 2013, 2014; Pierce and Shott, 2016). In the Brazilian context, we find substantial effects of trade liberalization on regional non-employment and informal employment. In particular, our results suggest that in regions facing larger tariff declines, after long periods of non-employment, trade-displaced formal-sector workers eventually settle for the fallback option of informal employment. This pattern suggests that in the absence of increased flexibility in the formal labor market, policies discouraging informal employment may increase non-employment following a trade policy shock, as trade-displaced workers cannot be as easily absorbed by the informal sector. However, the welfare implications of the expansion of the informal sector in response to trade are unclear. For example, Dix-Carneiro et al. (2018) show that Brazilian locations that were exposed to increasing import competition as a result of liberalization experienced relative declines in government revenue and spending, leading to a long-run contraction in the provision of public goods. This result mirrors findings by Feler and Senses (2017) who documented that U.S. regions exposed to increasing Chinese imports experienced a relative contraction in government revenues and in the provision of public goods. Further work is needed to rigorously weigh the various positive and negative effects of growing informal employment following a trade shock.

Although this paper focuses on a middle-income country with a large informal share of employment, with the emergence of the so-called “gig economy” an increasing share of high-income country jobs come with minimal job security, no benefits, and the possibility of part-time work. This sector may play a similar role to the informal sector in developing countries, in providing more flexible employment and in posing challenges for taxing authorities. Our findings on informality therefore suggest a direction for future research in high-income countries, as self-employment and other more flexible work arrangements have become more common. More generally, understanding these deeper interactions between labor regulations and changes in trade policies is an important avenue for future work.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jinteco.2019.01.005.

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