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THE POLITICAL ECONOMY BEHIND TRADE AND LAND USE: LEGAL AMAZON IN THE EU-MERCOSUR FREE TRADE AGREEMENT

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Abstract

Contingent free trade agreements are an instrument of interaction between countries that is being used more recently. In this paper, we consider the European Union-Mercosur Free Trade Agreement and how this FTA can be used by EU to induce certain land use changes in Brazil. This analysis uses a quantitative trade model and different trade arrangements to test whether these conditional trade agreements accomplish what they originally intend. We find that in the case of the EU-Mercosur FTA, Brazilian Legal Amazon states tend to alternate at seeing reduction of land use. However, for the kinds of trade arrangement, among the ones considered in this paper, welfare seems to increase state-wide. This indicates that even if Brazil concede entering in non-totally free trade agreements, there are trade gains to be obtained. Internally to Brazil, nevertheless, a contingent free trade agreement might create some political instability for the country. Our paper aims to anticipate this political discussion by bringing to the front the fact the any kind of trade agreement will benefit states differently.

Keywords: trade; land use; quantitative spatial model

Resumo

Acordos comerciais contigentes são um intrumento de interação entre países que vêm sendo mais usados recentemente. Neste artigo, consideramos o Acordo de Livre Comércio (FTA) entre União Europeia e Mercosul e como esse FTA pode ser usado pela UE para induzir certas mudanças do uso da terra no Brasil. Esta análise usa um modelo quantitativo de comércio e diferentes arranjos de comércio para testar se esse tipo de acordo comercial alcança seus objetivos. Nós encontramos que no caso do acordo comercial de EU-Mercosul, os estados da Amazônia Legal tendem a alternar sua redução no uso do fator terra. Contudo, para os tipos de acordos comerciais considerados neste artigo, o bem estar tende a aumentar para todos os estados. Isso indica que caso o Brasil opte por ingressar num acordo comercial não totalmente livre, há ainda ganhos de comércio a serem obtidos. Internamente para o Brasil, contudo, um acordo comercial contigente pode criar instabilidade política para o país. Este paper objetiva antecipar essa discussão ao explicitar as possíveis diferenças que um acordo comercial pode criar entre os estados da Amazônia Legal.

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Palavras-chaves: comércio; uso da terra; modelo quantitativo espacial

JEL Codes: C63; F18; Q15

1 Introduction

Trade and land are part of production-consumption nexus, which is strongly characterized by a feedback loop, that is, more trade tends to induce more land use and vice-versa. In Ricardian trade models, more trade tends to lead to intense use of the abundant factor available in the trade partner. For many countries, this abundant factor is land. According to literature (Pendrill et al., 2022), international trade is an important component of deforestation, with the foreign demand being responsible for 1/3 of deforestated land on average[1]. So, given the profile of emissions and biodiversity production, it is important to analyze the dynamic of land use in the context of a conditional trade agreement. Conditional (better say contingent) trade agreements (Harstad, 2022) are not exactly new; however, they merge two incentives that apparently tend to go in different direction on their impact on land use: (i) trade openness possibly increasing land use; (ii) hard regulation on not importing goods produced in some recently deforested land (say previously deforested land- see European-Parliament and of-the European-Union (2023)), decreasing land use.

Our main goal is to analyze whether free or almost free trade is compatible with land use reduction, which indicates a change in the production mix. We aim particularly to analyze the land use patterns in the Legal Amazon states, where new land is more accessible via deforestation. Given that current international discussions surrounding production in newly deforested land, these considerations are not self-evident. Even more so, we try to propose an economic mechanism in which rich countries such as those from EU can effectively affect production decisions in Brazil by offering more than only trade access. This is reasonable given that EU is not the main destination of Brazilian primary exports (Nonnemberg et al., 2024). Hence, we are interested in seeing how these conflicting interests play numerically. We deploy a quantitative spatial trade model, with focus on the EU-Mercosur Free Trade Agreement. Given that EU is not the main trade partner of Brazil in the goods that land use (and deforestation) matter the most (Nonnemberg et al., 2024)-China occupies this position-, then a free trade agreement with Brazil tends to increase EU's leverage on diffusing its regulatory ambitions regarding forests and land use, via the Brussels effect (Trevizan, 2024; Bradford, 2020; Leal & De Figueiredo, 2024). The European Union have been successful more recently in driving change abroad, according to its regulatory framework[2].To the Brazilian advantage, even for a trade agreement that restricts its land use, there might be some gains in the trade in the other kind of goods. We try to quantify these effects and see whether these two apparently conflicting directions are indeed divergent or not. We find that there are scenarios in which free (or almost-

[1]Even though recent works, such as Haddad et al. (2024), indicate the domestic demand is important driver of deforestation in Brazil, a general equilibrium model accounts for that possibility.

[2]Recent WTO panel manifestations (WTO (2022a, 2022b), due to complainants Malaysia and Indonesia against EU) have tended to allow EU even to impose a trade tariff larger in these countries than elsewhere, which would initially be considered a Most-Favorable Nation violation. We simulate this scenario for Brazil as the public and law perception surrounding this type of measure has been shifiting from negative-less free trade- to positive- more environmental consciousness.

free) trade agreements reduce land use, while increasing welfare. We try to investigate the mechanisms by which this result is possible. In speculative terms, free trade also increases the imports by Brazil from EU, which by the love of variety principle tends to increase Brazilian welfare-this is not testable, but it is a theoretical aspect of our modeling. Even though, there might be some reduction in land use, individuals are better off consuming an ample variety of goods. We detail other possible mechanisms in the text.

The rest of this text is organized in a section describing the more recent studies regarding trade and land and related subjects, a Methods sections detailing our theoretical model and computational aspects of it, a Political Economy Stability analysis of some trade scenarios of the EU-Mercosur FTA and their results, and a Concluding Remarks.

2 Trade and Land: Recent Results in Empiric and Theory

2.1 Empirical Links of Trade and Land

Most studies so far have analyzed the land embedded in trade, under the concept of virtual land. We detail some of these studies below. Qiang, Liu, Cheng, Kastner, and Xie (2013) analyze the virtual trade of land embedded in the agricultural trade for China. The authors analyze a period spanning the decades from 1980 to 2000 and they find that China left the position of a net land exporter to a net land importer with regards to its agricultural trade. This conclusion is drawn based on phenomena of China importing more soybeans, which is a input to oil and livestock feed, used in the production of higher valued goods, such as meat.

MacDonald et al. (2015), in turn, considers the relationship existing among land, grass, calories, and water used in the international trade of different countries. By considering these four aspects, they aim to emphasize interesting productive and trade aspects among the countries. It is possible that a country is a net exporter and importer of a certain good simultaneously, if you consider different measures. The conclusions are similar to other papers: China became a relevant net importer of several goods and also it caused several other countries to net export to it.

Taherzadeh and Caro (2019) asserts that 1/3 of land and water virtual trade can be attributed in the world to foreign demand for soybeans. Moreover, China is the most relevant player in net importing terms, while Brazil and United States alternate in the TOP 2 of land and water use net export, respectively, with Argentina being the 3rd net exporter in both cases. The authors argument that given that soybeans are input to many other relevant goods in production or consumption, it is important to trace their flows in terms of supply chains to properly measure all their supply and demand channels in water and land terms. The authors conclude by saying that they combine analysis of land, water, and emissions to account properly competition and synergies among these variables in the productive sector and the domestic and international consumption.

Liu et al. (2021) analyze the total land footprint embodied in the soybeans trade. They find that this global trade accounts for 16.51Mha. More qualitatively, though, China is a net importer of land in this trade flow, whereas United States and Brazil are positive net exporters of land in this trade flow directed to China. Moreover, these American and

Brazilian land trade flows directed to China are the largest flows in the data considered by the authors.

Yawson (2021) estimated the virtual land trade in the United Kingdom's wheat production. The country is a net land exporter by trade, however different climactic, political and productive scenarios might change this situation by 2050.

J. Wang, Wang, and Zhou (2021) use a Chinese multirregional input-output (MRIO) table to analyze the land use and virtual trade among the Chinese provinces. They find a somewhat established result that Northern and Western provincials are net land exporter to the net land importer in the Southern and Eastern provincials for the country. These results are also found by S. Wang and Wang (2023) and Han and Li (2021).

Hong et al. (2022) analyse, using multinational input-output tables, the flows of emissions and land in the international trade. United States has become a net land exporter, while Brazil and Indonesia have always been. By the end of 2010's, trade flows directed towards China has had the largest volume in the analysis, while flows directed towards Europe have reduced their overall relevance. An interesting point is that countries with small land per capita tend to import a large volume of emissions and land per capita in their trade.

Pellegrina (2022) is the closest paper to what we develop in this thesis, but barely so. This author develops a general equilibrium model aiming to quantify the impact of an agricultural technological innovation - soybeans plantation in tropical areas, possible due to EMBRAPA technology- on employment, GDP, income, land use, and the economic relationship among the states considered. The authors find positive aggregate effects for Brazil for GDP and employment, however regions in the Southern part of Brazil now face competition from the Mid-West in soybeans plantation, as it can be seen by their GDP and employment not growing as much.

2.2 General Equilibrium Models for Trade and Land

In terms of quantitative models available for analysis, there are three main alternatives for our goals here, which are gravitational models, computable general equilibrium models, and exact-hat algebra models. We synthesize this literature here and use it to inform our choice for the exact-hat algebra models. We follow Bekkers (2019) e Leal (2024) in this analysis. CGE and exact-hat algebra models are general equilibrium model, in the sense that they mimic the economy using a full general equilibrium model of the economy, while gravitational models are econometric and partial method to estimate the effect of some policy. CGE simulates a baseline and counterfactual scenario while exact-hat algebra simulates only the counterfactual scenario to make their estimation. At the same time, gravity models calibrate internally the trade costs, implicit in the trade relations. CGE can use out-of-model parameters, while this does not happen often in the exact-hat algebra models. This paper uses hat-exact algebra due to its ability to deal with more granular data in terms of regions and countries. Usually, when using CGE, the researcher chooses whether to focus on many regions or many countries. Hat-exact algebra allows us to consider for instance the 27 Brazilian states and 43 countries (including rest of the world). This allows for very realistic simulations of trade policy.

3 Methods

3.1 Consumers

The consumers derive utility for consuming final goods, in a Cobb-Douglas utility function fashion, with shares α_n^j, such that $\sum_{j=1}^{J} \alpha_n^j = 1$. Income per capita in region n is given by I_n, such that $I_n = w_n + (r_n H_n - S_n)/L_n$, in which r_n is the rental rate of fixed factors, w_n is the wage, and S_n is the trade surplus. Moreover, L_n is the amount of labor employed in region/country n, while H_n is the amount of land and structures employed in region n.

Nationally, the welfare is equalized among the regions within a country, which implies that for the B country, $U^B = I_n/P_n$, for all n within the same country, with $P_n = \prod_{j=1}^{J} (P_n^j/\alpha_n^j)^{\alpha_n^j}$ as the ideal price index of region n and P_n^j.

3.2 Technology

There are two kinds of goods in this economy: final goods and intermediate goods. We detail below the production function of these two goods.

Intermediate goods are those goods that can be used in the production of other goods. Their production function is given by:

$$q_n^j(z_n^j) = z_n^j [T_n^j h_n^j(z_n^j)^{\beta_n} l_n^j(z_n^j)^{1-\beta_n}]^{\gamma_n^j} \prod_{k=1}^{J} M_n^{jk}(z_n^k)^{\gamma_n^{jk}}$$

Where h_n^j is the amount of land and structures spent by region n in sector j. l_n^j is the amount of labor spent by region n in sector j.M_n^{jk} is the amount the sector j in region n buys from sectors k, in and outside their own borders. z_n^j is a productivity draw for region n in sector j. Its draws are independent across regions and sectors, within or outside some country.

The optimal cost of input bundle is given by the following expression:
$x_n^j = F_n^j (r_n^{\beta_n} w_n^{1-\beta_n})^{\gamma_n^j} \prod_{k=1}^{J} (P_n^k)^{\gamma_n^{jk}}$, where F_n^j is scale parameters.

The unit cost will then be given by: $p_n^j(z_n^j) = x_n^j/[z_n^j (T_n^j)^{\gamma_n^j}]$.

The production of final goods can employ both national goods and international - imported - goods. Final goods also possess a production function that is given by the following expression.

$$Q_n^j = [\int_{R_+^N} \bar{q}_n^j(z^j)^{1-1/\eta_n^j} \phi^j(z^j) dz^j]^{\eta_n^j/(\eta_n^j - 1)}$$

3.3 Interregional and International Trade

Interregional and international trade is given by a minimum function of the cost of imports and national consumption. In that way, the final price of the good produced in the region n and sector j is given by:

$$p_n^j(z^j) = \min_i \left\{ \frac{\kappa_{ni}^j x_i^j}{z_i^j (T_i^j)^{\gamma_i^j}} \right\}$$

κ_{ni}^j is the iceberg cost for the sector j for exporting from region n into region i. We also assume that $\kappa_{ii}^j = 1, \forall j$ and $\kappa_{ni}^j \geq 1, \forall n \neq i$.The parameter $z_i^j(T_i^j)$ is of crucial interest as it informs the productivity patterns in regions and countries, according to an Extreme Type-II Distribution. Supposing that this parameter follows da Frethchet Distribution, Eaton and Kortum (2002) show that the share of imports in national production will be given by the parameter π_{nij}, which can be simplified into this, due to the statistical properties of the Frethchet distribution:

$$\pi_{ni}^j = \frac{(\kappa_{ni}^j x_i^j)^{-\theta_j} (T_i^j)^{\gamma_i^j}}{\sum_{m=1}^N (\kappa_{nm}^j x_m^j)^{-\theta^j} (T_m^j)^{\gamma_n^j \theta^j}}$$

The price index will be given by the following expression:

$$P_n^j = \Gamma(\xi_n^j)^{\frac{1}{1-\eta_n^j}} \left[\sum_{i=1}^N (\kappa_{ni}^j x_i^j)^{-\theta^j} (T_i^j)^{\theta^j \gamma_i^j} \right]^{-1/\theta_j}$$

3.4 Market Clearing

There are three market conditions for market clearing: one for the final consumption, one for the labor market, and finally one for the trade balance. These conditions are given by the following expressions:

1. market clearing for labor market

$$L_n = \frac{\left(\frac{\omega_n}{P_n U^B + \frac{S_n}{L_n}} \right)^{1/\beta_n} H_n}{\sum_{i=1}^{N^B} \left(\frac{\omega_i}{P_i U^B + \frac{S_i}{L_i}} \right)^{1/\beta_i} H_i} L^B$$

2. market clearing for final goods

$$X_n^j = \alpha_n^j (\omega_n H_n^{\beta_n} L_n^{1-\beta_n} - \Upsilon_n - S_n) + \sum_{k=1}^J \gamma_n^{kj} \sum_{in}^k X_i^k$$

3. Trade Balance

$$\sum_{j=1}^J X_n^j + \Upsilon_n + S_n = \sum_{i=1}^N \sum_{j=1}^J \pi_{in}^j X_i^j$$

3.5 Equilibrium

The equilibrium in this economy is given by:

$$P_n^j = \Gamma(\xi_n^j)^{\frac{1}{1-\eta_n^j}} \left[\sum_{i=1}^{N} (\kappa_{ni}^j x_i^j)^{-\theta^j} (T_i^j)^{\theta^j \gamma_i^j} \right]^{-1/\theta^j}, \forall j \in \{1, \ldots, J\}, \forall n \in \{1, \ldots, N\} \quad (1)$$

$$x_n^j = \tilde{F}_n^j \omega_n^{\gamma_n^j} \prod_{k=1}^{J} (P_n^k)^{\gamma_n^{jk}}, \forall j \in \{1, \ldots, J\}, \forall n \in \{1, \ldots, N\} \quad (2)$$

$$\pi_{ni}^j = \frac{(\kappa_{ni}^j x_i^j)^{-\theta^j} (T_i^j)^{\gamma_i^j \theta^j}}{\sum_{m=1}^{N} (\kappa_{nm}^j x_m^j)^{-\theta^j} (T_m^j)^{\gamma_i^j \theta^j}}, \forall j \in \{1, \ldots, J\}, \forall n \in \{1, \ldots, N\} \quad (3)$$

$$L_n = \frac{\left(\frac{\omega_n}{P_n U^B + \frac{S_n}{L_n}} \right)^{1/\beta_n} H_n}{\sum_{i=1}^{N^B} \left(\frac{\omega_i}{P_i U^B + \frac{S_i}{L_i}} \right)^{1/\beta_i} H_i} L^B \quad (4)$$

$$X_n^j = \alpha_n^j (\omega_n H_n^{\beta_n} L_n^{1-\beta_n} - \Upsilon_n - S_n) + \sum_{k=1}^{J} \gamma_n^{kj} \sum_{in}^{k} X_i^k \quad (5)$$

$$\sum_{j=1}^{J} X_n^j + \Upsilon_n + S_n = \sum_{i=1}^{N} \sum_{j=1}^{J} \pi_{in}^j X_i^j \quad (6)$$

3.6 Conterfactuals

Oftentimes, solving the model in counterfactuals is an easier task than solving the model with its equations in levels. This can be explained by the fact that solving the model in counterfactuals will reduce our need to estimate some non-policy relevant parameters. We define a variable $\hat{x} = x'/x$, in which x' is the new value of the x variable, while x is its initial value. In this way, the counterfactual equilibrium will be given by:

$$\hat{P}_n^j = \left\{ \sum_{i=1}^{N} \pi_{ni}^j (\hat{\kappa}_{ni}^j \hat{x}_i^j)^{\theta^j} (\hat{T}_i^j)^{\gamma_i^j \theta^j} \right\}^{-1/\theta^j}, \forall j \in \{1, \ldots, J\}, \forall n \in \{1, \ldots, N\} \quad (7)$$

$$\hat{x}_n^j = \hat{\omega}_n^{\gamma_n^j} \prod_{k=1}^{J} (\hat{P}_n^k)^{\gamma_n^{jk}}, \forall j \in \{1, \ldots, J\}, \forall n \in \{1, \ldots, N\} \quad (8)$$

$$\pi_{ni}^{j'} = \pi_{ni}^j \left(\frac{\hat{P}_n^j}{\hat{\kappa}_{ni}^j \hat{x}_i^j} \right)^{\theta^j} (\hat{T}_i^j)^{\gamma_i^j \theta^j}, \forall j \in \{1, \ldots, J\}, \forall n, i \in \{1, \ldots, N\} \quad (9)$$

$$\hat{H}_n = \frac{\hat{L}_n \sum_{i=1} L_i \hat{H}_i \left(\frac{\hat{\omega}_i}{\phi_i \hat{P}_i \hat{U}^B + (1-\phi_i) \hat{S}_i / \hat{L}_i} \right)^{1/\beta_i}}{L^B \left(\frac{\hat{\omega}_n}{\phi_n \hat{P}_n \hat{U}^B + (1-\phi_n) \hat{S}_n / \hat{L}_n} \right)^{1/\beta_n}} \quad (10)$$

$$X_n^{j'} = \sum_{k=1}^{J} \gamma_n^{kj} + \alpha_j(\hat{\omega}_n(\hat{H}_n)^{\beta_n}(\hat{L}_n)^{1-\beta_n}(L_n I_n + \Upsilon_n + S_n) - S_n^{'} - \Upsilon_n^{'}) \tag{11}$$

$$\hat{\omega}_n(\hat{H}_n)^{\beta_n}(\hat{L}_n)^{1-\beta_n}(L_n I_n + \Upsilon_n + S_n) = \sum_j \gamma_n^j \sum_i \pi_{in}^{j'} X_j^{'j} \tag{12}$$

3.7 Solution Algorithm

The solution algorithm uses data on $\{I_n, L_n, S_n, \pi_{ni}^j\}_{n=1,i=1,j=1}^{N,N,J}$, with parameters $\{\beta_n, \theta^j, \alpha_n^j, \gamma_n^j, \gamma_n^{jk}\}_{n=1,j=1,k=1}^{N,J,J}$. Moreover, we consider relative changes on the following variables $\{\hat{S}_n, \hat{T}_n^j, \hat{\kappa}_{ni}^j\}_{n=1,i=1,j=1}^{N,N,J}$. Next, we iterate through the following algorithm:

Given an ω_0 estimate and $\epsilon > 0$:

1. Solve simultaneously the system given by $\hat{P}_n^j$ and $\hat{x}_n^j$, given the ω_0 estimate.
2. Compute $\pi_{ni}^{j'}$ considering $\hat{P}_n^j$ and $\hat{x}_n^j$.
3. Solve for $\hat{H}_n$ consistent with $\hat{P}_n^j$.
4. Solve $X_n^{j'}$, using matrix inversion methods.
5. Obtain a new guess for $\hat{\omega}_n$.
6. Re-do all steps until $|\hat{\omega}_n - \hat{\omega}_{n-1}| \leq \epsilon$.

3.8 Taking the Model to the Data

Data on flows and other kinds of data are necessary for the parameters and variables estimation. In the next paragraphs, we provide an outline of the source of data for the construction of the parameters and how they are constructed.

- Data on trade flows between Brazilian states and countries: this data has three sources: (i) WIOD; (ii) Brazilian state input-output; (iii) COMEX-Stat. WIOD provides us input-output exchanges among all countries considered in the analysis. Brazilian state input-output provides us data on trade flows among the Brazilian states. COMEX-Stat provides data on Brazilian states exports and imports to/from other countries considered.
- Data on social accounts: this data comes from WIOD and Brazilian state input-output and provides us data on level of usage and remuneration on the primary inputs.

All data considered here in this thesis is related to the economy as in 2008, which is the most recent year for which we have data available.

The construction of the variables follows the procedures outlined below:

- $\pi_{ni}^j = X_{ni}^j / \sum_{m=1}^N X_{nm}^j$
- $I_n = (VA_n - S_n)/L_n$

- $1-\beta_n = (w_n L_n)/VA_n$
- $\gamma_n^j = VA_n^j / Y_n^j$
- $\gamma_n^{jk} = M_n^{jk} / Y_n^j$
- $\alpha_n^j = (X_n^j - \sum_{k=1}^{J} \sum_{i=1}^{N} \pi_{in}^k X_i^k)$

Where X_{ni}^j is the flow of goods in sector j from country/region n unto region i. VA_n is the value added in region n. S_n is the trade superavit. L_n is the number of workers in the region n. $w_n L_n$ is the total labor payments in the region n. Y_n^j is the yield of the region n for the sector j. M_n^{jk} is the use of intermediary goods by region n and sector k from sector j. π_{in}^k is the share of imports in region n from region i of sector k.

Moreover, θ^j is estimated according to Caliendo and Parro (2015).

3.9 Changes in Total Factor Productivity (TFP)

The change in TFP for a pair region-sector n, j is given by:

$$\ln \hat{A}_n^j = \ln \left(\frac{(\hat{T}_n^j)^{\gamma_n^j}}{(\hat{\pi}_n^j)^{1/\theta^j}} \right) \tag{13}$$

Where T_n^j is the productivity shock in region n and j, assumed to be independent across sectors, regions, and countries. TFP is used in estimating the change in the welfare, whose formula is displayed down below.

3.10 Changes in Welfare

The change in welfare for region n is given by:

$$\ln \hat{U}_n = \sum_{j=1}^{J} \alpha_n^j \left\{ \ln \hat{A}_n^j + \ln \left[r_n \frac{\hat{\omega}_n}{\hat{x}_n^j} + (1-r_n) \frac{\hat{S}_n}{\hat{x}_n^j \hat{L}_n} \right] \right\} \tag{14}$$

Where A_n^j is the Total Factor Productivity of region n in sector j in relative changes. All other terms were previously defined. Interestingly, welfare is increasing in the TFP, final prices index and trade superavit. It is also decreasing in the input price index and labor change.

4 Political Economy of the Stability of Different Trade Arrangements

In this section, we create two simulations in order to analyze properly the political stability of these suggested trade arrangements. By political stability, we mean that the trade arrangement considered does not harm the welfare of the majority of Legal Amazon states. We consider the relevance and stability of these simulations, considering also their legal standing in relation to WTO. We focus on the Legal Amazon states, as a way to derive some relevant insights on the states with the Amazon rainforest, however results for all Brazilian states are presented in the Appendix.

We develop 2 basic scenarios, which are outlined below:

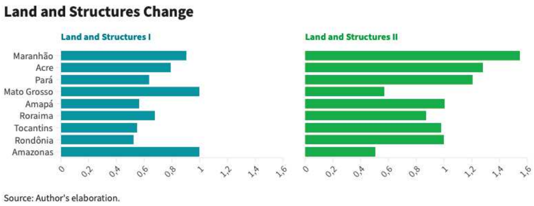
Table 1: Scenarios Simulation

Simulation	Description	Relevance
Scenario I	In this scenario, we reduce the transaction cost for any pair of Brazilian state-sector from/to any European country-sector, considering a homogeneous cost reduction in the tradable sectors of the members of this trade agreement	This is the scenario of an "undiscriminated" free trade agreement, reducing the tariffs levied on the trade from Brazil and to Brazil with regard to the European Union
Scenario II	In this scenario, we reduce the transaction cost homogeneously for any pair of Brazilian state-sector from/to any European country-sector, except the primary sectors, that is, Agriculture and Forest Exploration, Livestock and Fishing, and Mineral Extraction. In these three sectors, there is an increase in the cost of transaction, coming uniquely from higher trade tariffs applied by EU on certain Brazilian import	This scenario can be understood as WTO-allowed green protectionism, given that these sectors, which tend to heavily export in the case of Brazil and usually are nationally associated with some national subsidies by European countries, might not have the market opened so easily. Moreover, this scenario is also aligned with the EU's power to difuse its political preferences in several capabilities

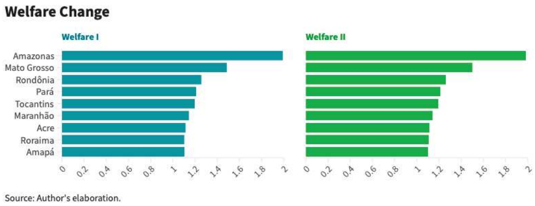
5 Results

We display the results of our simulation in different formats, as a way to emphasize the numerical and regional aspect of our model. Figure 1 displays the comparative variations in land and structures and welfare for the two scenarios analyzed.

Figure 1: Land and Structures, Welfare Change



(a) Land and Structures Change



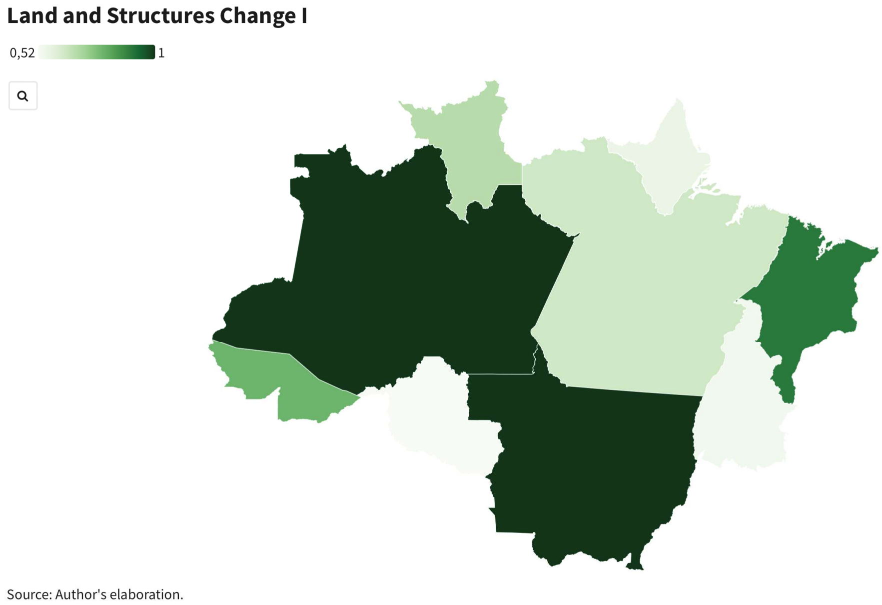
(b) Welfare Change

Source: Author's elaboration.

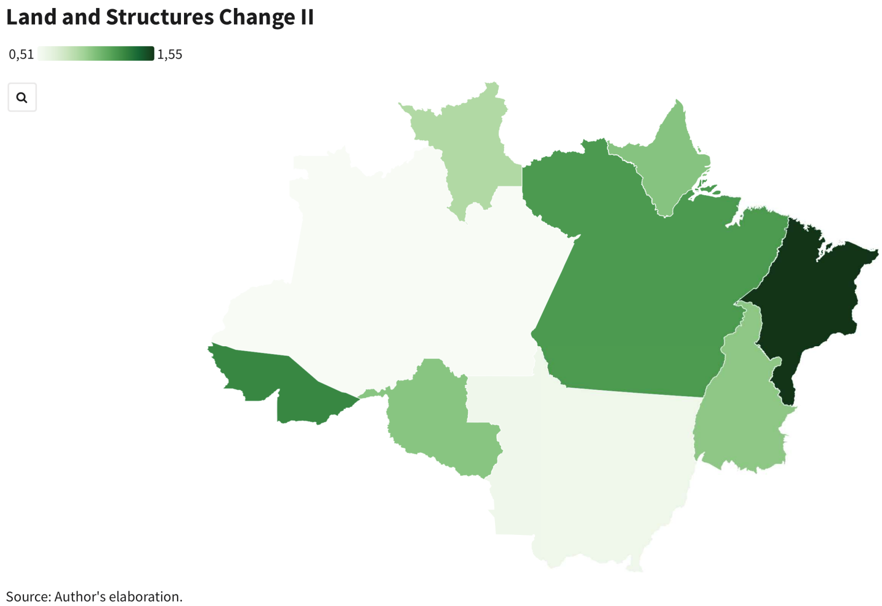
In terms of land change in the Legal Amazon states, both scenarios I and II imply a reduction of land use for almost states. This possibly indicates that engaging in a free trade changes the input mix used in the products consumed nationally and internationally. Our model accounts for international and intranational linkages in production and consumption. This allows for a richer structure of trade and input mix to appear because of its estimation. This is also the main advantage of our model, when compared with other general equilibrium and structural gravity models. In terms of welfare, as expected, welfare grows more evenly for all states in the Scenario I. For the Amazonas state, welfare increases the most in each scenario considered, among other Legal Amazon states. Given the industrial profile, this might occur because this state is more exposed to trade tariffs reduction in comparison to other Legal Amazon states.

In the following Figure 2, we display in a the map format the land and structures change in the two scenarios simulated here.

Figure 2: Land and Structures Change



(a) Scenario I



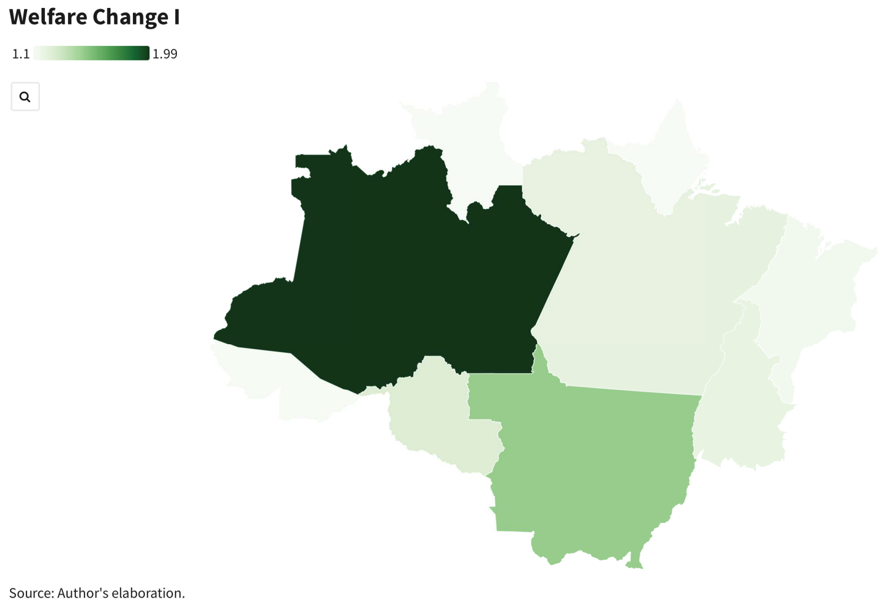
(b) Scenario II

Source: Author's elaboration.

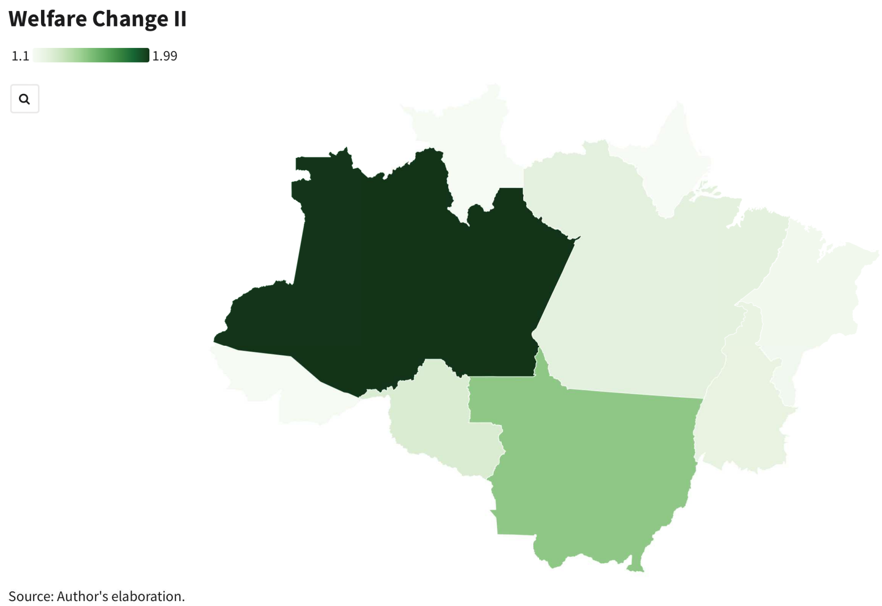
In terms of land and structures, while in Scenario I, Amazonas and Mato Grosso see the largest increase in this input use. In Scenario 2, there is a reversal, with a smaller use of land by the two states. Maranhão and Pará, which had land use reduction in Scenario I now sees increases in their land use for production. This is one interesting result. Maranhão and some parts of Pará could be seen as the frontier of the Legal Amazon rainforest, while Amazonas is where most of the virgin Amazon rainforest is located. The main message of this section should be the different trade arrangements will elicit different input mix. Given the relevance of the input mix on the deforestation and use of land, the design of a trade agreement must consider its linkages and what kind of economic result it induces.

In Figure 3, we display in a the map format the welfare change in the two scenarios simulated here.

Figure 3: Welfare Change



(a) Scenario I



(b) Scenario II

Source: Author's elaboration.

Both maps indicate that the economies more well positioned to enjoy any kind of free trade agreement are Amazonas and Mato Grosso. While welfare in other states also increase in both scenarios as previously outlined, these two states fare the best among all Legal Amazon states in our modeling and simulation.

6 Concluding Remarks

This paper aimed at characterizing numerically an important question: can trade agreements induce better outcomes, in terms of input mix? We find that the answer to this question is more nuanced that what we would expect. In more precise terms, freer trade sometimes induces better land use, while contingent trade seems to work even better for the question regarding trade and natural resources.

Our paper employed a quantitative trade model that allowed a rich regional and economic structure among the Brazilians states and many other countries, including 27 EU countries. Our modeling is innovative and unique in the sense that it endogenizes land and structures decisions in the economy, while keeping labor fixed. Hence, it is a short-term analysis of new trade arrangements effects of land in the Legal Amazon states. In terms of our results, different kind of free trade imply different uses of land, with free trade moving towards the center of rainforest, while contingent free trade moving the border of the rainforest. This is an interesting result as it details the non-neutrality of free trade, in any way of capacity, in changing land use.

Given these results, important political and political economic questions must be answered. The two free trade scenarios considered here are not an exhaustive simulation of all trade arrangements possible between Brazil and the European Union. Moreover, this is not feasible as both countries will choose the trade arrangements that is political sound for them in the moment of its conception. For instance, there have been manifestations by EU leaders that Brazil is getting into a EU-Mercosur free trade agreement with few strings attached in terms of competition with European farmers and Brazil's extensive practice of deforestation[3]. At the same time, one ponders how the EU-Mercosur will play out in terms of changing the relevance of EU as a Brazilian exports' destination. Nowadays, China is major destination of the country, with more than US$ 104 billion exported by Brazil alone in 2023, according to ComexStat. So, the question on whether Brazil will accommodate to EU's requirements for sanctioning the EU-Mercosur free trade agreement is not obvious or useless. In both political and political economic terms, Brazilian states will adapt differently to this agreement and given the political non-homogeneity of the country, these types of questions matter.

[3] Available at:https://valor.globo.com/brasil/noticia/2024/03/28/macron-diz-que-e-loucura-validar-acordo-mercosul-ue-com-base-em-texto-de-20-anos-atras.ghtml. Access: 28 June,2024

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APPENDIX

A List of Brazilian States and Countries in the Quantitative Spatial Model

Brazilian States	**Countries**
Acre	Australia
Amapá	Austria
Amazonas	Belgium
Pará	Bulgaria
Rondônia	Brazil
Roraima	Canada
Tocantins	Switzerland
Alagoas	China
Bahia	Cyprus
Ceará	Czech Republic
Maranhão	Germany
Paraíba	Denmark
Pernambuco	Spain
Piauí	Estonia
Sergipe	Finland
Rio Grande do Norte	France
Distrito Federal	Great Britain
Goiás	Greece
Mato Grosso	Croatia
Mato Grosso do Sul	Hungary
Espírito Santo	Indonesia
Minas Gerais	India
Rio de Janeiro	Ireland
São Paulo	Italy
Paraná	Japan
Santa Catarina	Korea
Rio Grande do Sul	Lithuania
	Luxembourg
	Latvia
	Mexico
	Malta
	Netherlands
	Norway
	Polonia
	Portugal
	Romania
	Russia
	Slovakia
	Slovenia
	Sweden
	Turkey
	Taiwan

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Table 2 – continued from previous page

Brazilian States	Countries
	United States of America Rest of the World

B Economic Sectors

Economic Sectors
Agriculture, forestry, and logging
Livestock farming and fishing
Mining
Food, beverages, and tobacco
Textile, apparel, and footwear
Wood, paper, and printing
Petroleum refining, coke, and alcohol
Other chemicals and pharmaceuticals
Rubber and plastic products
Cement and other non-metallic mineral products
Metallurgy
Machinery and equipment
Electrical and electronic equipment
Transport equipment
Miscellaneous industries
Electricity and gas, water, sewage, and urban cleaning
Construction
Commerce
Transportation, storage, and mail
Private services
Financial intermediation and insurance
Real estate and rental services
Accommodation and food services
Commercial and public education
Commercial and public health
Public administration and social security

C Sectoral Dispersion of Productivity

Industry	θ^j
Agriculture, forestry, and logging	6.09
Livestock farming and fishing	14.22
Mining	5.41
Food, beverages, and tobacco	5.43
Textile, apparel, and footwear	5.38
Wood, paper, and printing	7.04
Petroleum refining, coke, and alcohol	15.83
Other chemicals and pharmaceuticals	6.90

Rubber and plastic products	4.30
Cement and other non-metallic mineral products	11.37
Metallurgy	5.91
Machinery and equipment	42.53
Electrical and electronic equipment	3.09
Transportation equipment	9.29
Miscellaneous industries	15.66

D Land and Structures Change- Simulation Results

Legal Amazon	State	H1	H2
1	Acre (AC)	0.791	1.282
1	Amapá (AP)	0.566	1.004
1	Amazonas (AM)	1.000	0.506
1	Pará (PA)	0.636	1.206
1	Rondônia (RO)	0.524	1.002
1	Roraima (RR)	0.679	0.872
1	Tocantins (TO)	0.550	0.982
0	Alagoas (AL)	1.000	0.829
0	Bahia (BA)	1.000	0.667
0	Ceará (CE)	1.000	0.916
1	Maranhão (MA)	0.904	1.548
0	Paraíba (PB)	0.563	0.889
0	Pernambuco (PE)	1.000	0.671
0	Piauí (PI)	1.000	0.884
0	Sergipe (SE)	0.592	0.963
0	Rio Grande do Norte (RN)	0.501	1.044
0	Distrito Federal (DF)	1.000	0.574
0	Goiás (GO)	1.000	0.572
1	Mato Grosso (MT)	1.000	0.573
0	Mato Grosso do Sul (MS)	1.000	0.877
0	Espírito Santo (ES)	0.741	1.393
0	Minas Gerais (MG)	1.000	0.842
0	Rio de Janeiro (RJ)	0.759	0.993
0	São Paulo (SP)	1.000	0.560
0	Paraná (PR)	1.000	1.000
0	Santa Catarina (SC)	1.000	0.718
0	Rio Grande do Sul (RS)	1.000	0.718

E Welfare Change- Simulation Results

Legal Amazon	State	Welfare1	Welfare2
1	Acre (AC)	1.115	1.116
1	Amapá (AP)	1.105	1.101

Continued on next page

Table 6 – *Continued from previous page*

Legal Amazon	**State**	**Welfare1**	**Welfare2**
1	Amazonas (AM)	1.991	1.985
1	Pará (PA)	1.212	1.214
1	Rondônia (RO)	1.257	1.263
1	Roraima (RR)	1.104	1.107
1	Tocantins (TO)	1.199	1.195
0	Alagoas (AL)	1.233	1.234
0	Bahia (BA)	1.584	1.569
0	Ceará (CE)	1.218	1.233
1	Maranhão (MA)	1.145	1.142
0	Paraíba (PB)	1.197	1.187
0	Pernambuco (PE)	1.286	1.276
0	Piauí (PI)	1.240	1.241
0	Sergipe (SE)	1.193	1.197
0	Rio Grande do Norte (RN)	1.190	1.188
0	Distrito Federal (DF)	1.219	1.221
0	Goiás (GO)	1.576	1.595
1	Mato Grosso (MT)	1.487	1.501
0	Mato Grosso do Sul (MS)	1.449	1.462
0	Espírito Santo (ES)	1.218	1.218
0	Minas Gerais (MG)	1.396	1.415
0	Rio de Janeiro (RJ)	1.213	1.199
0	São Paulo (SP)	1.399	1.388
0	Paraná (PR)	1.594	1.575
0	Santa Catarina (SC)	1.417	1.391
0	Rio Grande do Sul (RS)	1.672	1.618