Trade Shocks and Gender: The China Shock's Labor Market Impacts in Brazil*

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Abstract

The China shock is one of the most significant trade shocks in recent history. This analysis investigates its impacts on the Brazilian labor market, with a focus on gender differences, using a dynamic spatial general equilibrium model. The results indicate that the China shock led to a reduction of approximately 0.5 percentage points in total employment participation for both men and women. This translates to a loss of about 400,000 manufacturing jobs compared to a scenario without the China shock. Given the initial differences in sectoral labor allocation by gender, the sectoral contributions and spatial effects differ for men and women. The welfare effects for workers are positive in aggregate terms, but differ by gender: 0.6% for men and 0.4% for women.

Keywords: Trade shocks, general equilibrium, gender differences, labor market, Brazil

1 Introduction

The emergence of China as a global economic power has had significant impacts on the global economy and local labor markets. Specifically, China's accession to the World Trade Organization (WTO) in 2001 and the subsequent expansion of its exports led to a global trade shock that affected various countries, including Brazil. According to Autor et al. (2013), the increase in Chinese imports had profound effects on the labor market in the United States. Regions more exposed to Chinese competition experienced greater job losses (or smaller job increases) in manufacturing, wage declines (or smaller wage growth), and increases (or smaller reductions) in unemployment rates relative to less exposed regions. These effects were particularly pronounced in areas with a high concentration of manufacturing industries, highlighting the magnitude of the impact of the Chinese trade shock.

Complementarily, Caliendo et al. (2019) (hereafter CDP) conducted an analysis of the effects of the China shock in the United States using a dynamic spatial trade and migration model to analyze the general equilibrium effects on the United States labor markets. These authors find that the China shock was responsible for the reduction of approximately 550,000 manufacturing jobs in the United States. Additionally, the authors show that, although the aggregate effect on workers' welfare variation is positive, the effects are quite heterogeneous, with welfare reductions being more common in labor markets related to manufacturing, which is the activity most exposed to Chinese competition.

Specifically regarding the effects of trade shocks on Brazilian labor markets, a set of studies has investigated how competition with Chinese products affected different sectors and regions of the country. For example, Costa et al. (2016) analyzed the effects of increased competition from Chinese imports and China's demand for

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commodities on employment and wages in Brazil, finding that regions more exposed to Chinese import competition experienced lower growth in manufacturing wages. Conversely, the shock to Brazilian commodity exports to China had a positive effect on wage growth in regions more exposed to this shock.

Another relevant point is presented by Dix-Carneiro and Kovak (2019) for the trade liberalization shock of the 1990s. The authors show that trade liberalization in Brazil had persistent effects on the labor market, with significant reductions in the relative wages of workers in tradable sectors. The authors also show that workers in tradable sectors have a higher probability of transitioning to the non-tradable sector. Worker migration effects between regions are quite low, indicating low spatial mobility of workers in Brazil. The evidence from Dix-Carneiro and Kovak (2019) highlights the importance of considering the existence of segmented labor markets with limited worker transitions between these markets, particularly transitions between regions.

Carneiro (2023) conducts a similar exercise to CDP but also analyzes the shock on commodity demand. The author finds that the China shock led to a reduction in the share of manufacturing in total employment in the Brazilian economy, for both the import shock and the export shock. The author also finds that the China shock led to an increase in the share of the services sector in total employment. Carneiro (2023) also investigates the heterogeneous effects on the Brazilian labor market, distinguishing between skilled and unskilled labor. The author finds that the China shock on Brazilian imports led to an increase in the share of unskilled labor, mainly in manufacturing and the services sector. For the export shock, the estimated effect is an increase in the share of unskilled labor in both tradable and non-tradable sectors. An empirical analysis, similar to those conducted by Autor et al. (2013) and Costa et al. (2016), also forms part of the study. The author does not find effects of the import shock on total employment but finds that there was a reduction in informal workers and an increase in formal workers. For the export shock, the author finds an increase in total employment, along with an increase in the participation of formal workers.

Connolly (2022) and Cristofani et al. (2023) analyze the impact of the China shock on Brazil's labor market, particularly its differing effects on men and women. Connolly (2022) finds that regions more exposed to China's import shock experienced slower wage growth compared to less affected areas, with this trend appearing for both men and women without significantly changing the wage ratio. In contrast, the export shock had the opposite effect, leading to higher wage growth in more exposed regions. Regarding employment, Connolly (2022) observes that the import shock increased overall employment and the share in total employment, primarily within the formal sector, while no notable employment effects were found for the export shock. Cristofani et al. (2023), however, identify that in cases with significant effects, the import shock contributed to a decline in women's relative participation in formal employment in Brazil between 2000 and 2010, although no substantial employment changes were observed when analyzing men and women separately. Interestingly, both studies find that the import shock resulted in an increase in women's wages relative to men's within the formal sector.

This study aims to contribute to the discussion on the effects of the China import shock on the Brazilian labor market, with a particular focus on gender differences. It employs a general equilibrium approach based on a dynamic spatial trade and migration model with capital accumulation, primarily building on CDP. The capital accumulation module generates larger results compared to the version without capital accumulation. The analysis involves constructing a counterfactual scenario in which the China shock, defined as the estimated increase in manufacturing sector imports between 2000 and 2010, does not occur. The resulting effects are then compared to a reference scenario where the China shock is present.

In aggregate terms, the results indicate a similar reduction in the share of manufacturing in total employment for men and women. However, there is a differentiation in the relocation trajectories. The gain in the share of agriculture is more significant for men than for women. The opposite is observed for the services sectors. For women, the textiles, apparel, and leather products sector presents the largest contribution to the reduction in the share of manufacturing, exceeding 60%. For men, the contribution is less concentrated in a single sector, with the textiles, apparel, and leather products sector presenting the largest contribution, but with a share slightly above 20%. As expected, the largest states contribute more to the reduction in the share of manufacturing, with São Paulo, Rio Grande do Sul, and Minas Gerais presenting the largest contributions. However, when the contribution is analyzed in normalized terms, the states of Ceará and Rio Grande do Sul present the largest relative contributions for female workers. For men, the largest contributions are in the states of the southern region of Brazil and in the state of São Paulo.

In terms of welfare, the vast majority of labor markets show gains, with some exceptions of welfare losses. However, it is found that the variation in welfare for women tends to be lower than for men. In aggregate terms, the results are positive for both genders. For capital owners, the results are also positive, with aggregate welfare gains in all states. Generally, labor markets linked to manufacturing sectors show a reduction in real wages more frequently compared to other sectors.

The remainder of this article is structured as follows: Section 2 presents the details of the model used, Section 3 presents the data used, Section 4 presents the details of the exercise conducted and its results, and finally, Section 5 presents the conclusions of the study.

2 Model

The model used in this work is heavily based on the model presented by CDP. However, the model is expanded to include differentiation in labor inputs and capital accumulation similar to Caliendo et al. (2023). While Caliendo et al. (2023) differentiate labor by skill level, in this study, the labor used by firms is a composition of male and female workers.

In the model, there are N regions, of which R regions are internal regions of a main region, in this study, Brazil. Additionally, there are J productive sectors and $G = 2$ (men and women) types of labor. The regions are indexed by n or i, the sectors by j or k, and the types of labor by g. Time is discrete and indexed by t. The model is solved using the "dynamic exact hat algebra" presented in CDP.

2.1 Households

Each worker supplies one unit of labor inelastically. This worker can be employed or non-employed.[1] The wage received by a worker in region n, sector j, and gender g is equal to w_t^{njg}. Workers consume final goods from all sectors based on a Cobb-Douglas aggregator. That is, in period t, this aggregator takes the form

$$C_t^{njg} = \prod_{k=1}^{J} \left(c_t^{njg,k}\right)^{\alpha^{nk}},$$

where $c_t^{njg,k}$ is the consumption of good k by the family in region n, sector j, and gender g, and α^{nk} is the share of good k in the final consumption of the family in region n, with $\sum_{k=1}^{J} \alpha^{nk} = 1$. Workers who are not employed have their consumption given in terms of own production, that is, $C_t^{n0g} = b^n$, with $b^n > 0$.

The model also considers the possibility that the worker can migrate between sectors and regions, based on a dynamic problem. Considering that workers have perfect foresight about the future, that the future is discounted at a rate β, that the worker has an adjustment cost of changing sector and region ($\tau^{nj,ik,g} \geq 0$), and is subject to idiosyncratic shocks ε_t^{ikg} distributed i.i.d. over time and distributed as a Type-I extreme value distribution with zero mean and dispersion factor equal to ν, the worker's problem can be expressed as

$$\begin{aligned} v_t^{njg} &= \log(C_t^{njg}) + \max_{\{i,k\}_{i=1,k=0}^{N,J}} \{\beta E[v_{t+1}^{ikg}] - \tau^{nj,ik,g} + \nu\varepsilon_t^{ikg}\} \\ \text{s.t. } C_t^{njg} &\equiv \begin{cases} b^n \text{ if } j = 0 \\ \frac{w_t^{njg}}{P_t^n} \text{ otherwise} \end{cases} \end{aligned} \tag{1}$$

where v_t^{njg} is the lifetime utility of the worker of gender g who is currently in region n and sector j. $\log(C_t^{njg})$ is the utility obtained by consuming C_t^{njg}, and $P_t^n = \prod_{k=1}^{J}(P_t^{nk}/\alpha^{nk})^{\alpha^{nk}}$ is the consumer price index in

[1] The sector referring to non-employment is indexed as $j = 0$.

region n. The expectation is calculated concerning future values of the shock. The worker chooses the region i and k that maximizes their expected utility, discounted and adjusted by the adjustment cost $\tau^{nj,ik,g}$ and the idiosyncratic shock ε_t^{ikg}.

Defining $V_{t+1}^{ikg} \equiv E[v_{t+1}^{ikg}]$ and considering the assumption about idiosyncratic shocks, in period t, we can rewrite Equation (1) as

$$V_t^{njg} = \log(C_t^{njg}) + \nu \log\left(\sum_{i=1}^{N}\sum_{k=0}^{J} \exp(\beta V_{t+1}^{ik} - \tau^{nj,ik,g})^{1/\nu}\right). \tag{2}$$

CDP also show that, considering the assumption about idiosyncratic shocks, in period t, the fraction of workers in region n and sector j who migrate to region i and sector k for gender g, $\mu_t^{nj,ik,g}$, follows

$$\mu_t^{nj,ik,g} = \frac{\exp\left(\beta V_{t+1}^{ikg} - \tau^{nj,ik,g}\right)^{1/\nu}}{\sum_{m=1}^{N}\sum_{h=0}^{J} \exp\left(\beta V_{t+1}^{mhg} - \tau^{nj,mh,g}\right)^{1/\nu}}. \tag{3}$$

From the values $\mu_t^{nj,ik,g}$ and the stock of workers in period t, L_t^{njg}, we calculate the stock of workers in period $t+1$ (L_{t+1}^{ikg}) as

$$L_{t+1}^{njg} = \sum_{i=1}^{N}\sum_{k=0}^{J} \mu_t^{ik,nj,g} L_t^{ikg}. \tag{4}$$

2.2 Capital Accumulation

The process of capital accumulation follows the one presented in Kleinman et al. (2023) and Caliendo et al. (2023). In each region n, the capital owners, who will be called landlords, make decisions about consumption and investment with the objective of maximizing lifetime utility subject to a budget constraint. The landlords' problem is

$$\begin{aligned} v_t^{l,n} &= \max_{\{C_t^{l,n}, K_{t+1}^n\}} \sum_{t=0}^{\infty} \beta^t \log(C_t^{l,n}) \\ \text{s.t.} \quad r_t^n K_t^n &= P_t^n (C_t^{l,n} + K_{t+1}^n - (1-\delta) K_t^n), \end{aligned} \tag{5}$$

where $v_t^{l,n}$ is the lifetime utility of the landlords in region n, $C_t^{l,n} = \prod_{k=1}^{J}\left(c_t^{l,nk}\right)^{\alpha^{nk}}$ is the aggregate consumption of the landlords, K_t^n is the capital stock in region n, P_t^n is the consumer price index in region n, δ is the capital depreciation rate.[2] K_0^n is the initial capital stock given in region n. It is assumed that capital is perfectly mobile between sectors within the same region, but not between regions. Thus, there is a single value for the return rate of capital in each region, r_t^n.

The solution to the landlords' problem yields the following policy functions

$$C_t^{l,n} = (1-\beta)[r_t^n / P_t^n + (1-\delta)] K_t^n, \tag{6}$$

and

$$K_{t+1}^n = \beta[r_t^n / P_t^n + (1-\delta)] K_t^n. \tag{7}$$

Equation (7) is the law of motion of capital in region n.

[2] In the simulations, we set $\delta = 0.05$.

2.3 Production

For each sector and region, it is possible to produce many varieties of products. Production is carried out using a Cobb-Douglas technology, with capital, labor, and materials as inputs. Capital and labor are the primary factors of production, with labor being an aggregation of male and female workers. Additionally, total factor productivity is composed of a time-varying term, A_t^{nj}, and another that is specific to each variety, z^{nj}. Thus, the production of an intermediate good with efficiency level equal to z^{nj} in a region n and sector j follows

$$q_t^{nj} = z^{nj} \left(A_t^{nj} (k_t^{nj})^{\xi^{nj}} (l_t^{nj})^{1-\xi^{nj}} \right)^{\gamma^{nj}} \prod_{k=1}^{J} \left(M_t^{nj,nk} \right)^{\gamma^{nj,nk}}, \tag{8}$$

where q_t^{nj} is the quantity produced of the variety with productivity z^{nj}, k_t^{nj} is the amount of capital, l_t^{nj} is the amount of labor, $M_t^{nj,nk}$ is the amount of material k used in the production of variety j in region n, and $\gamma^{nj} \geq 0$ and $\gamma^{nj,nk} \geq 0$ are, respectively, the shares of value added and materials from sector k in the production of variety z^{nj} in region n of sector j. ξ^{nj} is the share of capital in the value added of sector j in region n. Regarding the technical coefficients, assuming constant returns to scale, we have $\gamma^{nj} + \sum_{k=1}^{J} \gamma^{nj,nk} = 1$.

Additionally, l_t^{nj} is a CES (constant elasticity of substitution) aggregator of male and female workers, with elasticity of substitution σ. The total amount of labor used in the production of product varieties in a region n and sector j can be written as

$$l_t^{nj} = \left(\sum_{g=1}^{G} {\lambda_t^{njg}}^{\frac{1}{\sigma}} {l_t^{njg}}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{9}$$

where λ_t^{njg} and l_t^{njg} are, respectively, the distribution parameters and the amount of labor of type g used in the production of variety j in region n.

Considering that the remuneration of capital is equal to r_t^{nj}, the labor remuneration index is equal to w_t^{nj}, and the price of materials is equal to P_t^{nk}, the unit cost of the input basket, x_t^{nj}, equals

$$x_t^{nj} = \Upsilon \left((r_t^{nj})^{\xi^{nj}} (w_t^{nj})^{1-\xi^{nj}} \right)^{\gamma^{nj}} \prod_{k=1}^{J} \left(P_t^{nk} \right)^{\gamma^{nj,nk}}, \tag{10}$$

where Υ is a constant and $w_t^{nj} = \left(\sum_{g=1}^{G} \lambda_t^{njg} (w_t^{njg})^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$.

2.4 Trade

Trade is treated as a multi-sector version of the model by Eaton and Kortum (2002) developed by Caliendo and Parro (2015). In this model, each region consumes varieties from the origin that has the lowest price. Considering that there are iceberg-type trade costs between importer n and exporter i in sector j, $\kappa_t^{nj,ij} \geq 1$, the price of the variety $z^j = (z^{1j}, z^{2j}, ..., z^{Nj})$ consumed in region n becomes

$$p_t^{nj} = \min_{i=1}^{N} \left\{ \frac{\kappa_t^{nj,ij} x_t^{ij}}{z^{ij} (A_t^{ij})^{\gamma^{ij}}} \right\}. \tag{11}$$

These varieties are called intermediate goods and are aggregated into a final sectoral composite good using a CES aggregator with elasticity of substitution η^j. The local production in region n of the final good in sector j, Q_t^{nj}, corresponds to

$$Q_t^{nj} = \left(\int (\tilde{q}_t^{nj}(z^j))^{\frac{\eta^j-1}{\eta^j}} d\phi^j(z^j) \right)^{-\frac{\eta^j}{\eta^j-1}}, \tag{12}$$

where $\tilde{q}_t^{nj}(z^j)$ is the quantity demanded of a given intermediate good supplied by the lowest price source, $d\phi^j(z^j) = \exp\left\{-\sum_{n=1}^{N}(z^{nj})^{-\theta^j}\right\}$ is the joint distribution over the vector z^j, and the marginal distribution is given by $d\phi^j(z^{nj}) = \exp\left\{-(z^{nj})^{-\theta^j}\right\}$, with the integral over $\mathbb{R}_+^N$. The parameter θ^j defines the productivity dispersion within the sector. The higher its value, the lower the dispersion. The final good can be used both in the consumption for the production of intermediate goods and for final consumption.

Considering the Fréchet distribution, Caliendo and Parro (2015) show that the price index of the final good, P_t^{nj}, and the share of each origin i in the total expenditure of sector j in region n, $\pi_t^{nj,ij}$, are

$$P_t^{nj} = \Gamma^{nj}\left(\sum_{i=1}^{N}(x_t^{ij}\kappa_t^{nj,ij})^{-\theta^j}(A_t^{ij})^{\theta^j\gamma^{ij}}\right)^{-1/\theta^j}, \tag{13}$$

and

$$\pi_t^{nj,ij} = \frac{(x_t^{ij}\kappa_t^{nj,ij})^{-\theta^j}(A_t^{ij})^{\theta^j\gamma^{ij}}}{\sum_{m=1}^{N}(x_t^{mj}\kappa_t^{nj,mj})^{-\theta^j}(A_t^{mj})^{\theta^j\gamma^{mj}}}. \tag{14}$$

Equation (14) shows that this model also generates a gravity equation. Trade flows are directly influenced by productivities and trade costs.

2.5 Market Clearing

In order to define the market clearing conditions for labor and capital factors, it is necessary to define the total expenditure of each region in each sector. Following the approach of CDP to accommodate trade deficits, we will assume that landlords send their incomes to a global portfolio and receive a constant share, ι^n of this portfolio. Thus, the capital income received by each region n is equal to $\iota^n\sum_{i=1}^{N}r_t^nK_t^n$. Additionally, the total labor income is equal to $\sum_{j=1}^{J}\sum_{g=1}^{G}w_t^{njg}L_t^{njg}$. Thus, the total expenditure of each region n in sector j amounts to

$$X_t^{nj} = \sum_{k=1}^{J}\gamma^{nk,nj}\sum_{i=1}^{N}\pi_t^{ik,nk}X_t^{ik} + \alpha^{nj}I_t^n, \tag{15}$$

where $I_t^n = \sum_{j=1}^{J}\sum_{g=1}^{G}w_t^{njg}L_t^{njg} + \iota^n\sum_{i=1}^{N}r_t^nK_t^n$. The first part of Equation (15) represents the expenditure originating from the consumption of activities for the production of varieties, and the second part refers to the final consumption of each region.

Using the expenditure, it is possible to compute the demands for capital and labor by the producers of each region. For labor, the market clearing condition reads

$$L_t^{njg} = \frac{\psi_t^{njg}(1-\xi^{nj})\gamma^{nj}\sum_{i=1}^{N}\pi_t^{ij,nj}X_t^{ij}}{w_t^{njg}}, \tag{16}$$

where $\psi_t^{njg} = (\lambda_t^{njg}(w_t^{njg})^{1-\sigma})/(\sum_{g=1}^{G}\lambda_t^{njg}(w_t^{njg})^{1-\sigma})$ is the gender g labor share in the wage bill of sector j in region n. For capital, the market clearing condition becomes

$$K_t^n = \frac{\sum_{j=1}^{J}\xi^{nj}\gamma^{nj}\sum_{i=1}^{N}\pi_t^{ij,nj}X_t^{ij}}{r_t^n}. \tag{17}$$

2.6 Equilibrium

Given the initial allocations of labor, $\{L_0^{njg}\}_{i=1,j=1,g=1}^{N,J,G}$, and the initial capital stock of each region, $\{K_0^n\}_{n=1}^{N}$, in addition to the sequence of fundamentals $\{\{\tau^{nj,ik,g}, b^n, A_t^{nj}, \lambda_t^{njg}\kappa_t^{nj,ij}\}_{n=1,j=1,g=1}^{N,J,G}\}_{t=0}^{\infty}$, it is possible to define the sequential competitive equilibrium as a sequence of values, labor allocations, capital stocks, prices of goods and factors, trade shares, and production costs, $\{\{V_t^{njg}, L_t^{njg}, K_t^n, P_t^{nj}, w_t^{njg}, r_t^n, x_t^{nj}, \pi_t^{nj,ij}\}_{n=1,j=1,g=1,i=1}^{N,J,G,N}\}_{t=0}^{\infty}$. Additionally, the model parameters are $\{\{\alpha^{nk}, \nu, \gamma^{nj}, \gamma^{nj,nk}, \xi^{nj}, \sigma, \theta^j\}_{n=1,j=1,k=1}^{N,J,J}\}$. It is worth noting that $-\theta^j$ is interpreted in this model as the trade elasticity and ν is the inverse of the migration elasticity.

2.7 Solving the model

The model can be solved using the dynamic-hat algebra technique introduced in CDP. This approach allows the construction of counterfactual scenarios without needing the values of the fundamentals, only their variations. This significantly reduces the information required for simulations. To implement this, the model must first be expressed in relative differences over time. CDP thoroughly explain the derivation of this model in exact differences, so we will not reproduce it here for brevity.

The model solution can be divided into two components. In the dynamic component, the equations (2), (3), (4), and (7) form a system of non-linear equations for the variables V_t^{njg}, $\mu_t^{nj,ik,g}$, L_t^{njg}, and K_t^n. However, this system relies on other variables such as r_t^n, P_t^n, and w_t^{njg}. These variables are determined in what is known as temporary equilibrium. This equilibrium is established by the equations (10), (13), (14), (15), (16), and (17). These equations constitute a system of non-linear equations for the variables x_t^{nj}, P_t^{nj}, $\pi_t^{nj,ij}$, X_t^{nj}, w_t^{njg}, and r_t^n.

Finally, applying propositions 1 to 3 of CDP, it is possible to solve the baseline and the counterfactual of this model. The baseline can be calculated in part using time-varying fundamentals for the period for which there is data available and constant fundamentals for the other periods. The counterfactual, in turn, is calculated relative to the baseline. Thus, it is only necessary to know the relative variation of the fundamentals between the baseline and the counterfactual, without the need to know the actual variations of the base scenario.

3 Data

To simulate the impacts of the China shock, it is necessary to gather data to estimate model parameters and establish initial values for key variables. These include transition probabilities between sectors and regions, initial worker allocation, capital stock, trade matrices, and other relevant factors.

The main data sources used in this study are as follows: from the Brazilian Institute of Geography and Statistics (IBGE), the Demographic Censuses of 2000 and 2010, the National Household Sample Survey (PNAD), the Regional Accounts System from 2002 to 2014, and the Annual Industrial Survey - Enterprise (PIA-Empresa) from 2000 to 2014; from the Ministry of Labor and Employment of Brazil, the Annual Social Information Report (RAIS) from 1999 to 2014; from the Brazilian Foreign Trade Secretariat (SECEX), the export and import data for each state in Brazil; and finally, the data from the World Input-Output Database (WIOD) for the years 2000 to 2014.

The data from the Demographic Censuses, PNAD, and RAIS are used to estimate the transition matrix between sectors and regions of Brazilian states. For the other regions, it is assumed that there is no possibility of transition between regions, but within each of these other regions, labor is perfectly mobile. In the Appendix, we detail the methodology used to estimate these matrices.

The labor stock for the initial year, L_0^{njg}, is computed from the 2000 Demographic Census data. The sectors are aggregated from CNAE-Domiciliar to the International Standard Industrial Classification (ISIC Rev. 4) and from ISIC to WIOD sectors. Finally, the WIOD sectors are aggregated to the final level used in this study. The Census data also allowed for the calculation of the share of men and women in the wage bill of each sector and state. These shares are used to compute ψ_0^{njg}.

The WIOD data is initially aggregated into 5 regions: Brazil, China, European Union, United States, and Rest of the World. The WIOD data allows for the calculation of the coefficients α^{nk}, γ^{nj}, $\gamma^{nk,nj}$, ξ^{nj}.

These parameters were computed using, respectively, the final consumption data, value added over production, intermediate consumption value over production, and capital remuneration share in value added. The data for the year 2000 was considered the base for calculating these coefficients. The WIOD also provides the trade share matrices between regions by sector, $\pi_t^{nj,ij}$. These matrices are computed for the years 2000 to 2014 and will be used in the baseline construction. The capital stock from 2000 to 2014 originates from the Socio-Economic Accounts (SEA) of WIOD for the years 2000 to 2014.

However, it is worth noting that this data initially does not cover state-level disaggregation for Brazil. Therefore, before computing the coefficients and variables, a disaggregation process of Brazilian data is carried out considering the databases listed above and the detailed process in the Appendix.

3.1 Elasticities

To conduct the simulation analyzing the effects of the China shock, we require values for certain model parameters, such as the trade elasticities, θ^j, the elasticity of substitution between male and female workers, σ, and the inverse of the migration elasticity, ν.

For trade elasticity, we will consider values derived from the Armington elasticities estimated by Oliveira and Cordeiro (2023) for Brazil using the method of Feenstra et al. (2018). This work estimates the Armington elasticities. However, Eaton and Kortum (2002) also noted that the Armington model generates a formula for trade shares that is equal to their model, with the distinction of using $-\theta^j$ or $(1 - \sigma_A^j)$ as the parameter, where σ_A^j is the Armington elasticity for sector j. Thus, we will use the values of σ_A^j from Oliveira and Cordeiro (2023) to compute $\theta^j = \sigma_A^j - 1$.[3]

For the elasticity of substitution between male and female workers, σ, Bekkers et al. (2023) list a variety of estimates available in the literature. For the United States, Weinberg (2000) consider substitution elasticities ranging from 1.6 to 3.2. Also for the United States, Acemoglu et al. (2004) estimate a substitution elasticity of approximately 3. Meanwhile, Giorgi et al. (2015) estimate a substitution elasticity between 1 and 1.4. We chose to use 1.6, which is the same value used by Bekkers et al. (2023).

For the inverse of the migration elasticity, ν, we use the adaptation by CDP for the log utility of the method proposed by Artuç et al. (2010). The following specification is estimated:

$$\log(\mu_t^{nj,nk}/\mu_t^{nj,nj}) = \tilde{C} + \frac{\beta}{\nu}\log(w_t^{nk}/w_t^{nj}) + \beta\log(\mu_{t+1}^{nj,nk}/\mu_{t+1}^{nj,nj}) + \bar{\omega}_{t+1}, \tag{18}$$

where $\tilde{C}$ is a constant term and $\bar{\omega}_{t+1}$ is an error term. The value of β is set to 0.95. The gender index g is omitted, considering that the estimation is conducted for male and female workers in aggregate. Additionally, the sectoral aggregation considered is the same as used by Artuç et al. (2010). The data used for the estimation comes from RAIS. The obtained estimate is $\nu = 4.66$ with a standard deviation of 0.96.

3.2 Labor Allocation in Brazil

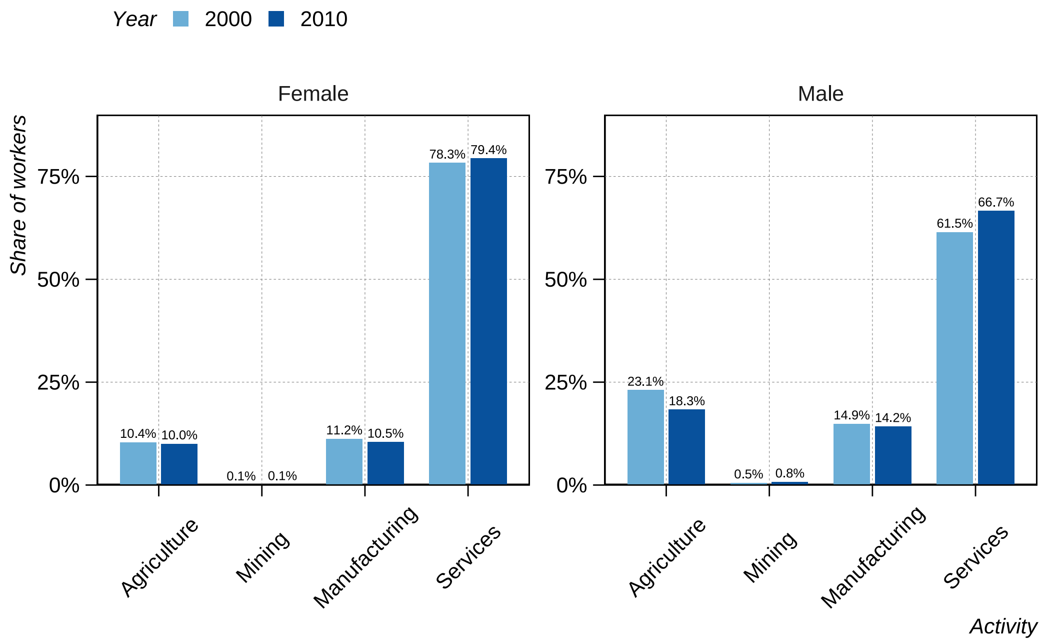
We will briefly contextualize the distribution of labor by gender across sectors in Brazil using data from the 2000 and 2010 Censuses. Figure 1 presents the distribution of employment by economic activity in Brazil for the years 2000 and 2010 disaggregated by gender. Firstly, for Agriculture, there is a considerable difference in the share of total employment between men and women, being much more relevant for men, representing 23.3% of total employment observed in 2000 for this group of workers. For women, in 2000, agriculture represented 10.5% of total employment. However, there is a loss of Agriculture's share in total employment for both genders, being much more pronounced for men.

For manufacturing, in 2000, a higher share is also observed for men (14.8%) than for women (11.2%). For these two groups, there was a slight reduction in the share of manufacturing in total employment between

[3] We use the values of the Armington microelasticities presented in Table 2 of Oliveira and Cordeiro (2023).

2000 and 2010. Additionally, the services sector is relatively more important for women than for men, but it has been gaining share in total employment for both genders.

Figure 1: Distribution of workers by activity - Brazil - 2000 and 2010



Note: The distribution of employment by economic activity in Brazil is shown for the years 2000 and 2010 disaggregated by gender. Authors' calculations based on Brazilian population census data.

Figure 2 demonstrates the heterogeneity in the sectoral distribution of employment within the manufacturing sector in Brazil for the years 2000 and 2010. It is observed that employment is much more sectorally concentrated for women than for men. For women, the textiles, clothing, and footwear sector represents more than 50% of employment in manufacturing in 2000 and 2010. For men, the level of concentration is lower, with no sector exceeding 20% of employment in manufacturing.

Figure 3 presents the share of manufacturing in total employment for each Brazilian state by gender in the year 2000. Generally, the share of manufacturing in total employment is higher for men than for women. An exception is the state of Ceará (CE), which shows a higher share of manufacturing in total employment for women at 15.7% compared to 10.7% for men. For women, the states with the highest shares are Santa Catarina (SC), Ceará (CE), Rio Grande do Sul (RS), São Paulo (SP), and Goiás (GO). For men, the states with the highest shares are Santa Catarina (SC), São Paulo (SP), Rio Grande do Sul (RS), Paraná (PR), and Minas Gerais (MG).

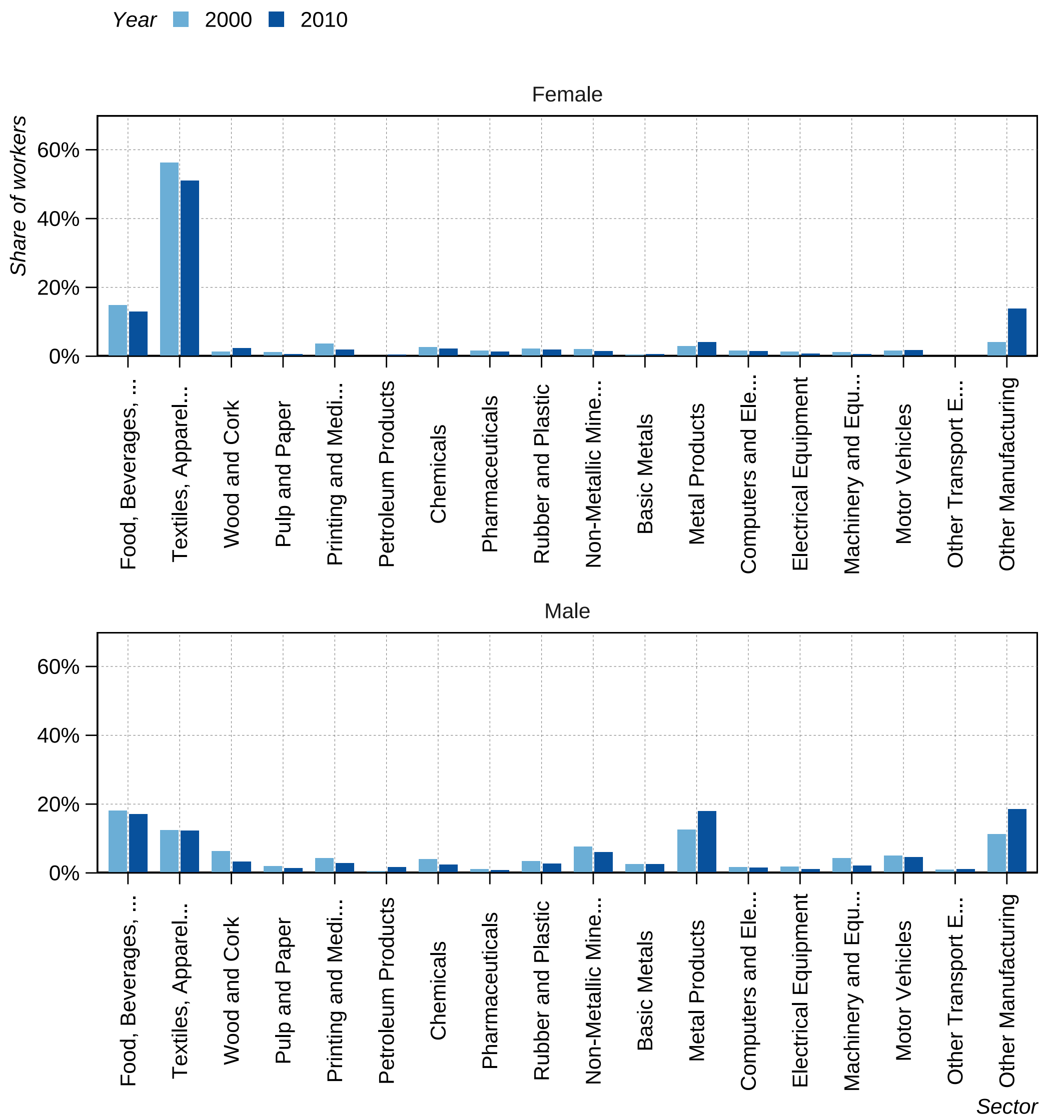
4 Simulation and Results

This section details the exercise conducted to estimate the effects of the China shock on the Brazilian labor market. First, we contextualize the increase in imports from China to Brazil between 2000 and 2010. Next, we detail the process of identifying the China shock. With the China shock estimated, we then describe the construction of the baseline and counterfactual scenarios used to estimate its effects on the Brazilian labor market. Finally, we present the detailed simulation results.

4.1 Increase in Chinese Import Penetration

In this subsection, we analyze the increase in Chinese import penetration in Brazil by sector. Using WIOD data for 2000 and 2010, the period considered for the China shock, we calculate the ratio between imports from

Figure 2: Distribution of workers by sector in manufacturing - Brazil - 2000 and 2010



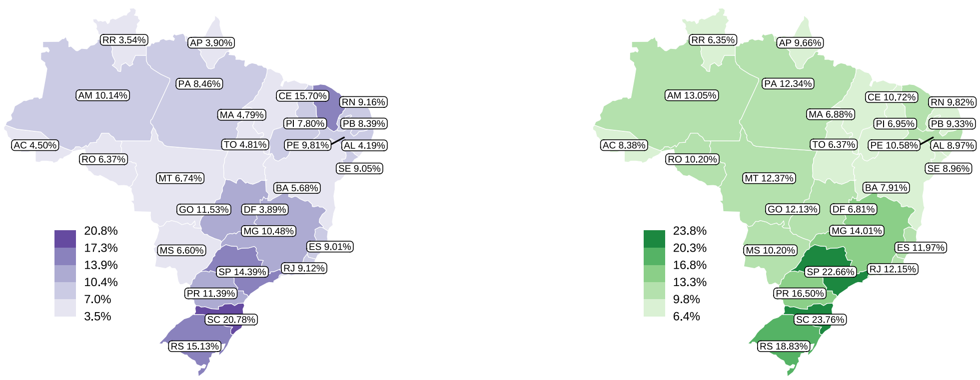
Note: The distribution of employment by sector within manufacturing is shown for Brazil for the years 2000 and 2010. Source: Authors' calculations based on Brazilian population census data.

China and apparent consumption in Brazil. Figure 4 demonstrates how the growth of Chinese import penetration was more pronounced in specific sectors. For example, in the computer and electronics sector, this index rose from less than 3% to approximately 12% over the period considered. Other notable sectors include electrical equipment, machinery and equipment, and textiles, apparel, and leather products.

For labor market effects, it is important to note the difference in employment participation in these sectors. For example, although it is not the sector with the highest variation in Chinese import penetration, the textiles, apparel, and leather products sector has the highest employment participation within the manufacturing industry for women. For both men and women, the computer and electronics sector represents a small share of employment in the manufacturing industry.

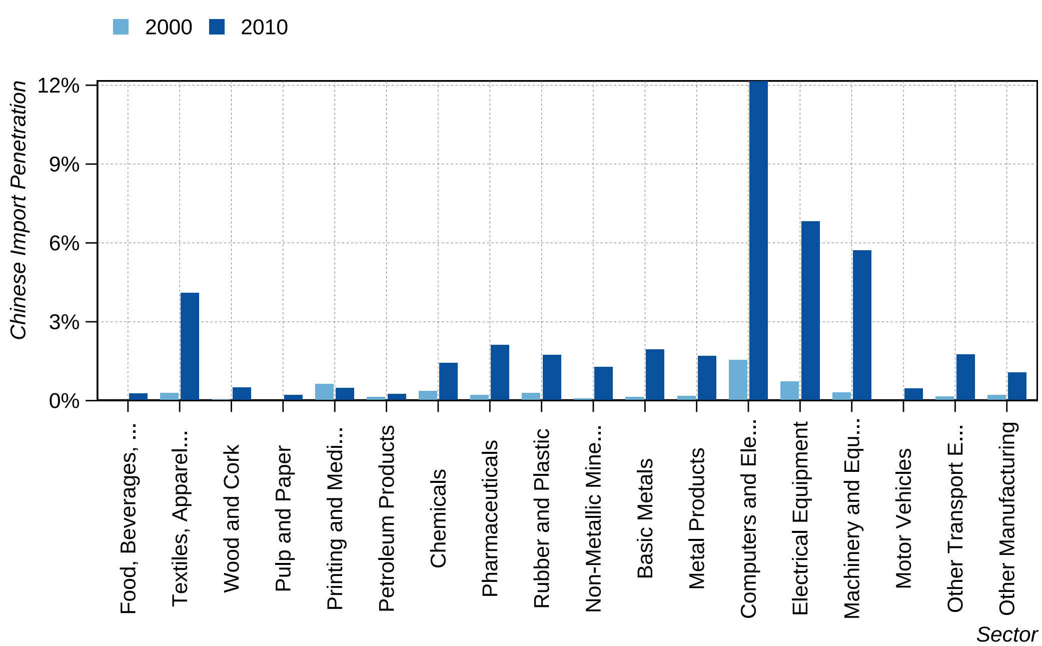
Figure 3: Manufacturing share in total employment by state - Brazil - 2000

(a) Female (b) Male



Note: For each state, the proportion of manufacturing in total employment is shown by gender for 2000. Source: Authors' calculations based on Brazilian population census data.

Figure 4: Increase in Chinese Import Penetration by Sector - Brazil



Note: Authors' calculations based on trade data from WIOD. Chinese import penetration is calculated as the ratio between Chinese imports and apparent consumption in Brazil.

4.2 Identification of the China Shock

The identification of the China shock aims to assess the effect of imports from China that can be attributed to supply shocks in this country. To achieve this, we apply a methodology similar to that of Costa et al. (2016), which was initially inspired by Autor et al. (2013) and used to estimate the supply shock on Brazilian imports from China, as well as the increased demand for Brazilian exports to China. An estimation of the excess growth of Chinese exports in manufacturing sectors relative to the world average will be performed following the approach in Costa et al. (2016), but applied to China's total exports to the world, including Brazil. Since Brazil is a small player in international trade, Brazil's domestic effects related to China are expected to have a minimal impact on these estimates. As explained by Costa et al. (2016), this estimation seeks to control for common shocks that affected exports from all origins, not just Chinese exports. The purpose of estimating a global effect, rather than focusing solely on Brazil, is based on the premise that the productivity shocks identified in this analysis will influence Chinese imports across all destinations. Furthermore, limiting the estimation of productivity changes in China to Brazilian imports alone could introduce bias, particularly in sectors where Brazil has a relatively low import share.

To do this, we will estimate the following specification:

$$\frac{\Delta X_{ij}}{X_{ij,2000}} = \gamma_j + \delta_{j,\text{CHN}} + u_{ij}, \tag{19}$$

where $\Delta X_{ij}/X_{ij,2000}$ is the growth of exports from country i in sector j between 2000 and 2010, γ_j is the parameter that measures the growth of exports in sector j, $\delta_{j,\text{CHN}}$ is the parameter that measures the excess growth of Chinese exports in sector j relative to the world average, and u_{ij} is the error term. The estimation is weighted by the value of exports from each origin and sector in 2000. Based on the estimation for $\delta_{j,\text{CHN}}$, the growth of Chinese exports that can be attributed to supply shocks in China is calculated as $\hat{\delta}_{j,\text{CHN}} X_{\text{CHN}j,2000}$. Thus, based on this estimate, it is possible to calculate the counterfactual exports of China to the world, discounting from the observed value in 2010 the estimated value of the excess growth of Chinese exports. The model above is estimated with BACI data and, subsequently, the coefficients found are used to compute the data of Chinese exports in the baseline and counterfactual scenarios.

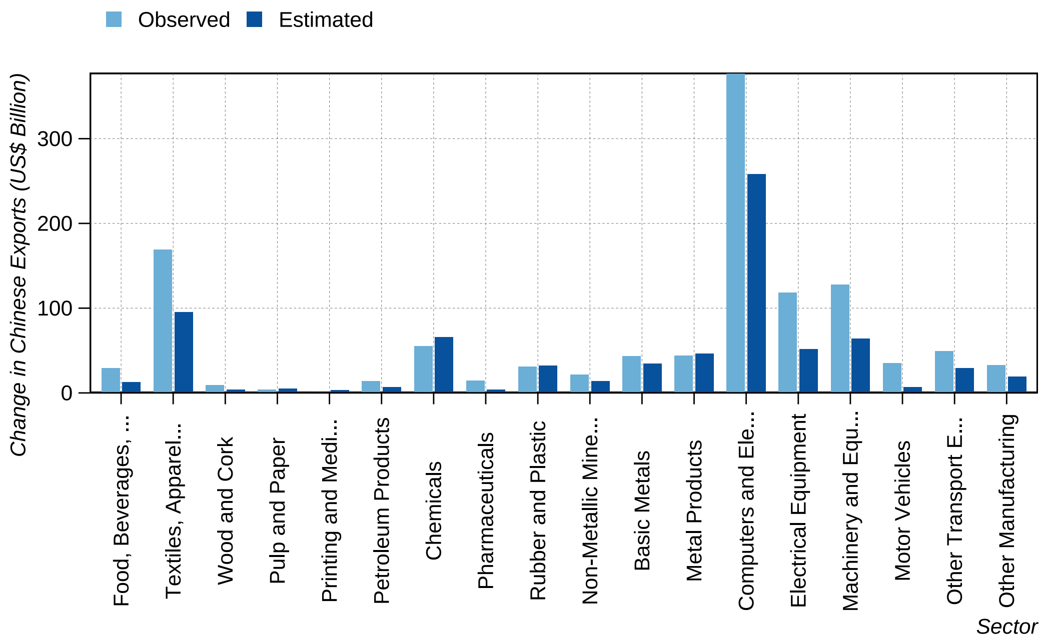
Figure 5 presents the variations in world imports originating from China between 2000 and 2010 by manufacturing sector and the estimated variation that will be attributed to the supply shock from China. For example, for the textiles, apparel, and leather products sector, China's exports increased by US\$ 169 billion. Of this total, it is estimated that approximately US\$ 96 billion of this increase is due to the excess growth of Chinese exports relative to the rest of the world, i.e., 57% of the observed variation. Similarly, for the computers and electronics sector, it is estimated that US\$ 258 billion of the US\$ 378 billion increase in Chinese exports is due to the supply shock from China, representing 68% of the observed growth.

4.3 Baseline and Counterfactual Construction

To construct the baseline scenario, we utilize the observed data until 2014. From 2014 onwards, it is assumed that the fundamentals remain constant over time. For employment, we use the labor stock in 2000 and the transition estimates between 2000 and 2014 to compute the employment evolution until 2014. The WIOD trade matrices are employed to calculate the evolution of trade shares in 2000 and 2014. Additionally, the WIOD capital stock data is used to determine the evolution of capital until 2014. In the period for which there is factual evolution data, the baseline is computed using Proposition 3 of CDP. From 2015 onwards, the equilibrium is computed using Propositions 1 and 2 of CDP.

The computation of the counterfactual scenario employs Proposition 3 of CDP and is calculated in relation to the previously computed baseline scenario. The counterfactual scenario will consider the variation in productivity of China's manufacturing sectors that would be necessary for imports from China to grow between 2000 and 2010 by the amount estimated in Figure 5. That is, it grows only by the equivalent of the difference between the observed variation and the variation attributed to the China shock. In summary, we will compute

Figure 5: Estimated and Observed Changes in Chinese Exports to the World by Sector



Note: Authors' calculations based on trade data from BACI and WIOD. Changes between 2000 and 2010 measured in US$ Billion.

values for $\{\widehat{A}_t^{\text{CHN}j}\}_{j=3,t=2000}^{20,2010}$ that generate a relative reduction in world imports from China as estimated in the previous subsection.[4] The shocks are equally distributed over the considered time. Note that the variation in China's productivity will affect exports destined for the world as a whole, including Brazil, which is the main region of interest in this study.

With the two scenarios calculated, the results will compute the variations between the scenario with the China shock (baseline scenario) and the scenario without the China shock (counterfactual scenario).

4.4 Results

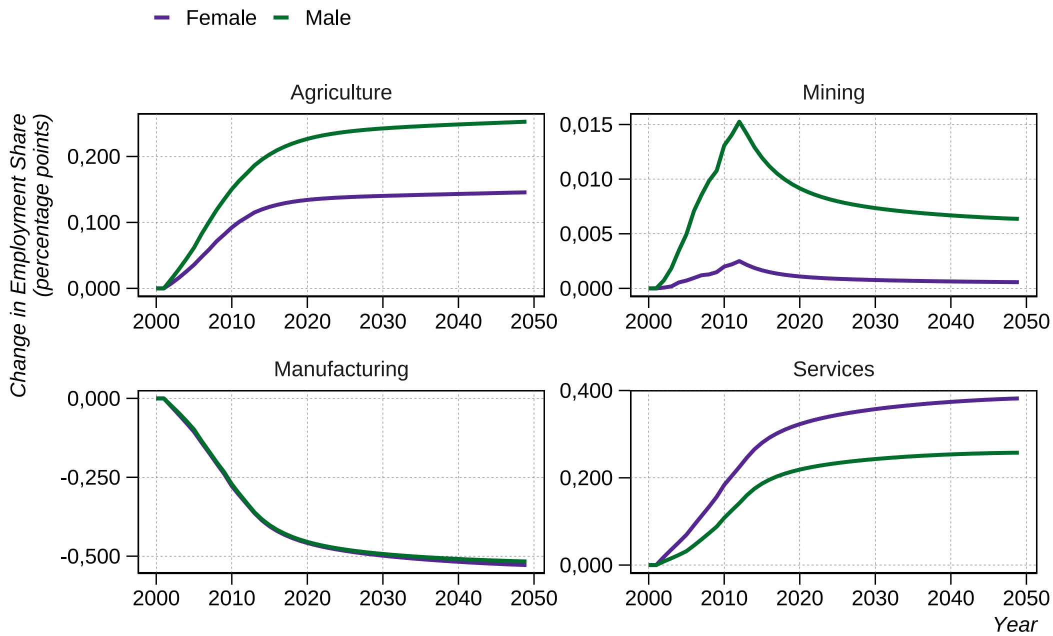
4.4.1 Employment effects

Initially, we present in Figure 6 the estimated effects of the China shock on the share of each activity in total employment in the Brazilian economy. First, it is estimated that the China shock generated a reduction in the share of manufacturing in total employment in the Brazilian economy. By 2010, the estimated impact is approximately a 0.3 percentage point reduction in share for both men and women. In the long term, the effect of the China shock reaches close to a 0.5 percentage point reduction. Using the labor stock of approximately 80 million workers in 2010 as a reference, 0.3 and 0.5 percentage points would represent, respectively, 240,000 and 400,000 fewer jobs in manufacturing.

Furthermore, as illustrated in Figure 6, notable differences in sectoral reallocation between men and women are evident. The services sector emerges as the most relevant for women, with significant gains in employment share. For men, the reallocation of workers was divided between agriculture and the services sectors. The increase in agricultural employment share for men is almost double that estimated for women. Additionally, in the mining sector, the change in employment share remains minimal due to its relatively small proportion within the total employment structure.

[4] $\hat{A}_t^{nj}$ is the relative variation of the counterfactual scenario in relation to the baseline scenario. That is, $\hat{A}_t^{nj} = \dot{A}_t^{nj\prime}/\dot{A}_t^{nj}$ where $\dot{A}_t^{nj} = A_t^{nj}/A_{t-1}^{nj}$ is the time difference in the baseline and the symbol $\prime$ indicates that it is the value of the variable in the counterfactual.

Figure 6: Change in Employment Share by Activity



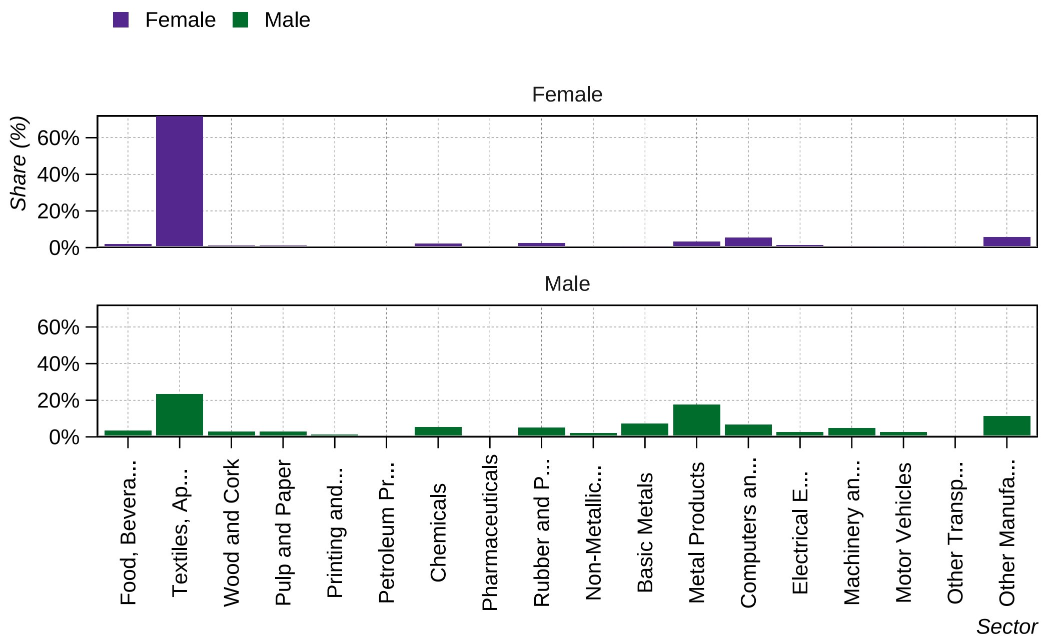
Note: Difference in percentage points between the share of total employment in the scenario with the China shock and the scenario without it.

An analysis of manufacturing activity reveals specific sectors that have significantly contributed to the decline in manufacturing's share of total employment within the Brazilian economy. As illustrated in Figure 7, the textiles, apparel, and leather products sector emerges as the primary contributor to this reduction. This sector alone accounts for more than 60% of the total decrease in women's manufacturing employment. For men, although this sector remains significant, contributing nearly 20% to the reduction, its impact is considerably lower compared to women. Additionally, other relevant sectors in terms of job reduction for men include metal products, basic metals, and computers and electronics. Carneiro (2023), using the CDP model with skill heterogeneity, finds that the largest contributions to the reduction in manufacturing employment in Brazil are from the textiles, metal products, and computers and electronics sectors. This result shows that the adjustment process in the labor market is different for men and women and trade shocks can have differentiated effects between genders.

Manufacturing employment is unevenly distributed across Brazilian states, leading to varying state-level contributions to its reduction. Figure 8 highlights these contributions, with São Paulo (SP) accounting for the largest share of the decline in manufacturing jobs among both men and women. Rio Grande do Sul (RS) and Minas Gerais (MG) also make significant contributions. However, there is notable variation between genders in state-level impacts. For instance, while Rio Grande do Sul (RS) plays an important role in reducing manufacturing employment for both genders, its impact is more pronounced among women. Similarly, in Ceará (CE), the reduction in manufacturing jobs affects women more substantially than men. This discrepancy is largely due to the higher concentration of jobs in the textiles, apparel, and leather industries in Ceará (CE) that have experienced significant declines in employment overall.

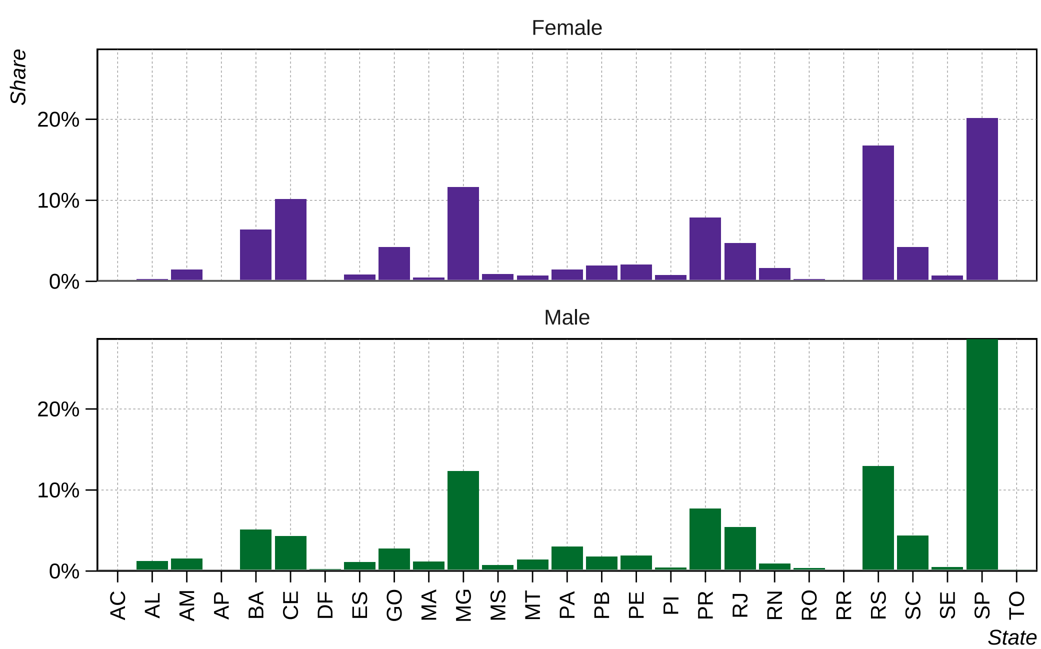
Figure 9 provides an overview of the normalized contribution of each state. The goal is to determine whether a state is contributing more or less than the change observed for Brazil as a whole. For women, the states of Rio Grande do Sul (RS), Ceará (CE), and Santa Catarina (SC) show the highest relative contributions. Conversely, Amapá (AP), Roraima (RR), and the Federal District (DF) show the lowest relative contributions. In general, for women, states with higher shares of the textiles, apparel, and leather products sector in employment tend to have higher contributions to the reduction in manufacturing employment. For men, the state of Rio

Figure 7: Contribution to the Reduction in Employment Share in Manufacturing by Sector - 2010



Note: For each sector, the reduction in employment is calculated by comparing the scenario with the China shock and the scenario without the China shock. The reduction value obtained is divided by the total reduction in jobs for manufacturing.

Figure 8: Contribution to the Reduction in Employment Share in Manufacturing by State - 2010

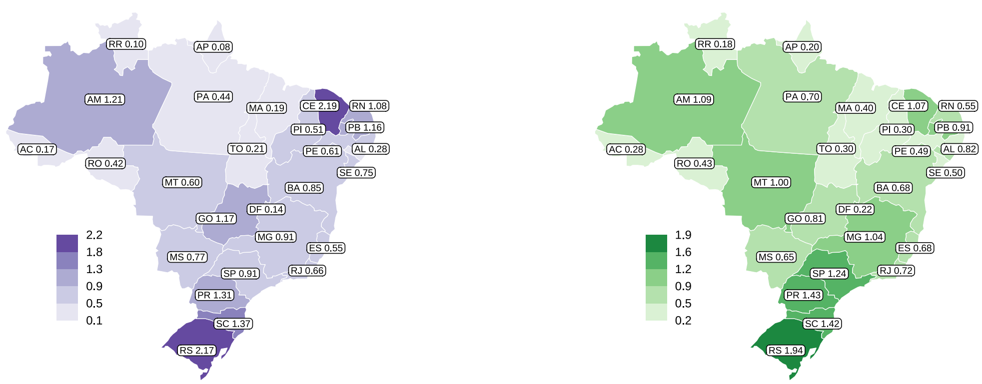


Note: For each state, the reduction in employment is calculated by comparing the scenario with the China shock and the scenario without the China shock. The reduction value obtained is divided by the total reduction in jobs for manufacturing.

Grande do Sul (RS) has a normalized contribution coefficient greater than 1.94, meaning that this state shows a reduction in the share of manufacturing employment 1.94 times larger than the change observed for Brazil. The state of São Paulo (SP), which is the largest employer in the manufacturing sector in Brazil, has a normalized contribution below 1 for women, mainly because São Paulo (SP) is more diversified in manufacturing employment. For men, São Paulo's (SP) contribution is 1.24, indicating that the reduction in manufacturing employment in São Paulo (SP) is 1.24 times the change observed for Brazil. The state of Amazonas (AM) differs from the other states in the Northern region due to the presence of the Manaus Free Trade Zone, which is an industrial hub in that region.

Figure 9: Normalized contribution to the Reduction in Employment Share in Manufacturing by State - 2010

(a) Female (b) Male



Note: For each state, the reduction in employment is calculated by comparing the scenario with the China shock and the scenario without the China shock. The reduction value obtained is divided by the total reduction in jobs for manufacturing. After that, the normalized contribution is calculated by dividing the reduction in employment by the share of each state in total manufacturing employment in Brazil.

Figure 10 illustrates the change in the non-employment shares in workforce within the Brazilian states as a consequence of the China shock for 2010. The findings indicate that the China shock led to a relative decrease in the number of non-employed individuals in most states. The exception occurs only for male workers in the states of Pará (PA). Visually, it is not possible to observe a spatial pattern for the estimated variations. For the state of São Paulo (SP), it is observed that the reduction in non-employment is greater, in absolute terms, for women (-0.17%) than for men (-0.08%). This pattern is repeated for several states. Analyzing the variations between 2000 and 2010, Connolly (2022) finds a relative increase in women's employment. This increase would be mainly due to the expansion of formal employment for women more significantly than for men. As demonstrated later, there is a positive correlation between exposure to the China shock and the model-predicted change in non-employment participation.

4.4.2 Welfare effects

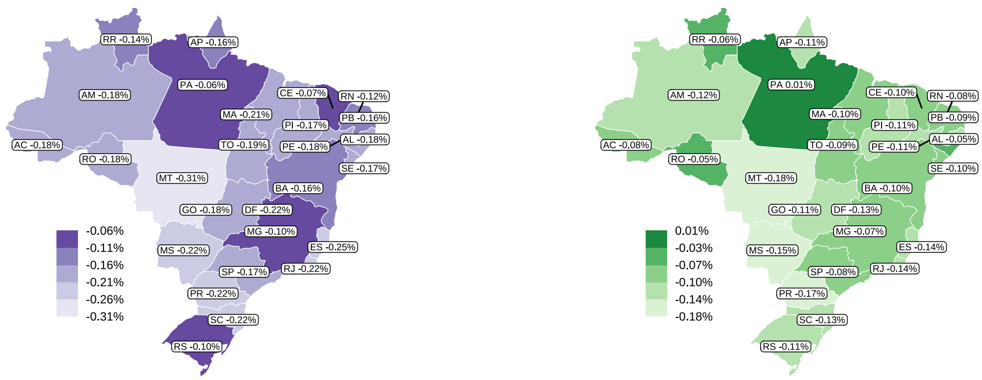
The welfare effects are computed separately for workers and capitalists. For workers, the measure considered is the equivalent consumption variation, according to the formula derived by CDP:

$$\hat{W}^{njg} = \sum_{s=1}^{\infty} \beta^s \log \left(\frac{\hat{C}_s^{njg}}{(\hat{\mu}_s^{nj,nj,g})^{\nu}} \right).$$

Note that, for employed workers, $\hat{C}_s^{njg} = w_s^{njg}/P_s^n$. For non-employed workers, it is assumed that $\hat{C}_s^{n0g} = 1$. Additionally, the numerator term measures the value of the worker's options. If the probability of the worker remaining in the same sector is high, the welfare measure is reduced because the worker is in a situation with low chances of moving to markets with better values. The measure is computed for 1,782 markets and the

Figure 10: Change in Non-Employment Shares - 2010

(a) Female (b) Male



Note: Relative change in the number of workers in the Brazilian economy in the scenario with the China shock compared to the scenario without it.

aggregations consider the number of workers in the initial year as weights. In aggregate terms, the estimated welfare variation for Brazil is approximately 0.5%.[5]

It is also important to consider that the effects are not homogeneous across labor markets. By analyzing the distribution of welfare variations by labor market, we observe that most markets present gains, but some show welfare losses. In Figure 11, it is evident that the larger welfare variation are more common for men than for women. The aggregate effects for men and women are 0.6% and 0.4%, respectively. Considering the welfare variation formula, it is possible that the real wage has decreased more for women than for men, and/or that the value of options in other sectors has been relatively lower for women. In other words, the chances of moving to sectors with better-paying jobs were lower for women.

Figure 11b shows that the estimated real wage variations are similar between men and women. Panels Figure 11c and Figure 11d provide a detailed view showing that various manufacturing sectors present a reduction in real wages, but for other activities (agriculture, mining, and services), the most observed pattern is an increase in real wages. The result for real wages combined with the welfare variation result indicates that labor market mobility may be quite relevant in defining the outcomes for male and female workers.

Regarding the variation among states, Figure 12 shows that, generally, for the same state, women exhibit lower welfare variations compared to men. For women, the highest welfare variations are estimated for the states of Mato Grosso (MT), Mato Grosso do Sul (MS) and Santa Catarina (SC). For men, the three states with the highest variations are Mato Grosso (MT), Mato Grosso do Sul (MS) and Paraná (PR). These states have a high share of agriculture and the food and beverage industry, which may explain their relative gains. Panels (c) and (d) of Figure 12 show the results of welfare variation considering only workers employed in manufacturing. For women, the states of Rio Grande do Sul (RS), Ceará (CE), and Paraíba (PB) exhibit the lowest welfare variations. For men, the states of Rio Grande do Sul (RS), Pará (PA), and Paraíba (PB) show the lowest variations.

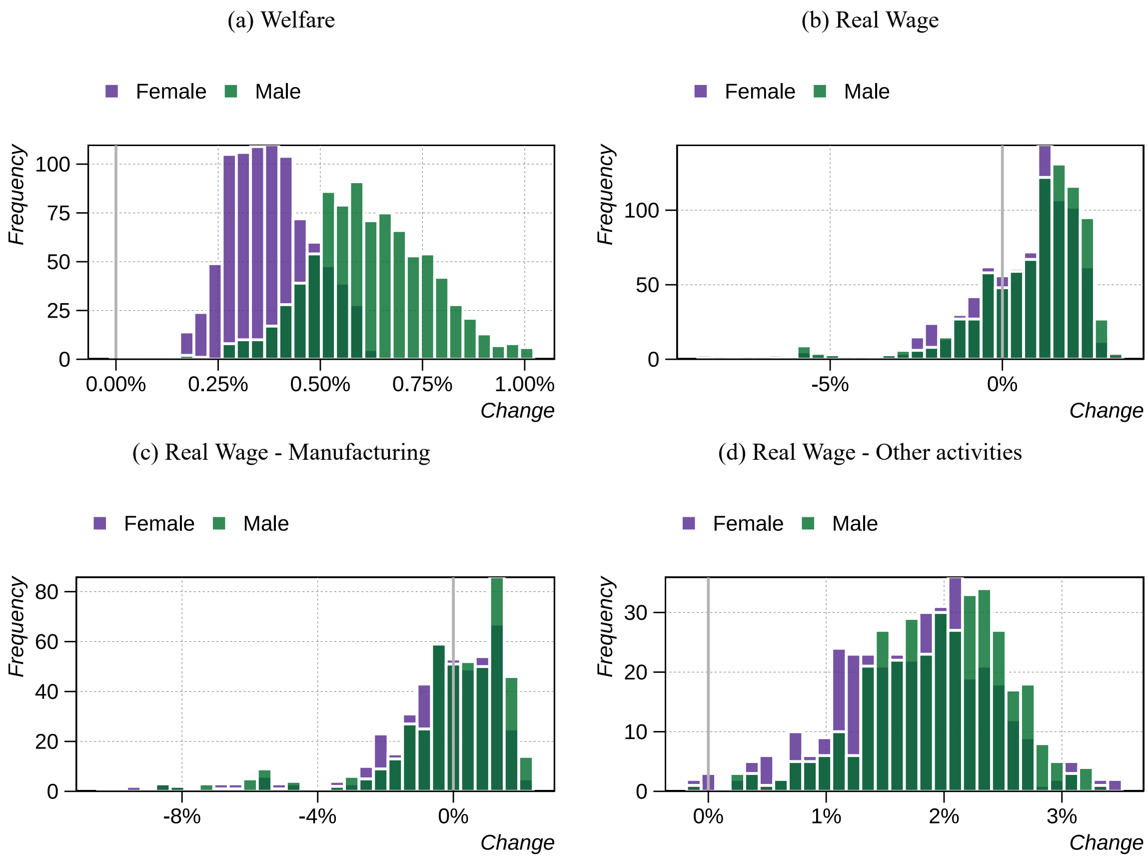
Additionally, we will compute two more metrics by state: welfare variation for capital owners and real income variation. The welfare variation for capitalists is measured as the equivalent consumption variation, computed as follows:

$$\hat{W}^{l,n} = \sum_{s=1}^{\infty} \beta^s \log\left(\hat{C}_s^{l,n}\right), \tag{20}$$

where $\hat{C}_s^{l,n} = r_s^n / P_s^n$. Real income is calculated as I_t^n / P_t^n. The variations presented are between the baseline scenario (with China shock) and the counterfactual scenario (without China shock). Figure 13 presents the

[5]Without capital accumulation, the estimated welfare variation is 0.17%, which is a value close to that estimated by CDP for Brazil.

Figure 11: Distribution of Welfare Variation by Gender



Note: Authors' calculations based on the model. Welfare variation is calculated as the percentage change in equivalent consumption. The distributions are truncated at the 1st and 99th percentiles. For the real wage, the accumulated variation of the real wage in the baseline scenario compared to the counterfactual scenario is being computed.

estimated values for the welfare variation of capitalists and the relative variation of real income in 2010 between the analyzed scenarios. The China shock had a positive effect on the welfare of capitalists, with all Brazilian states showing positive variations. We find a weak correlation between manufacturing share in employment and welfare variations for capital owners. Additionally, real income in 2010 varied positively for all states when comparing the scenarios with and without the China shock. The estimated variations range between 4.1% and 6.0%. It is observed that there is not a very large variation between states. This lack of variation in results between states may be a limitation of the quantitative model presented in CDP, as discussed by Adão et al. (2025).

4.5 Model validation

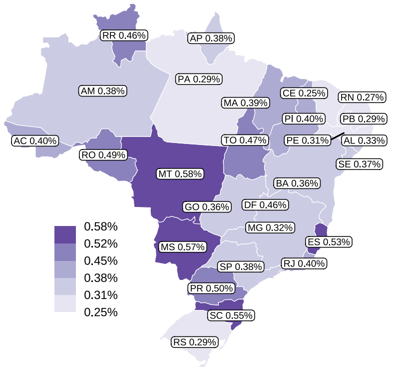
In order to validate the model, we perform an exercise similar to the one used by CDP. For this, we compare the predictions of a reduced-form model based on Autor et al. (2013) with the predictions of the quantitative trade model. As an exposure variable, we use a measure defined in Rodríguez-Clare et al. (2025):

$$\text{Exposure}_r = \sum_m \frac{L_{rm,2000}}{L_{r,2000}} \frac{\Delta M_{\text{BRA,CHN},m}}{O_{\text{BRA},m,2000} - X_{\text{BRA},m,2000} + M_{\text{BRA},m,2000}} \times 100$$

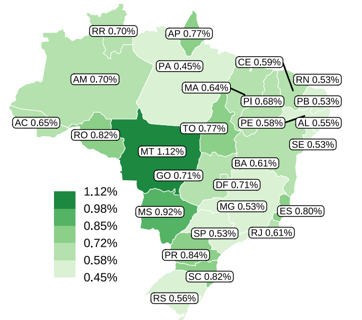
where Exposure_r is the exposure of region r to the China shock, $L_{rm,2000}$ is employment in region r and manufacturing sector m in 2000, $L_{r,2000}$ is total employment of region r in 2000, $\Delta M_{\text{BRA,CHN},m}$ is the change

Figure 12: Welfare Change by State

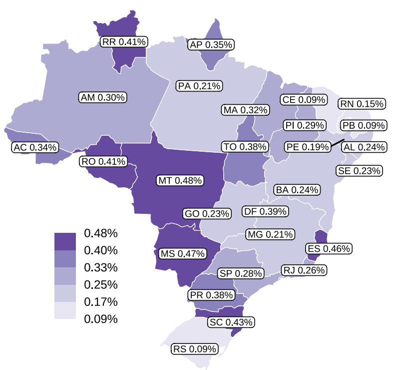
(a) Female - All Sectors



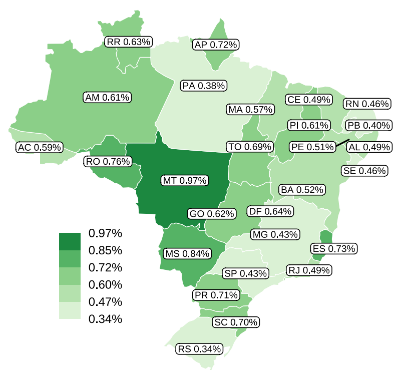
(b) Male - All Sectors



(c) Female - Manufacturing



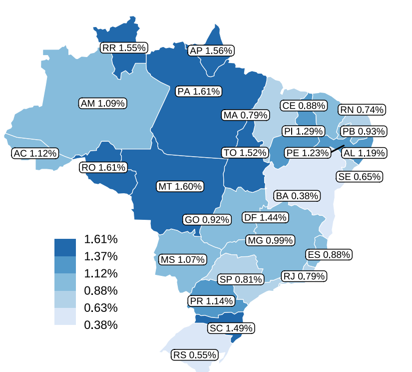
(d)



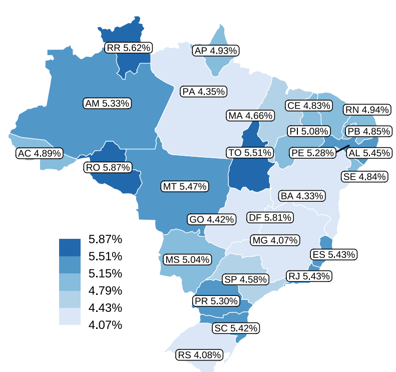
Note: Authors' calculations based on the model. Welfare variation is calculated as the percentage change in equivalent consumption.

Figure 13: Welfare Effects for Capitalists and Change in Real Income

(a) Welfare Variation for Capitalists



(b) Change in Real Income



Note: Authors' calculations based on the model. Welfare variation is calculated as the percentage change in equivalent consumption. The variation in real income is calculated as the change in real income between the baseline scenario (with China shock) and the counterfactual scenario (without China shock).

between 2000 and 2010 in Brazil's imports from China in sector m, and $(O_{\text{BRA},m,2000} - X_{\text{BRA},m,2000} + M_{\text{BRA},m,2000})$ is the domestic absorption of sector m in Brazil in 2000.

Once the exposure variable is defined, we estimate the following empirical model:

$$\Delta L_r = \alpha + \beta \times \text{Exposure}_r + \epsilon_r \tag{21}$$

where ΔL_r is a measure of variation in the share of manufacturing employment (or non-employment) between 2000 and 2010. For manufacturing employment, the share is calculated with respect to total employment or the working-age population. In the case of non-employment, this measure is calculated with respect to the working-age population. Following standard practice, imports from other upper-middle-income countries are used to create an instrument for Brazil's exposure variable. Thus, the model is estimated using Two-Stage Least Squares (2SLS).

With the estimate of β, we compute an estimate of the effect of the China shock as $\hat{\beta} \times \text{Exposure}_r$, where Exposure_r is the predicted value from the first stage regression. Based on this estimate, we compare the predictions of the empirical model with those of the quantitative model used in the simulations by estimating:

$$Y_r = \gamma + \rho^Y Y_r^M + v_r \tag{22}$$

where Y_r is the estimate of the reduced-form model, and Y_r^M is the estimate from the quantitative model. The slope test checks the null hypothesis that $\rho^Y = 1$, in a procedure similar to that used by CDP. If the differential effects across regions are aligned between the reduced-form model and the simulation model, the coefficient ρ^Y will be close to 1. If the coefficient is greater than 1, it indicates that the simulation model underestimates the effects of the China shock compared to empirical evidence. If the coefficient is less than 0, it indicates that the models produce effects in opposite directions.

Table 1 presents the results of the model validation. Panel A shows the results of estimating Equation 21. First, the expected negative effect of manufacturing share on total employment in regions more exposed to the China shock is observed. However, this effect is not statistically significant for any group analyzed. Costa et al. (2016) also identifies effects in this direction but without statistical significance. Oppositely, when manufacturing share is calculated relative to the working-age population, the effect turns positive but remains statistically insignificant. Regarding the non-employment rate, we observe a negative effect, suggesting that regions more exposed to the China shock exhibited relative reductions in the non-employment rate compared to less exposed regions. This finding contrasts with Autor et al. (2013)'s conclusions for the United States but aligns with Costa et al. (2016) and Connolly (2022)'s results for Brazil, though these effects are not robust across different specifications.

Panel B of Table 1 presents the slope tests comparing predictions from the reduced-form model with those generated by the quantitative model. For the variable measuring manufacturing employment as a share of total employment, the slope test indicates that the null hypothesis of a coefficient equal to 1 cannot be rejected in the predictions for both male and female workers. This result suggests consistency between the quantitative and reduced-form model predictions. Conversely, when manufacturing share is expressed relative to the working-age population, the null hypothesis is rejected, with the estimated coefficient falling below zero. This outcome reveals that the empirical and quantitative models yield conflicting directional predictions.

For the non-employment rate, while the null hypothesis is not rejected, the coefficient estimates are negative. This suggests the quantitative model produces predictions opposite to the empirically estimated effects. Moreover, it is important to note that the standard errors in the slope test estimates for the non-employment rate are relatively large, further complicating the interpretation of these results.

The results presented in Table 1 suggest that the CDP model fails to fully capture the effects of the China shock, particularly its impact on overall employment. However, in the case of Brazil, there is an additional challenge due to the lack of identification of the expected effect of the China shock on non-employment rates in the reduced form analysis. The model's limitation regarding the adjustment of employment levels in response to this shock has been highlighted by Adão et al. (2025) and Rodríguez-Clare et al. (2025), who propose mechanisms—such as agglomeration effects and nominal wage rigidity—to enhance the model's predictive capacity.

Table 1: Comparison of the model predictions

	Manufacturing share:		Non-employment share:
	Employment	Population	Population
Panel A: Reduced form estimates			
All			
Exposure$_r$	-0.58	0.30	-2.28
	(0.61)	(0.36)	(0.67)
Male			
Exposure$_r$	-0.26	0.15	-2.38
	(0.55)	(0.39)	(0.91)
Female			
Exposure$_r$	-0.64	0.49	-2.10
	(0.58)	(0.40)	(0.60)
Panel B: Slope test estimates			
All			
ρ^Y	1.68	-1.25	-3.23
Std. error	(0.38)	(0.29)	(4.81)
p-value of $H_0 : \rho^Y = 1$	0.08	0.00	0.38
Male			
ρ^Y	0.85	-0.63	-1.58
Std. error	(0.19)	(0.15)	(7.47)
p-value of $H_0 : \rho^Y = 1$	0.43	0.00	0.73
Female			
ρ^Y	1.14	-1.53	-2.58
Std. error	(0.27)	(0.36)	(3.12)
p-value of $H_0 : \rho^Y = 1$	0.61	0.00	0.25

Note: Panel A presents the estimates of Equation (21). Panel B presents the estimates of Equation (22). All estimates consider $N = 27$. In the first column of estimates, the variable of interest is the manufacturing share in total employment. In the second column, the variable of interest is the manufacturing share in the working-age population. In the third column, the variable of interest is the non-employment rate in relation to the working-age population. In Panel A, the estimates are performed using Two-Stage Least Squares (2SLS).

5 Conclusion

This study investigates the impact of the China shock on the Brazilian labor market using a general equilibrium approach, with a particular focus on gender differences. In fact, this is one of the main trade shocks in Brazil, in addition to the trade liberalization of the 1990s. Thus, studying its impacts is relevant and has been specifically studied for Brazil by several authors (Carneiro, 2023; Costa et al., 2016; Connolly, 2022; Cristofani et al., 2023). The general equilibrium analysis of this study allows for examining the effects beyond the relative analysis between regions more or less exposed to the China shock.

The China shock led to a reduction in the share of manufacturing employment in Brazil. Although the loss of manufacturing participation in total employment is similar for men and women, the reallocation between activities occurs differently for men and women. The services sector plays a predominant role in absorbing female workers who lost their jobs in manufacturing. For men, agriculture and the services sector have similar importance.

Within the manufacturing sector, the textiles, apparel, and leather products sector contributed significantly to the reduction in women's manufacturing employment. For men, this sector is also important, but its relative contribution is much smaller, with other sectors also making significant contributions, such as the basic metals sector.

The impact of the China shock on manufacturing employment varied across Brazilian states. São Paulo, Rio Grande do Sul, and Minas Gerais showed significant contributions to the reduction in manufacturing jobs. There was noticeable heterogeneity in state contributions between men and women. For example, for women, the contributions of the state of Rio Grande do Sul are considerably higher than its contributions to the reduction of men's manufacturing jobs.

The welfare change for workers showed that most labor markets experienced gains, although some markets exhibited welfare losses. The welfare variation for women tended to be lower than for men, but, in aggregate terms, the results found are positive for both genders. For capital owners, the results are also positive, with aggregate welfare gains in all states. The China shock led to a positive variation in real income across all states, with no significant differences between regions of Brazil.

Finally, this analysis aimed to contribute to the study of the effects of the China shock on the Brazilian labor market, focusing on gender differences. The results suggest that the China shock had significant impacts on the Brazilian labor market, with a reduction in manufacturing employment and an increase in the services sector. The results also indicate that the impacts of the China shock varied between Brazilian states and between men and women. The welfare results suggest that, in aggregate terms, the China shock had positive effects on the Brazilian labor market, with welfare gains for workers and capital owners. The validation process indicates that the model can and should be expanded to include other mechanisms that may transmit the effects of the China shock on labor market outcomes.

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A Data

This appendix contains additional information about the data construction used in the analysis.

A.1 Sectoral Aggregation

The data from the 57 WIOD sectors were aggregated into 32 sectors to facilitate compatibility with Brazilian data. This correspondence is presented in Table 2. The first two columns present the WIOD codes and descriptions, while the last two columns show the aggregated codes and descriptions used in this study.

Table 2: Correspondência entre setores da WIOD e setores agregados

WIOD Code	WIOD Description	Agg Code	Agg Description
A01	Crop and animal production, hunting and related service a...	S01	Agriculture
A02	Forestry and logging	S01	
A03	Fishing and aquaculture	S01	
B	Mining and quarrying	S02	Extractive Industry
C10-C12	Manufacture of food products, beverages and tobacco products	S03	Food, Beverages, and Tobacco
C13-C15	Manufacture of textiles, wearing apparel and leather prod...	S04	Textiles, Apparel, and Leather Products
C16	Manufacture of wood and of products of wood and cork, exc...	S05	Wood and Cork
C17	Manufacture of paper and paper products	S06	Pulp and Paper
C18	Printing and reproduction of recorded media	S07	Printing and Media Reproduction
C19	Manufacture of coke and refined petroleum products	S08	Petroleum Products
C20	Manufacture of chemicals and chemical products	S09	Chemicals
C21	Manufacture of basic pharmaceutical products and pharmace...	S10	Pharmaceuticals
C22	Manufacture of rubber and plastic products	S11	Rubber and Plastic
C23	Manufacture of other non-metallic mineral products	S12	Non-Metallic Minerals
C24	Manufacture of basic metals	S13	Basic Metals
C25	Manufacture of fabricated metal products, except machiner...	S14	Metal Products
C26	Manufacture of computer, electronic and optical products	S15	Computers and Electronics
C27	Manufacture of electrical equipment	S16	Electrical Equipment
C28	Manufacture of machinery and equipment n.e.c.	S17	Machinery and Equipment
C29	Manufacture of motor vehicles, trailers and semi-trailers	S18	Motor Vehicles
C30	Manufacture of other transport equipment	S19	Other Transport Equipment

(continued)

WIOD Code	WIOD Description	Agg Code	Agg Description
C31_C32	Manufacture of furniture; other manufacturing	S20	Other Manufacturing
C33	Repair and installation of machinery and equipment	S20	
D35	Electricity, gas, steam and air conditioning supply	S21	Electricity, Gas, and Water
E36	Water collection, treatment and supply	S21	
E37-E39	Sewerage; waste collection, treatment and disposal activi...	S21	
F	Construction	S22	Construction
G45	Wholesale and retail trade and repair of motor vehicles a...	S23	Trade
G46	Wholesale trade, except of motor vehicles and motorcycles	S23	
G47	Retail trade, except of motor vehicles and motorcycles	S23	
H49	Land transport and transport via pipelines	S24	Transportation and Storage
H50	Water transport	S24	
H51	Air transport	S24	
H52	Warehousing and support activities for transportation	S24	
H53	Postal and courier activities	S24	
I	Accommodation and food service activities	S25	Accommodation and Food Services
J58	Publishing activities	S26	Information and Communication
J59_J60	Motion picture, video and television programme production...	S26	
J61	Telecommunications	S26	
J62_J63	Computer programming, consultancy and related activities;...	S26	
K64	Financial service activities, except insurance and pensio...	S27	Finance and Insurance
K65	Insurance, reinsurance and pension funding, except compul...	S27	
K66	Activities auxiliary to financial services and insurance ...	S27	
L68	Real estate activities	S28	Real Estate
M69_M70	Legal and accounting activities; activities of head offic...	S29	Professional and Scientific Services
M71	Architectural and engineering activities; technical testi...	S29	
M72	Scientific research and development	S29	
M73	Advertising and market research	S29	
M74_M75	Other professional, scientific and technical activities; ...	S29	

(continued)

WIOD Code	WIOD Description	Agg Code	Agg Description
N	Administrative and support service activities	S29	
O84	Public administration and defence; compulsory social secu...	S30	Public Administration
P85	Education	S31	Education and Health
Q	Human health and social work activities	S31	
R_S	Other service activities	S32	Other Services
T	Activities of households as employers; undifferentiated g...	S32	
U	Activities of extraterritorial organizations and bodies	S32	

A.2 Labor Stock and Migration

Labor Stock. The initial labor stock for the year 2000 is obtained from the microdata of the 2000 demographic census sample provided by IBGE. The data are disaggregated by sector, state (Federation Units), and gender, considering all individuals aged 14 and above.[6] The matching procedure initially uses the correspondence between WIOD sectors and CNAE-Domiciliar sectors. Subsequently, the data are grouped into the 32 sectors listed in Table 2.

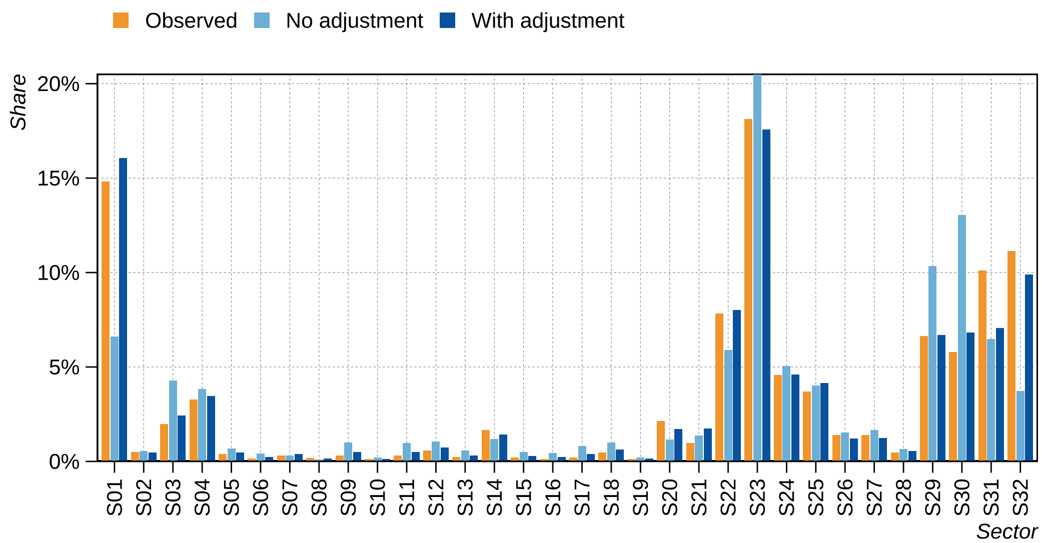
Migration. Constructing the migration matrix between sectors and states for Brazil requires a more elaborate procedure, since there is no identified dataset that enables tracking the same workers over multiple years. The Relação Anual de Informações Sociais (RAIS) is an administrative database that partially fulfills this purpose. However, it is limited to Brazil's formal labor market, which represents only part of the labor force. Nonetheless, RAIS is used as an initial source to estimate transitions between sectors in the formal economy for workers who remain employed for two consecutive years. This calculation uses RAIS data from 1999 to 2014.

The second step uses the Pesquisa Nacional por Amostra de Domicílios (PNAD) to estimate the probability of transitioning between employment and non-employment from 2001 to 2014, excluding 2010 as it is a census year. Additionally, using information on whether an individual lived in another Unit of the Federation (UF) the previous year, it was possible to estimate the probability of migration across states.

Based on these initial probabilities, a complete matrix of transition probabilities between sectors and UFs was constructed. Because part of this calculation only considers the formal labor market, a scaling factor was needed for the initially calculated transitions in RAIS. This factor was derived by comparing sectoral employment shares in the 2000 and 2010 censuses with RAIS data from 2000 to 2014, applying linear interpolation for the years between the censuses. For 2011 to 2014, the shares estimated for 2010 were used. The final sectoral transition data represent a weighted average between the original transitions calculated from RAIS and the adjusted transitions. The weight was chosen to minimize the difference between the observed employment shares in 2010 and those projected by using the 2000 labor stock and the transition matrix for the intervening years. The resulting weight was 0.6. Figure 14 shows that, without this adjustment, there are significant divergences between the shares observed in 2010 and those projected from the 2000 labor stock and the calculated transitions. After applying the proposed adjustment, the projected shares align more closely with the observed data. For example, without the adjustment, the projected share in agriculture is noticeably lower than observed, whereas with the adjustment the projected share is slightly overestimated but much closer to the actual figure.

[6] In Brazil, the term "state" is used as a synonym for Federation Units, which include 26 states and the Federal District.

Figure 14: Employment share by sector observed in the 2010 Census and shares projected based on calculated transitions.



Note: Sectoral shares of employment observed in the 2010 Census and sectoral shares projected based on transitions calculated with and without adjustment.

A.3 Disaggregation of Brazilian Data

The data for Brazil were disaggregated into its 27 Federation Units (UFs). For this, various data sources were used, such as the data from the Regional Accounts of IBGE, the Annual Industrial Survey - Enterprise (PIA-Empresa), Foreign Trade data from the Brazilian Foreign Trade Secretariat (SECEX), non-residential electricity consumption data from the Brazilian Statistical Yearbook (AEB) of IBGE and the Energy Research Company (EPE).

The production, value-added, and intermediate consumption data were disaggregated from the data of the Regional Accounts of IBGE and PIA-Empresa for the manufacturing sectors. In the case of manufacturing sectors, there is the possibility of data omission for some regions when the number of reporting companies is less than three. In these cases, the total participation of the regions with available data in relation to the total production of Brazil was computed. The value of the remaining participation was divided among the regions without information based on their employment shares.

The capital stock was disaggregated considering the average of the regional coefficients calculated using two distinct variables: non-residential energy consumption and the gross value of production in the construction sector. The residential energy consumption data are from the AEB for the shares in 1999 and from EPE for the years 2004 to 2014. Thus, for the years 2000 and 2001, the coefficients obtained for 1999 were replicated. For the years 2002 and 2003, the same coefficients from 2004 were considered. The gross value of production in the construction sector was obtained from the Regional Accounts of IBGE.

The export and import data were disaggregated from the foreign trade data of SECEX, which are available at the level of Brazilian states. Internal trade was obtained using the distance data between state capitals and the method presented in Haddad et al. (2018) for estimating interstate trade matrices.

Final consumption was disaggregated considering the shares of each state in the total value-added of Brazil from the data of the Regional Accounts of IBGE.

A.4 Trade Elasticities

The sectoral trade elasticities in the model are represented by θ^j. As described in the main text, the simulations consider the trade elasticities obtained from the substitution elasticities estimated by Oliveira and Cordeiro (2023), considering that in an Armington model, the trade elasticity is equal to $\sigma_A^j - 1$, where σ_A^j is the substitution elasticity between origins in sector j. For service sectors, the average elasticity of the other sectors was used. Table 3 presents the trade elasticities used in the simulations.

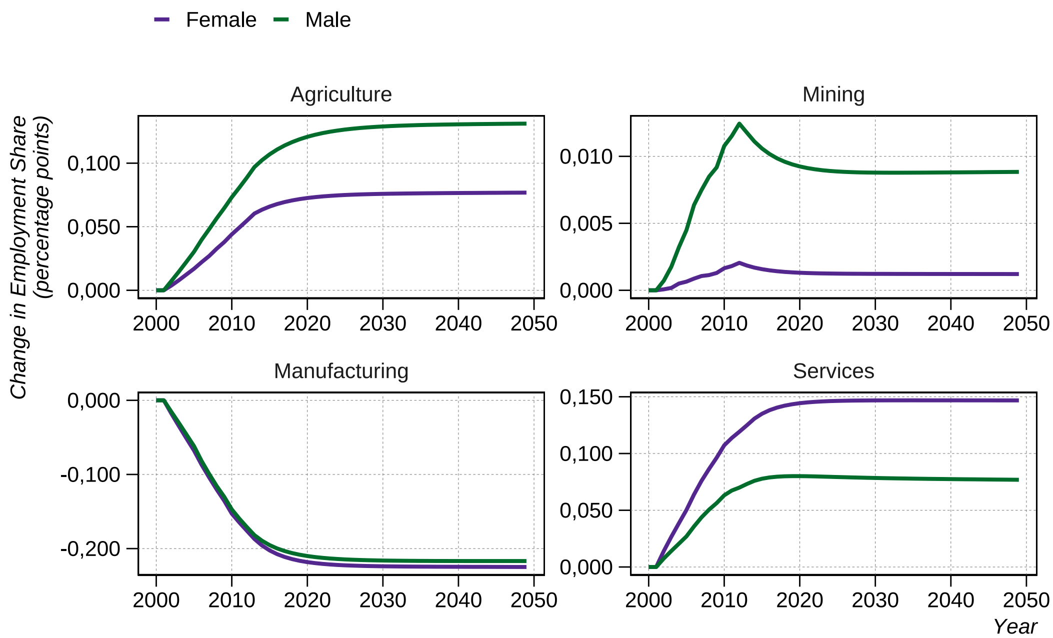
Table 3: Elasticidades de comércio

Code	Description	θ^j
S01	Agriculture	5.51
S02	Extractive Industry	2.05
S03	Food, Beverages, and Tobacco	3.20
S04	Textiles, Apparel, and Leather Products	4.38
S05	Wood and Cork	2.72
S06	Pulp and Paper	3.01
S07	Printing and Media Reproduction	7.00
S08	Petroleum Products	1.50
S09	Chemicals	1.68
S10	Pharmaceuticals	3.05
S11	Rubber and Plastic	2.29
S12	Non-Metallic Minerals	1.53
S13	Basic Metals	3.42
S14	Metal Products	3.13
S15	Computers and Electronics	4.69
S16	Electrical Equipment	2.13
S17	Machinery and Equipment	2.13
S18	Motor Vehicles	3.68
S19	Other Transport Equipment	1.03
S20	Other Manufacturing	3.43
S21	Electricity, Gas, and Water	3.08
S22	Construction	3.08
S23	Trade	3.08
S24	Transportation and Storage	3.08
S25	Accommodation and Food Services	3.08
S26	Information and Communication	3.08
S27	Finance and Insurance	3.08
S28	Real Estate	3.08
S29	Professional and Scientific Services	3.08
S30	Public Administration	3.08
S31	Education and Health	3.08
S32	Other Services	3.08

Note: Note: The trade elasticities (θ^j) were calculated based on the substitution elasticities estimated by Oliveira and Cordeiro (2023). In an Armington model, the trade elasticity is equal to the substitution elasticity minus one ($\sigma_A^j - 1$). For service sectors, the average elasticity of the other sectors was used.

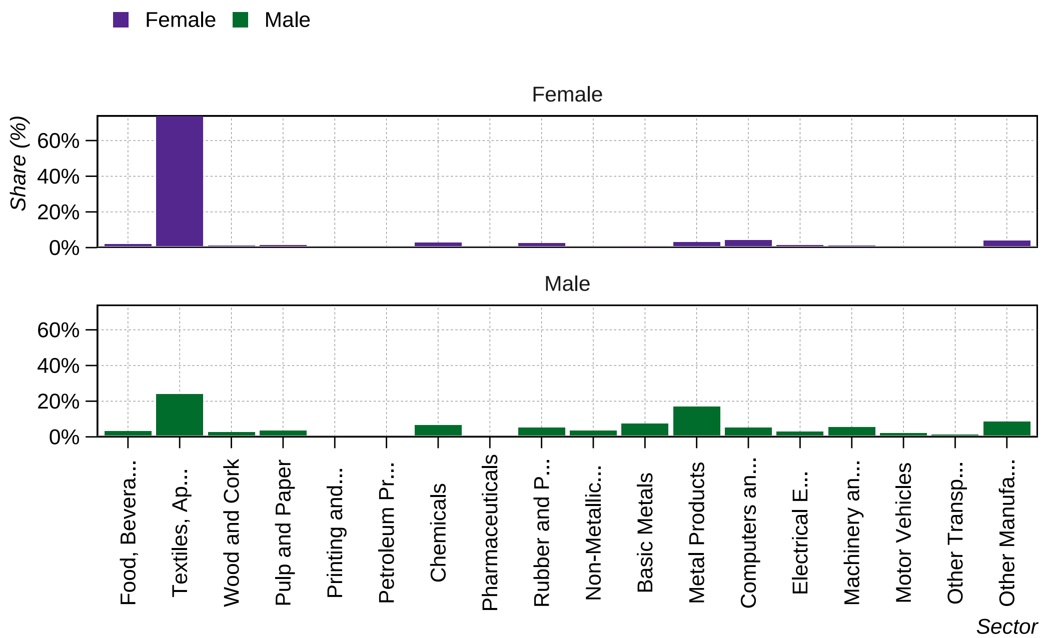
B Results without Capital Accumulation

Figure 15: Change in Employment Share by Activity



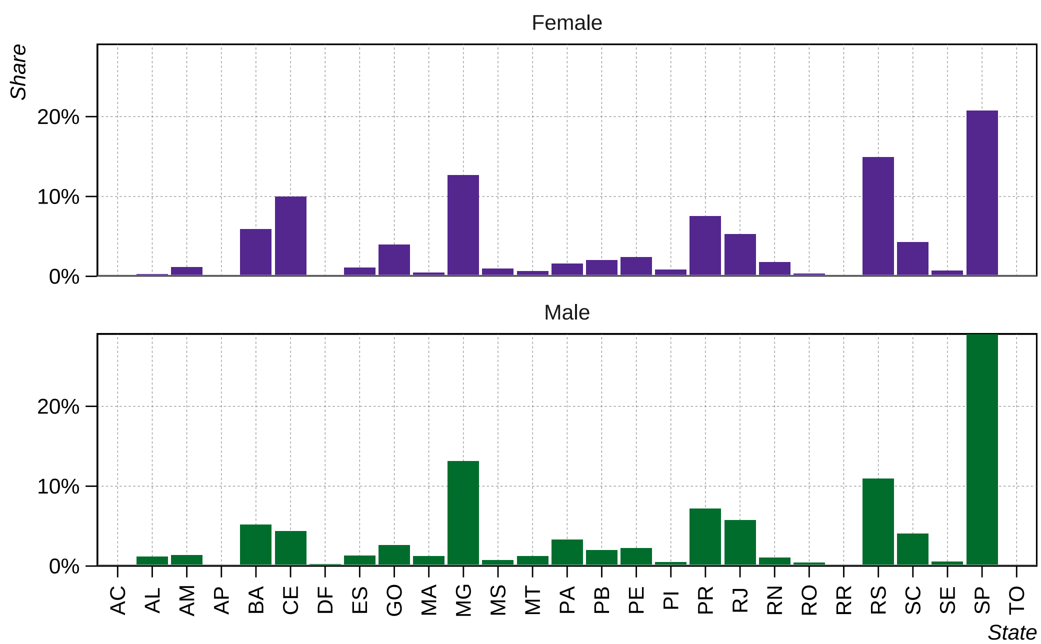
Note: Difference in percentage points between the share of total employment in the scenario with the China shock and the scenario without it.

Figure 16: Contribution to the Reduction in Employment Share in Manufacturing by Sector - 2010



Note: For each sector, the reduction in employment is calculated by comparing the scenario with the China shock and the scenario without the China shock. The reduction value obtained is divided by the total reduction in jobs for manufacturing.

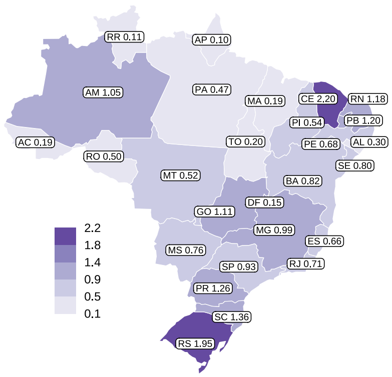
Figure 17: Contribution to the Reduction in Employment Share in Manufacturing by State - 2010



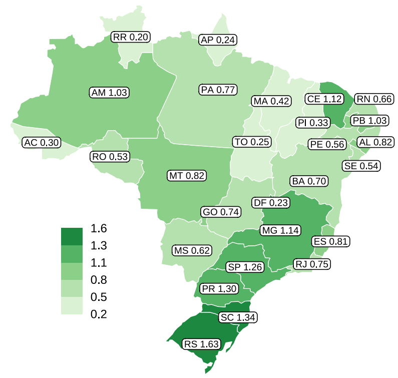
Note: For each state, the reduction in employment is calculated by comparing the scenario with the China shock and the scenario without the China shock. The reduction value obtained is divided by the total reduction in jobs for manufacturing.

Figure 18: Normalized contribution to the Reduction in Employment Share in Manufacturing by State - 2010

(a) Female



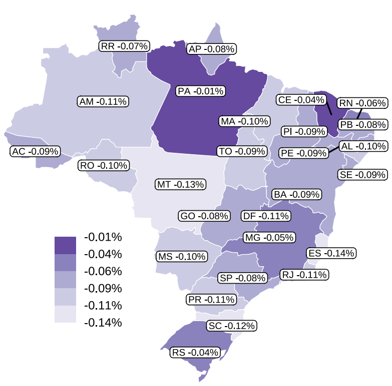
(b) Male



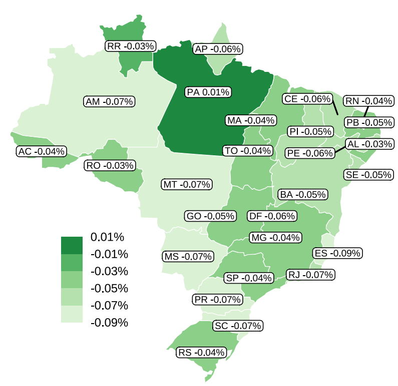
Note: For each state, the reduction in employment is calculated by comparing the scenario with the China shock and the scenario without the China shock. The reduction value obtained is divided by the total reduction in jobs for manufacturing. After that, the normalized contribution is calculated by dividing the reduction in employment by the share of each state in total manufacturing employment in Brazil.

Figure 19: Change in Non-Employment Shares - 2010

(a) Female

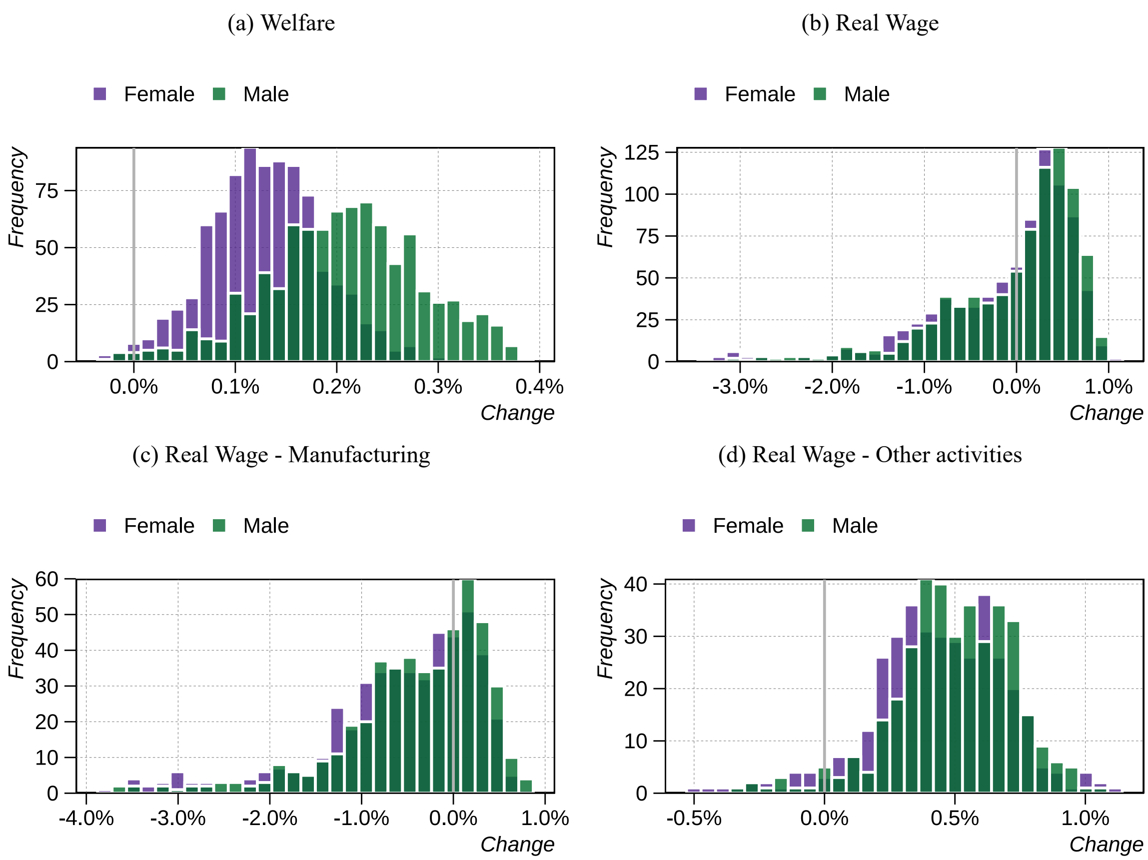


(b) Male



Note: Relative change in the number of workers in the Brazilian economy in the scenario with the China shock compared to the scenario without it.

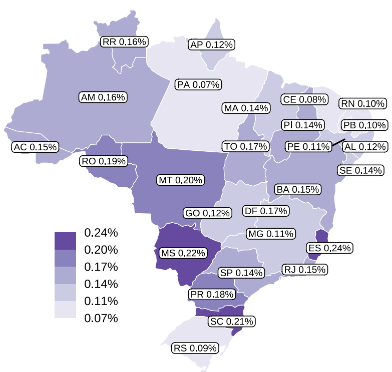
Figure 20: Distribution of Welfare Variation by Gender



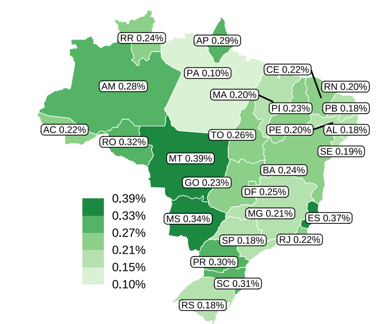
Note: Authors' calculations based on the model. Welfare variation is calculated as the percentage change in equivalent consumption. The distributions are truncated at the 1st and 99th percentiles. For the real wage, the accumulated variation of the real wage in the baseline scenario compared to the counterfactual scenario is being computed.

Figure 21: Welfare Change by State

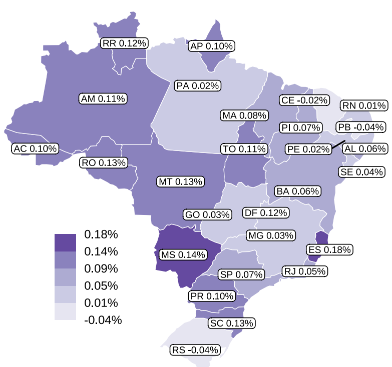
(a) Female - All Sectors



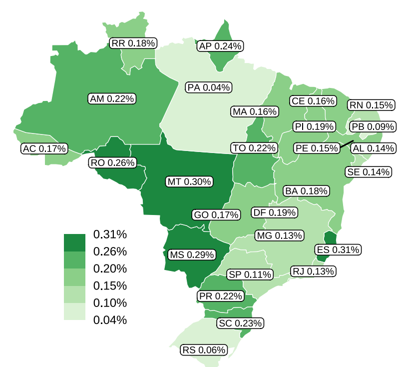
(b) Male - All Sectors



(c) Female - Manufacturing



(d) Male - Manufacturing



Note: Authors' calculations based on the model. Welfare variation is calculated as the percentage change in equivalent consumption.

C Solving the Model

The model's solution uses the dynamic hat algebra technique presented in CDP. To make the model's solution process clearer, we must define the "dot" and "hat" notations. The "dot" notation denotes a variable's change between two periods. For example, for a scalar (or vector) x, we define $\dot{x}_{t+1} \equiv (\dot{x}^1_{t+1}/\dot{x}^1_t,\ \dot{x}^2_{t+1}/\dot{x}^2_t,\ ...)$. The "hat" notation denotes a variable's change between the baseline and counterfactual scenarios. For example, for a scalar (or vector) x, we define $\hat{x}_{t+1} \equiv (\dot{x}'^1_{t+1}/\dot{x}^1_{t+1},\ \dot{x}'^2_{t+1}/\dot{x}^2_{t+1},\ ...)$, where x' represents the variable's value in the counterfactual scenario and x is its value in the baseline scenario. The complete steps for rewriting the level equations into "dot" and "hat" notation are detailed in CDP.

C.0.1 Baseline

We use the derivations and results presented in Propositions 1 and 2 to solve the baseline. First, an initial guess is defined for $\{\dot{u}^{njg}_{t+1}\}^T_{t=0}$, considering $u^{njg}_t \equiv \exp(V^{njg}_t)$. Based on this guess, the transition matrices $\{\mu^{nj,ik,g}_t\}^T_{t=0}$ are calculated as

$$\mu^{nj,ik,g}_{t+1} = \frac{\mu^{nj,ik,g}_{t+1}(\dot{u}^{njg}_{t+2})^{\beta/\nu}}{\sum_{m=1}^{N}\sum_{h=0}^{J}\mu^{nj,mh,g}_t(\dot{u}^{mhg}_{t+2})^{\beta/\nu}}.$$

Using these transition matrices, the trajectories of the labor stock $\{L^{njg}_{t+1}\}^T_{t=0}$ are calculated as

$$L^{njg}_{t+1} = \sum_{i=1}^{N}\sum_{k=0}^{J}\mu^{nj,ik,g}_t L^{ikg}_t.$$

Next, for $t = 0, 1, \ldots, T$, we sequentially compute temporary equilibria. First, we calculate the variation of the capital stock at $t+1$ as

$$\dot{K}^n_{t+1} = \beta[r^n_t/P^n_t + (1-\delta)].$$

Given $\dot{L}^{njg}_{t+1}$, $\dot{K}^n_{t+1}$, and the changes in the fundamentals $\dot{\kappa}^{nj,ij}_{t+1}$ and $\dot{A}^{ij}_{t+1}$, the following system is solved for $t+1$:

- Unit cost of the input basket

$$\dot{x}^{nj}_{t+1} = \left((\dot{r}^{nj}_{t+1})^{\xi^{nj}}(\dot{w}^{nj}_{t+1})^{1-\xi^{nj}}\right)^{\gamma^{nj}}\prod_{k=1}^{J}(\dot{P}^{nk}_{t+1})^{\gamma^{nj,nk}}.$$

- Wage index in market nj

$$\dot{w}^{nj}_{t+1} = \left(\sum_{g=1}^{G}\psi^{w,njg}_t(\dot{w}^{njg}_{t+1})^{1-\sigma}\right)^{\frac{1}{1-\sigma}}.$$

- Final good price index

$$\dot{P}^{nj}_{t+1} = \left(\sum_{i=1}^{N}\pi^{nj,ij}_t(\dot{x}^{ij}_{t+1}\dot{\kappa}^{nj,ij}_{t+1})^{-\theta^j}(\dot{A}^{ij}_{t+1})^{\theta^j\gamma^{ij}}\right)^{-\frac{1}{\theta^j}}.$$

- Bilateral trade shares

$$\pi^{nj,ij}_{t+1} = \pi^{nj,ij}_t\left(\frac{\dot{x}^{ij}_{t+1}\dot{\kappa}^{nj,ij}_{t+1}}{\dot{P}^{nj}_{t+1}}\right)^{-\theta^j}\left(\dot{A}^{ij}_{t+1}\right)^{\theta^j\gamma^{ij}}.$$

- Expenditure

$$X_{t+1}^{nj} = \sum_{k=1}^{J} \gamma^{nk,nj} \sum_{i=1}^{N} \pi_{t+1}^{ik,nk} X_{t+1}^{ik} + \alpha^{nj} \left(\sum_{j=1}^{J} \sum_{g=1}^{G} \dot{w}_{t+1}^{njg} \dot{L}_{t+1}^{njg} w_t^{njg} L_t^{njg} + \iota^n \sum_{i=1}^{N} \dot{r}_{t+1}^{n} \dot{K}_{t+1}^{n} r_t^n K_t^n \right).$$

- Gender share in the wage bill

$$\psi_{t+1}^{njg} = \psi_t^{njg} \left(\frac{\dot{w}_{t+1}^{njg}}{\dot{w}_{t+1}^{nj}} \right)^{1-\sigma}.$$

- Labor demand

$$\dot{w}_{t+1}^{njg} \dot{L}_{t+1}^{njg} = \frac{\psi_{t+1}^{njg} (1-\xi^{nj}) \gamma^{nj} \sum_{i=1}^{N} \pi_{t+1}^{ij,nj} X_{t+1}^{ij}}{w_t^{njg} L_t^{njg}},$$

- Capital demand

$$\dot{r}_{t+1}^{n} \dot{K}_{t+1}^{n} = \frac{\sum_{j=1}^{J} \xi^{nj} \gamma^{nj} \sum_{i=1}^{N} \pi_{t+1}^{ij,nj} X_{t+1}^{ij}}{r_t^n K_t^n}.$$

Once this system is solved and $\dot{P}_{t+1}^{n} = \prod_{j=1}^{J} (\dot{P}_{t+1}^{nj})^{\alpha_{nk}}$ is computed for $t = 0, 1, \ldots, T$, we can calculate the real wage variation, $\dot{w}_{t+1}^{njg} / \dot{P}_{t+1}^{n}$, and update $\{\dot{u}_{t+1}^{njg(1)}\}_{t=0}^{T}$ as:

$$\dot{u}_{t+1}^{njg(1)} = \frac{\dot{w}_{t+1}^{njg}}{\dot{P}_{t+1}^{n}} \left(\sum_{i=1}^{N} \sum_{k=0}^{J} \mu_t^{nj,ik,g} (\dot{u}_{t+2}^{ikg})^{\beta/\nu} \right)^{\nu}.$$

If the difference between the initial $\{\dot{u}_{t+1}^{njg}\}$ and updated $\{\dot{u}_{t+1}^{njg(1)}\}$ exceeds a chosen tolerance, we iterate again with the updated values.

C.0.2 Counterfactual

The counterfactual solution uses Proposition 3 in CDP and the baseline scenario's results. We first guess an initial path for $\{\hat{u}_{t+1}^{njg}\}_{t=0}^{T}$. Using these guesses, the transition matrices $\{\mu_t'^{nj,ik,g}\}_{t=0}^{T}$ are calculated as follows:

- For $t = 0$ and assuming $\hat{u}_0^{njg} = 1$,

$$\mu_0'^{nj,ik,g} = \mu_0^{nj,ik,g}.$$

- For $t = 1$,

$$\mu_1'^{nj,ik,g} = \frac{\mu_1^{nj,ik,g} (\hat{u}_1^{ikg})^{\beta/\nu} (\hat{u}_2^{ikg})^{\beta/\nu}}{\sum_{m=1}^{N} \sum_{h=0}^{J} \mu_1^{nj,mh,g} (\hat{u}_1^{mhg})^{\beta/\nu} (\hat{u}_2^{mhg})^{\beta/\nu}}.$$

- For $t \geq 2$,

$$\mu_t'^{nj,ik,g} = \frac{\mu_{t-1}'^{nj,ik,g} \dot{\mu}_t^{nj,ik,g} (\hat{u}_{t+1}^{njg})^{\beta/\nu}}{\sum_{m=1}^{N} \sum_{h=0}^{J} \mu_{t-1}'^{nj,mh,g} \dot{\mu}_t^{nj,mh,g} (\hat{u}_{t+1}^{mhg})^{\beta/\nu}}.$$

The labor stocks $\{L'^{njg}_{t+1}\}_{t=0}^{T}$ then follow

$$L'^{njg}_{t+1} = \sum_{i=1}^{N}\sum_{k=0}^{J} \mu'^{nj,ik,g}_{t} L'^{ikg}_{t}.$$

For $t = 0, 1, \dots, T$, we sequentially compute temporary equilibria. First, we calculate the capital stock variation at $t+1$

$$\hat{K}^{n}_{t+1} = \frac{[r'^{n}_{t}/P'^{n}_{t} + (1-\delta)]}{[r^{n}_{t}/P^{n}_{t} + (1-\delta)]}.$$

Given $\hat{L}^{njg}_{t+1}$, $\hat{K}^{n}_{t+1}$, and the fundamentals $\hat{\kappa}^{nj,ij}_{t+1}$ and $\hat{A}^{ij}_{t+1}$ relative to the baseline, we solve this system for $t+1$:

- Unit cost of the input basket

$$\hat{x}^{nj}_{t+1} = \left((\hat{r}^{nj}_{t+1})^{\xi^{nj}}(\hat{w}^{nj}_{t+1})^{1-\xi^{nj}}\right)^{\gamma^{nj}} \prod_{k=1}^{J}(\hat{P}^{nk}_{t+1})^{\gamma^{nj,nk}}.$$

- Wage index in market nj

$$\hat{w}^{nj}_{t+1} = \left(\sum_{g=1}^{G} \psi'^{njg}_{t}\dot{\psi}'^{njg}_{t+1}(\hat{w}^{njg}_{t+1})^{1-\sigma}\right)^{\frac{1}{1-\sigma}}.$$

- Final good price index

$$\hat{P}^{nj}_{t+1} = \left(\sum_{i=1}^{N} \pi'^{nj,ij}_{t}\dot{\pi}^{nj,ij}_{t+1}(\hat{x}^{ij}_{t+1}\hat{\kappa}^{nj,ij}_{t+1})^{-\theta^{j}}(\hat{A}^{ij}_{t+1})^{\theta^{j}\gamma^{ij}}\right)^{-\frac{1}{\theta^{j}}}.$$

- Bilateral trade shares

$$\pi'^{nj,ij}_{t+1} = \pi'^{nj,ij}_{t}\pi^{nj,ij}_{t+1}\left(\frac{\hat{x}^{ij}_{t+1}\hat{\kappa}^{nj,ij}_{t+1}}{\hat{P}^{nj}_{t+1}}\right)^{-\theta^{j}}\left(\hat{A}^{ij}_{t+1}\right)^{\theta^{j}\gamma^{ij}}.$$

- Expenditure

$$\begin{aligned} X'^{nj}_{t+1} = &\sum_{k=1}^{J}\gamma^{nk,nj}\sum_{i=1}^{N}\pi'^{ik,nk}_{t+1}X'^{ik}_{t+1} \\ &+ \alpha^{nj}\left(\sum_{j=1}^{J}\sum_{g=1}^{G}\hat{w}^{njg}_{t+1}\hat{L}^{njg}_{t+1}, w'^{njg}_{t}L'^{njg}_{t}\dot{w}^{njg}_{t+1}\dot{L}^{njg}_{t+1} + \iota^{n}\sum_{i=1}^{N}\hat{r}^{n}_{t+1}\hat{K}^{n}_{t+1}r'^{n}_{t}K'^{n}_{t}\dot{r}^{n}_{t+1}\dot{K}^{n}_{t+1}\right).\end{aligned}$$

- Gender share in the wage bill

$$\psi'^{njg}_{t+1} = \psi'^{njg}_{t}\psi^{njg}_{t+1}\left(\frac{\hat{w}^{njg}_{t+1}}{\hat{w}^{nj}_{t+1}}\right)^{1-\sigma}.$$

- Labor demand

$$\hat{w}^{njg}_{t+1}\hat{L}^{njg}_{t+1} = \frac{\psi'^{njg}_{t+1}(1-\xi^{nj})\gamma^{nj}\sum_{i=1}^{N}\pi'^{ij,nj}_{t+1}X'^{ij}_{t+1}}{w'^{njg}_{t}L'^{njg}_{t}\dot{w}^{njg}_{t+1}\dot{L}^{njg}_{t+1}}.$$

- Capital demand

$$\hat{r}^n_{t+1}\hat{K}^n_{t+1} = \frac{\sum_{j=1}^{J} \xi^{nj}\gamma^{nj} \sum_{i=1}^{N} \pi'^{ij,nj}_{t+1} X'^{ij}_{t+1}}{r^n_t K^n_t \dot{r}^n_{t+1} \dot{K}^n_{t+1}}.$$

After solving this system, setting $\hat{P}^n_{t+1} = \prod_{j=1}^{J} = (\hat{P}^{nj}_{t+1})^{\alpha_{nk}}$, and calculating $\hat{w}^{njg}_{t+1}/\hat{P}^n_{t+1}$, we update $\{\hat{u}^{njg(1)}_{t+1}\}^T_{t=0}$:

- For $t \geq 2$,

$$\hat{u}^{njg(1)}_t = \frac{\hat{w}^{njg}_t}{\hat{P}^n_t}\Big(\sum_{i=1}^{N}\sum_{k=0}^{J} \mu'^{nj,ik,g}_{t-1} \dot{\mu}^{nj,ik,g}_t (\hat{u}^{ikg}_{t+1})^{\beta/\nu}\Big)^{\nu}.$$

- For $t = 1$,

$$\hat{u}^{njg(1)}_1 = \frac{\hat{w}^{njg}_1}{\hat{P}^n_1}\Big(\sum_{i=1}^{N}\sum_{k=0}^{J} \mu^{nj,ik,g}_1 (\hat{u}^{ikg}_1)^{\beta/\nu} (\hat{u}^{ikg}_2)^{\beta/\nu}\Big)^{\nu}.$$

If the difference between $\{\hat{u}^{njg}_{t+1}\}$ and $\{\hat{u}^{njg(1)}_{t+1}\}$ is larger than a given tolerance, the process is repeated with updated $\{\hat{u}^{njg}_{t+1}\}$.