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Investigating the Growth of Brazilian Agricultural Exports

By Heidi Schweizer[1] and Yasin Yildirim[2]

Abstract
Brazilian agricultural exports have increased 12 percent per year since 2000 and the agricultural sector has been a critical contribution to growth in Brazilian gross domestic product (CEPII-CHELEM, 2021). Many explanations have been offered for the rapid rise of Brazilian market share in the global marketplace such as increased agricultural land, infrastructure improvements, and a supportive policy environment. However, previous literature has been focused on specific crops and specific policies, and it is unclear which factors overall are associated with the largest increases to Brazilian agricultural export flows. Using a gravity model where the dependent variable is the value of Brazilian agricultural exports to its trading partners, we examine the collection of factors commonly included in explanations of Brazilian agricultural and export growth between the years 1996-2018. Specifically, we include measures for currency depreciation, domestic agricultural policies, improvements to internal infrastructure (rail and road), changes in agricultural inputs like land use and technology adoption, as well as the standard set of explanatory origin/destination variables such as bilateral trade agreements. We combine commonly used trade data (CEPII-CHELEM, World Bank Databank, OECD, FAO) with sources related to internal trade costs (CNT, DNIT, ANFAVEA). Our results show that agricultural export flows are dominantly associated with domestic factors including changes in agricultural inputs and transportation infrastructure.
Keywords: Agriculture exports, gravity model, Brazil, infrastructure

JEL codes: Q17; Q18, Q19

Introduction

With a rapid rise in agricultural exports, Brazil has become an agricultural superpower and the largest competitor of the United States. It is now the biggest supplier of soybean and poultry products in the global market, having surpassed the United States in terms of market share over the last two decades (Observatory of Economic Complexity, 2021). While other BRICS countries (Brazil, Russia, India, China, and South Africa) also grew in terms of gross domestic product, Brazil is the only one where, shown in Figure 1, the share of food exports has remained high and even increased from 1994 to 2020. Figure 2 compares major agricultural exports for the years 2000 and 2018, showing that soybeans, in particular, have been a driver of this growth.

[1] Heidi Schweizer, Corresponding Author, Agricultural and Resource Economics, North Carolina State University, email: hschwei@ncsu.edu, phone: 919.515.5276;

[2] Yasin Yildirim Agricultural and Resource Economics, North Carolina State University, email: yyildir@ncsu.edu. We are grateful to the anonymous reviewers for their clarifying suggestions and to Xiaoyong Zheng and Zheng Li for their comments at Yasin's thesis defense.

In addition to its geographic advantage for both agriculture and trade, a relatively liberal economy and a supportive policy environment have boosted the agro-export of Brazil. The Brazilian government has made substantial attempts to improve foreign relations and domestic infrastructure; particularly in regions where agricultural activities are abundant. Also in recent history, Brazilian farming has grown in land share and become more automated. This has occurred concurrently with economic crisis and currency depreciation. Various explanations have been offered for the rapid rise of Brazil in the global marketplace. However, previous literature has been focused on specific crops and specific policies (Porto, 2002; Siroën and Yucer, 2012; Guilhoto et al., 2015; Valerius et al., 2018; Ribeiro et al., 2019; Viera and Reis, 2019). In work that is not specifically trade-related, Mendes et al. (2009) and Rada and Valdes (2012) have positively linked Brazilian infrastructure to agricultural productivity. It is unclear which overall factors are associated with the largest increases to Brazilian agricultural export flows.

In this paper we examine the factors behind the growth of Brazilian agricultural exports with a gravity model, covering 83 importing partners from 1996 to 2018. The goal of this work is to contribute towards a better understanding of Brazil's rise in the global market by considering five different points as well as traditional gravity model factors: macroeconomic policies, institutional quality, currency depreciation, domestic infrastructure change, and changes in agricultural inputs. We fill a gap in the existing literature by considering the full range of factors that may have contributed to Brazilian agricultural export growth.

Methods and Data

The Gravity Model

We use a standard gravity model to explore potential determinants of Brazilian agricultural export flows.[3] The typical gravity model is given in equation 1. T_{ijt} represents bilateral trade flows between exporter i and importer j at time t; A refers to a constant; Y_{it} and Y_{jt} represent the economic mass of exporters and importers during t, respectively; D_{ijt} indicates the distance/friction between exporters and importers at time t. The exponents α, β, and θ represent potential to increase or impede flows.

$$T_{ijt} = A \times \frac{Y_{it}^{\alpha} Y_{jt}^{ß}}{D_{ijt}^{\theta}} \quad (1)$$

In words, the general model states trade flows increase with the economic sizes of trade partners and decrease with trade frictions. Here we focus on unilateral trade flows from Brazil to its importing partners, see equation 2. Using the unilateral gravity model to focus on factors specific to the Brazilian context is like previous literature including Lee and Lim (2014) and Atif et al. (2017).

$$T_{Brazil\ jt} = A \times \frac{Y_{Brazil\ t}^{\alpha} Y_{jt}^{ß}}{D_{Brazil\ jt}^{\theta}} \quad (2)$$

By taking the log of both sides we obtain equation 3, which is now linear, and we can empirically estimate the gravity model given data on flows, economic masses, and trade frictions.

$$lnT_{Brazil\ jt} = lnA + \alpha lnY_{Brazil\ t} + \beta lnY_{jt} - \theta lnD_{Brazil\ jt} \quad (3)$$

The set of attraction/friction variables we include are described in the next subsections.

[3] Comprehensive resources describing how two gravity models can be applied in international trade are Baier and Standaert (2020) and Yotov et al. (2016).

Model Specification
We considered a wide range of agriculture- and Brazil-specific factors to explain export flows: Brazil and importer gross domestic products, geographic distance, exchange rates, Brazilian producer support, quantity of paved roads in Brazil, quantity of railway tracks in Brazil, both Brazil and importer share of land use in agriculture, other Brazilian agricultural inputs (machinery sales, fertilizer, and pesticide use), Brazilian producer prices, Brazilian institutional quality, importer trade openness, preferential trade agreements with importers, importer adjacency to Brazil, and importer ocean accessibility.

Several of the independent variables are worth discussing even though they are often included in gravity models. The Brazilian economy was restructured in the 80s and 90s. During this time, trade was liberalized, and hyperinflation was brought under control.[4] Exchange rates, producer prices, and trade agreements, are key metrics of the Brazilian macroeconomic story. Favorable exchange rates, low producer prices, and the existence of a trade agreement likely increases exports.

In addition to the standard set of gravity model explanatory variables, primary agricultural inputs are included because increased technology adoption, mechanization, and land conversion into agriculture are features of recent Brazilian history.[5] We expect increases in these inputs to increase production and productivity, and therefore increase exports. Infrastructure improvements have also been a theme of discussion regarding Brazilian agriculture and trade. Rail and road both connect production regions to ports, and new connections and improvements to infrastructure quality reduces internal transportation costs – which we expect also increases exports.

To assess if these factors are significantly correlated with Brazilian agricultural exports, we employ fixed effect and random effect models to account for unobserved importer heterogeneity. Prior to estimation, we performed a variety of tests to compare fixed and random effects to their alternatives, and to identify potential challenges in the error structure. For model selection we used Breusch-Pagan Lagrange Multiplier and Hausman tests. This was followed by Wald, Wooldridge, and Pearsan Tests to check the panel for heteroskedasticity, serial correlation, and cross-sectional correlation. We also conducted principal component analysis to guide the development of more parsimonious models.

Although fixed and random effects models are used often to estimate gravity models, Poisson pseudo maximum likelihood (PPML) estimation is considered superior. The primary advantages are that it can address the issues of zero trade flows – which can be prevalent in large panels with many exporter-importer pairs – and problems associated with non-linearly transforming the dependent variable in the presence of heteroskedasticity (Yotov et al., 2016).

Since we only have one exporter rather than many exporter-importer pairs and we faced data limitations regarding non-trading partners, we chose fixed and random effects models in favor of direct interpretation of the coefficient estimates. The issues of zero trade flows and heteroskedasticity were taken into consideration when building our dataset and during model selection and testing.

[4] The average applied tariff rate decreased from around 30 percent to 12 percent in the 90s (World Bank, 2022), and hyperinflation was curbed when the government launched the Plano Real program. The inflation rate went from 2,500 percent in 1993 to below 20 percent in early 1996 (World Trade Organization, 1996).

[5] Modernization picked up from the 1970s to 1990s with the help of cooperative extension services being established and subsidized farm credit. Also, Amazon rainforest deforestation brought new lands into livestock and crop production (see Baer, 2002; Simon and Garagorry, 2005).

Panel Data

We created a balanced panel covering Brazilian agricultural export flows to 83 trade partners for the years 1996 to 2018. The trading partners of Brazil were determined based on data availability. All countries that consistently have non-zero values for agricultural imports from Brazil given in the CEPII-CHELEM database are included. The annual values of Brazilian agricultural exports to its trading partners are taken from CEPII-CHELEM using sector code AL, which represents food and agricultural products.[6] PPML would allow us to include more importing countries in the sample. However, as shown in Figure 3, the countries we were able to include represent around 90 percent of total Brazilian agricultural exports. Figure 4 also shows the sample countries and the change in trade intensity from the first five years to the last five years of the study.[7]

Data for the independent variables come from many sources. Gross domestic product for Brazil and its importing partners were taken from the World Bank's World Development Indicators. Estimates of Brazilian agricultural producer support were obtained from the Producer Support Estimate Database of the Organization for Economic Co-operation and Development. The monetary value of these variables was converted from nominal to real using the gross domestic product price deflator of Brazil based on 2010 prices. Information about adjacency and preferential trade agreements between Brazil and its partners was sourced from the CEPII-CHELEM database again. Importers' port access and distance "as the crow flies" in terms of direct linear distance between Brasilia and capital cities of the importing countries were taken from the internet (freemaptools.com and worldportsource.com). Real effective exchange rates are from Darvas (2012). Importer trade freedom indices were taken from the Heritage Foundation (2021). Institutional quality of Brazil was taken from the World Governance Indicators Database provided by the World Bank (2021).

In addition to the commonly used trade data, we collected data related to internal transportation costs and agricultural inputs. The paved road length and rail length were collected from annual statistical reports produced by the government agencies Confederação Nacional do Transporte and Departamento Nacional de Infraestrutura de Transportes (from 1996 to 2019). The annual quantities of agricultural machines sold were from the manufacturers' association Associação Nacional dos Fabricantes de Veículos Automotores 2021 statistical yearbook. Data on agricultural land share of Brazil and land share of importing countries, fertilizer and pesticide use in Brazil, and the Brazilian agricultural producer price index were obtained from the Food and Agriculture Organization's FAOSTAT Database. Table 1 displays summary statistics of all variables.

Estimation Results

Estimation results are presented in Table 2. The first column shows that Brazilian agricultural export flows are consistent with traditional gravity theory. Flows increase with Brazilian and importer gross domestic product and decrease with distance. Models B through D retain consistency with theory,

[6] The product categories included in AL are cereals, edible agricultural products, non-edible agricultural products, cereal products, fats of vegetable or animal origin, meat and fish, preserved meat and fish products, preserved fruit and vegetable products, sugar products, animal foodstuffs, beverages and manufactured tobaccos.

[7] Serbia and Montenegro were treated as a single unit for this study because there are no separate data prior to 2006. Podgorica, the capital of Montenegro, was taken as the basis for the distance variable. The Serbian dinar is taken as the national currency because Montenegro switched to the Euro post-separation.

and indicate that infrastructure improvements, changes in input use, and preferential trade agreements are significantly associated with Brazilian agricultural export flows.

We focus the discussion and interpretation on the parsimonious fixed effects model D. Table 2 includes results for B and C as well. Model B contains all explanatory variables, except for time-invariant variables which cannot be identified with fixed effects. For this specification, the fixed effects model is preferred over random effects, and we use Driscoll-Kraay standard errors to adjust the standard errors for detected spatial dependence (Hoechle 2007). Models C and D are the more parsimonious models. Model C includes the time-invariant variables whereas model D, which also uses Driscoll-Kraay standard errors, does not.

The estimates for lagged machinery sales and preferential trade agreements were positive as expected. A 1 percent increase in new machinery is associated with a 0.19 percent increase in agricultural exports the following year. The existence of a preferential free trade agreement is associated with a 0.51 percent increase in bilateral flows. The coefficient estimates on paved road length and rail length indicate that Brazilian agricultural exports increase in tandem with improvements in road and rail infrastructure. For roads, which are important for the first mile of exports, a 1 percent increase in the quantity of paved roads is associated with a 0.76 percent increase in bilateral agricultural export flows. The estimates for rail quantity are striking. A 1 percent increase in rail length is associated with a 2.45 percent increase in agricultural exports.

Surprisingly, the estimate for the share of Brazilian land in agriculture is negative. A 1 percent increase in the share of land used in agriculture is associated with export flows declining 0.42 percent. New land area that Brazil has added to agricultural production are mainly from the Amazon rainforest, which has primarily been converted for cattle ranching and soybean production (Simon and Garagorry, 2005). According to Brondizio et al. (2009), most of the converted land that was previously rainforest is used by smaller farmers. These farmers have less resources and limited market access which would help explain a non-result on the share of agricultural land, but the negative association is still puzzling.

Concluding Remarks

Rail length is our most interesting estimate, and the result underscores the fact that rail looms large in the Brazilian agricultural export system. However, there are caveats regarding causal interpretation. Little is known about the causal effects of domestic infrastructure on exports because relevant data that varies over time are difficult to obtain and there are potential simultaneity problems between trade flows and investment in capital goods and infrastructure. The latter is of concern here. Improvements to freight infrastructure have long lag times between initial investment and project completion requiring long time series or an instrumental variable associated with use of the completed infrastructure.[8] Even if we assume that increases in track length have led to higher agricultural export volumes, say due to increased freight system access in agricultural regions, the addition of the marginal length of track at this moment would be difficult to predict. Laying more tracks will not necessarily correspond to higher freight volumes. Network structure and management

[8] A possible instrumental variable for increased road quantity and quality may be passenger vehicles per 1000 people. However, Brazil is like the United States in that the rail system is largely used for freight rather than passenger service. Additionally, the nature of rail systems makes it difficult to find an alternative use that does not directly affect agricultural shipments.

are crucial in rail and changes anywhere in the system can influence service quality. Also, we include road and rail infrastructure, but have not included inland waterway and port infrastructure. We do not have data on navigable waters, but, since only a small portion of Brazilian freight travels via river (Ministério da Infraestrutura, 2020), we predict our results are uninfluenced by this omission. However, it is not possible to assess whether future resources would be best spent on a specific type of transportation infrastructure given the data and analytical approaches available at this time.

Finally, a major challenge of research studying the determinants of trade is that there is often country-specific, time-varying factors of interest. Obtaining data for a long-enough panel to identify these factors is difficult. Here we were fortunate to be able to include 22 years of data, there was meaningful variation in factors that typically have slight variation over time (e.g., infrastructure), and it was possible to create a more parsimonious model that included variables of interest. But, given the data-related challenges, it is important to put our results in context with the existing literature. Other researchers have positively linked Brazilian infrastructure to agricultural productivity (Mendes et al., 2009; Rada and Valdes, 2012). General research about Brazilian trade has also found preferential trade agreements and transportation costs are significantly associated with trade flows (Porto, 2002; Guilhoto et al., 2015; Sireon and Yucel, 2011; Ribeiro et al., 2019; Viera and Reis, 2019). Our results are consistent with these narratives in the adjacent research and provide quantitative context relevant to common causal claims about the evolution of Brazilian importance in global agricultural markets.

The results presented here could be useful to policymakers in Brazil and countries that compete in global agricultural markets. Further research is needed to evaluate if Brazilian policymakers with the goal of increasing agricultural exports should consider diverting resources away from producer supports towards putting policies in place that minimize Amazon deforestation. Policymakers in competing countries, specifically in the United States where soybean exports are important, will want to evaluate their own competitiveness as Brazilian investment in highway, rail, and port access continues.

References

Associação Nacional dos Fabricantes de Veículos Automotores (ANFAVEA). 2021. Anuário Da Indústria Automobilística Brasileira (Brazilian Automotive Industry Yearbook). https://anfavea.com.br/site/yearbooks/?lang=en

Atif, R. M., Haiyun, L., & Mahmood, H. 2017. Pakistan's agricultural exports, determinants, and its potential: an application of stochastic frontier gravity model. The Journal of International Trade & Economic Development, 26(3), 257-276.

Baer, W. 2002. Economia Brasileira. NBL Editora.

Brondízio, Eduardo S., Anthony Cak, Marcellus M. Caldas, Carlos Mena, Richard Bilsborrow, Celia T. Futemma, Thomas Ludewigs, Emilio F. Moran, and Mateus Batistella. 2009. Small farmers and deforestation in Amazonia.

CEPII-CHELEM (Centre d'Etudes Prospectives et d'Informations Internationales-Comptes Harmonisés sur les Echanges et L'Economie Mondial), International Trade Database. http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp [Accessed 5 March, 2021].

Confederação Nacional do Transporte (CNT). 1996-2019. Anuário CNT do Transporte: Estatístico Consolidades (CNT Transport Yearbook: Consolidated Statistics).

Darvas, Z. 2012. "Real effective exchange rates for 178 countries: a new database." Bruegel Working Paper 2012/06, Brussels, Belgium.

Departamento Nacional de Infraestrutura de Transportes (DNIT). 1996-2019. Anuário Estatístico de Transportes (Annual Transportation Statistics).

Food and Agriculture Organization of the United Nations. 2021. FAOSTAT statistical database.

Guilhoto, J., J.M. Siroën and Yücer, A. 2015. "The Gravity Model, Global Value Chain and the Brazilian States." Working Papers DT/2015/02 DIAL. Paris.'

Hoechle, D. 2007. Robust standard errors for panel regressions with cross-sectional dependence. The Stata Journal, 7(3), 281-312.

Index of Economic Freedom. The Heritage Foundation. https://www.heritage.org/index/ [Accessed 1 September, 2021].

Lee, S. Y., & Lim, S. S. 2014. Determinants of the Korean agricultural trade with the LDCs and the OECD countries. Agricultural Economics, 60(3), 110-122.

Mendes, S. M., Teixeira, E. C., & Salvato, M. A. 2009. Effect of infrastructure investments on total factor productivity (TFP) in Brazilian agriculture. Contributed paper prepared for presentation at the International Association of Agricultural Economists Conference, Beijing, China, August 16– 22.

Observatory of Economic Complexity. https://oec.world/en/profile/country/bra [Accessed 2 October, 2021].

Organization for Economic Co-operation and Development, 2021. Agricultural support database. https://data.oecd.org/agrpolicy/agricultural-support.htm

Porto, P. C. 2002. Mercosur and regional development in Brazil: a gravity model approach. Estudos Econômicos, 32(1), 125-153.

Rada, N., & Valdes, C. 2012. Policy, technology, and efficiency of Brazilian agriculture. USDA-ERS Economic Research Report -137.

Ribeiro, M. C. P., da Silva Martins, F. V., Pereira, R. S. C., & da Silva, J. R. 2019. Exports and the gravitational model: The Brazilian case and the mercosul, nafta and EU blocks. Estudios de economía aplicada, 37(2), 54-62.

Simon, M., & Garagorry, F. 2005. The expansion of agriculture in the Brazilian Amazon. Environmental Conservation, 32(3), 203-212.

Siroën, J. M., & Yucer, A. 2012. The impact of MERCOSUR on trade of Brazilian states. Review of World Economics, 148(3), 553-582.

Vieira, E. R., & Reis, D. H. A. 2019. Determinants of Brazilian exports by levels of technological intensity: a gravity model analysis using the PPML estimator. Journal of Business and Economics, 10(9), 861-879.

Valerius, J., Bittencourt, M. V. L., Silva, J. C. G. L., & Frega, J. R. 2018. Analysis of Brazilian Exports of Conifer Wood Moldings Through Gravity Trade Model. Revista Árvore, 41.

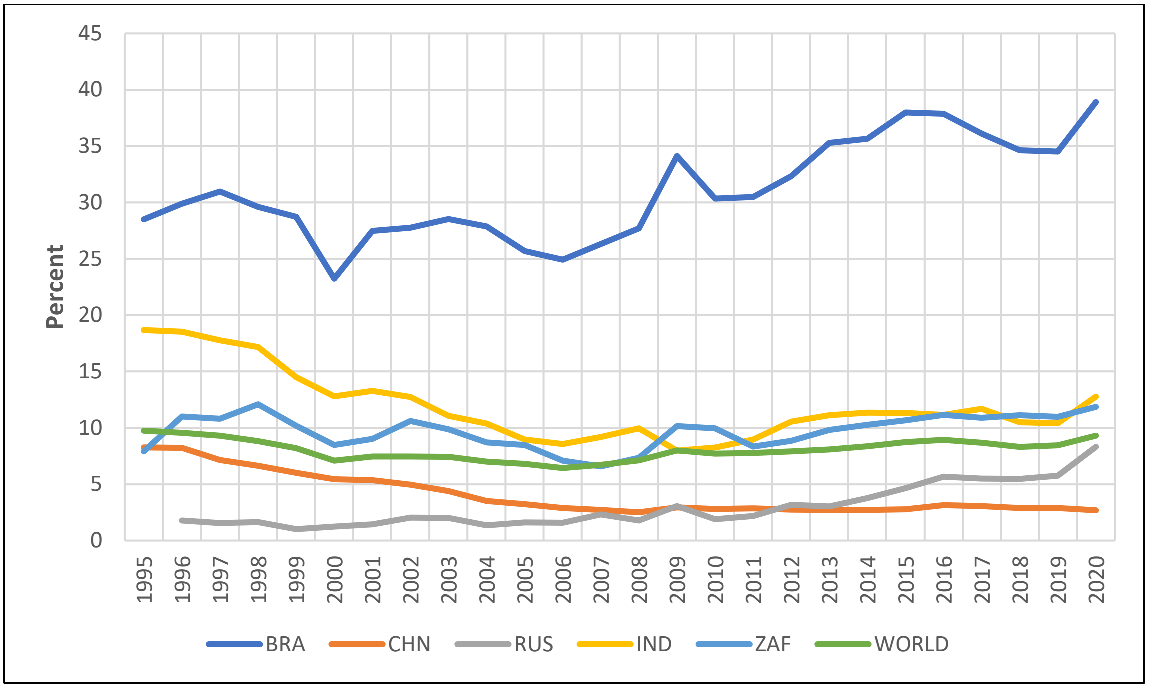
World Bank, World Development Indicators. Agricultural raw material exports and food exports. https://databank.worldbank.org/source/world-development-indicators [Accessed 14 January, 2022].

World Bank, World Government Indicator. Institutional Quality Index. https://databank.worldbank.org/source/worldwide-governance-indicators [Accessed 1 June, 2021].

World Trade Organization, 1996. Brazil's reforms promote economic gains, but implementation of trade policy remains complex. https://www.wto.org/english/tratop_e/tpr_e/tp045_e.htm

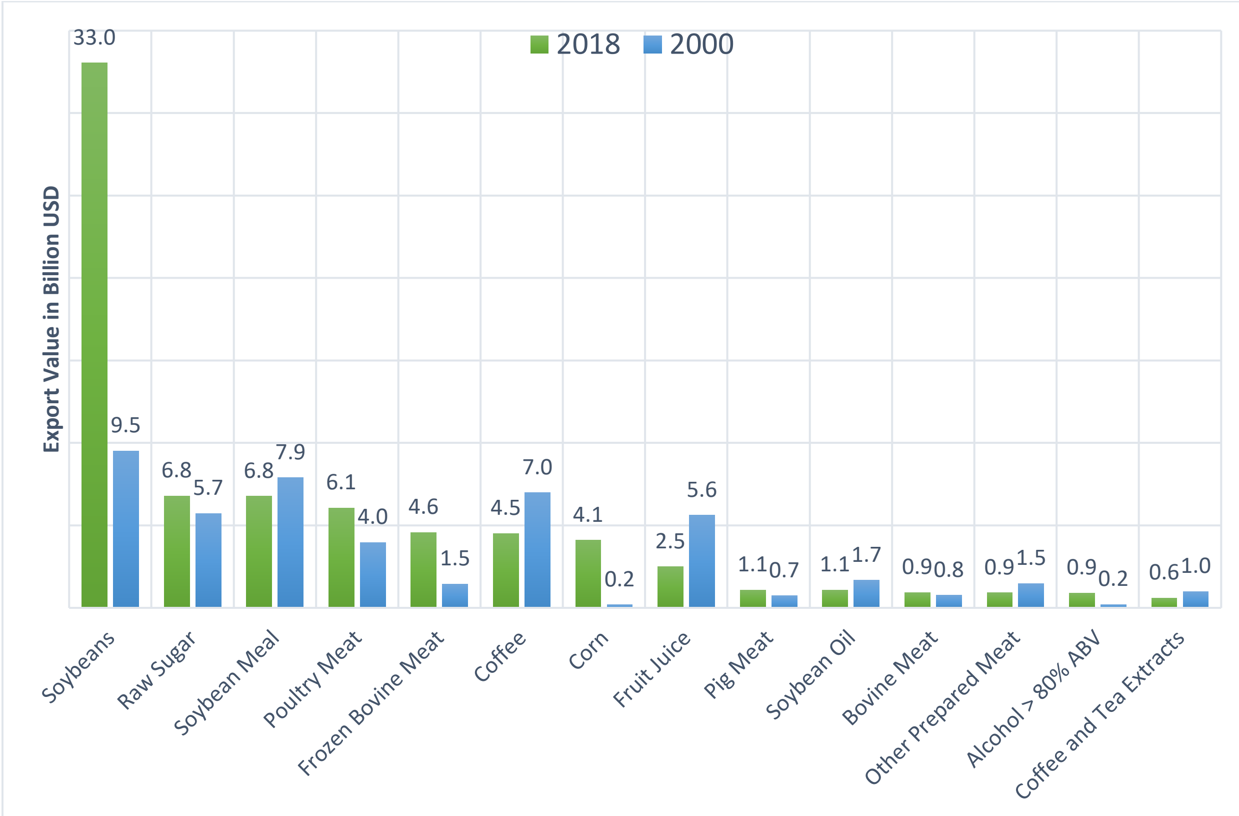
Yotov, Y. V., Piermartini, R., Monteiro, J. A., & Larch, M. 2016. An advanced guide to trade policy analysis: The structural gravity model. Geneva: World Trade Organization.

Figure 1. Share of Food Exports to Total Merchandise Exports of BRICS and the World



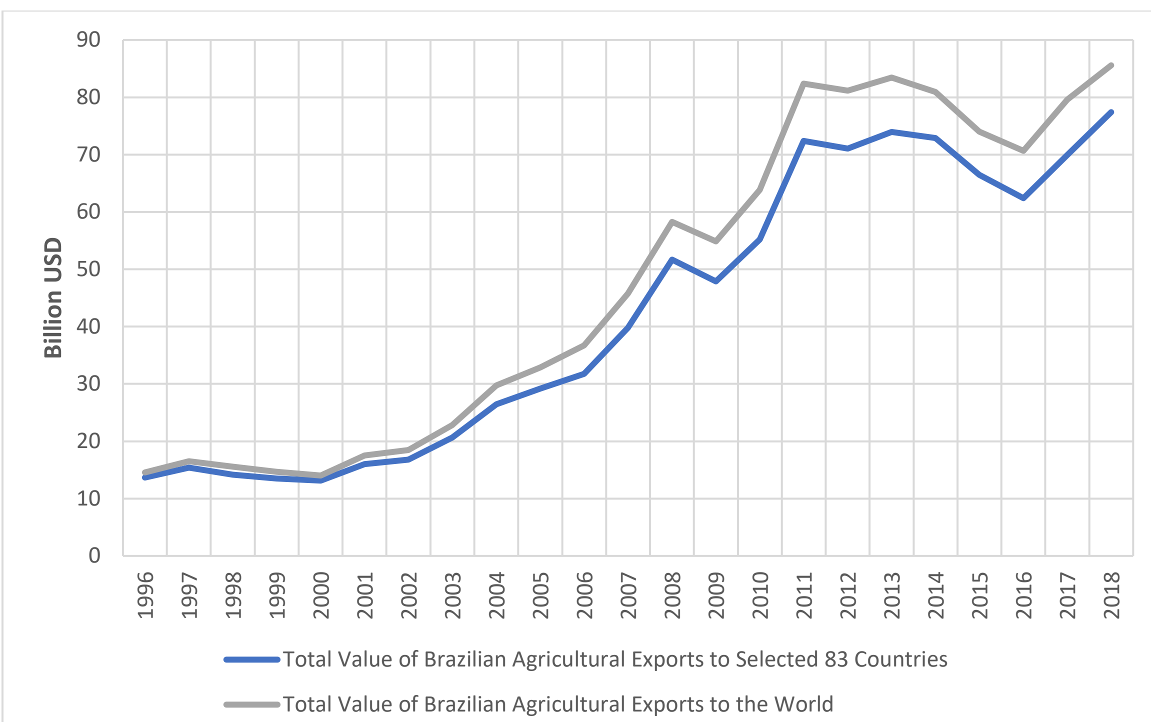
Note. Data are from the World Bank World Integrated Trade Solution database. World represents all countries, including BRICS countries which are Brazil, Russia, India, China, and South Africa.

Figure 2. Composition of Major Brazilian Exports for the Years 2000 and 2018



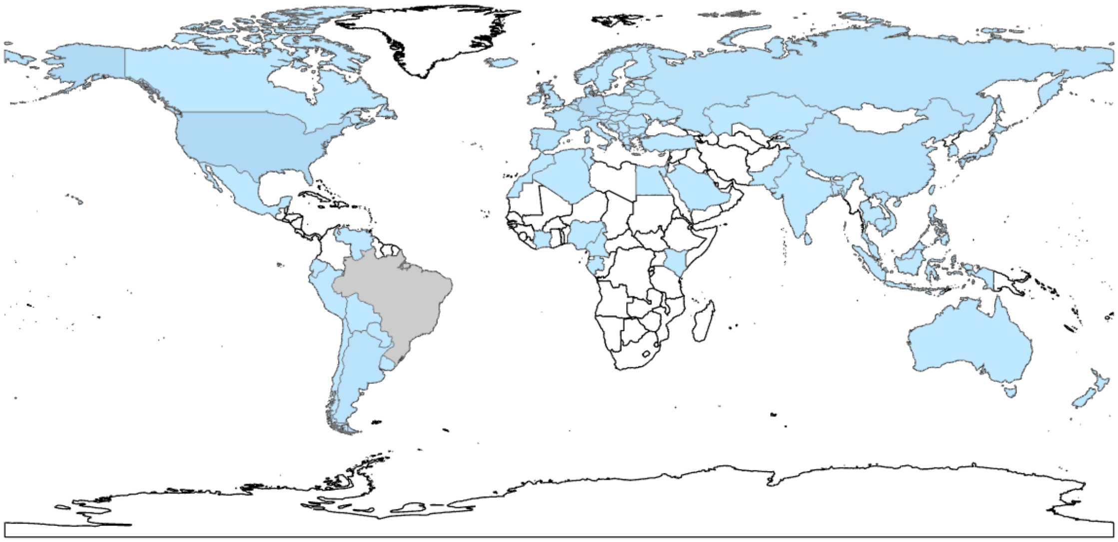
Note. We show HS4 product groups that represented over $600M USD in trade value in 2018. Export value is indexed to year 2018 real dollars and data are from the Observatory of Economic Complexity.

Figure 3. Total Values of the Agricultural Exports to Sample Countries and to the World

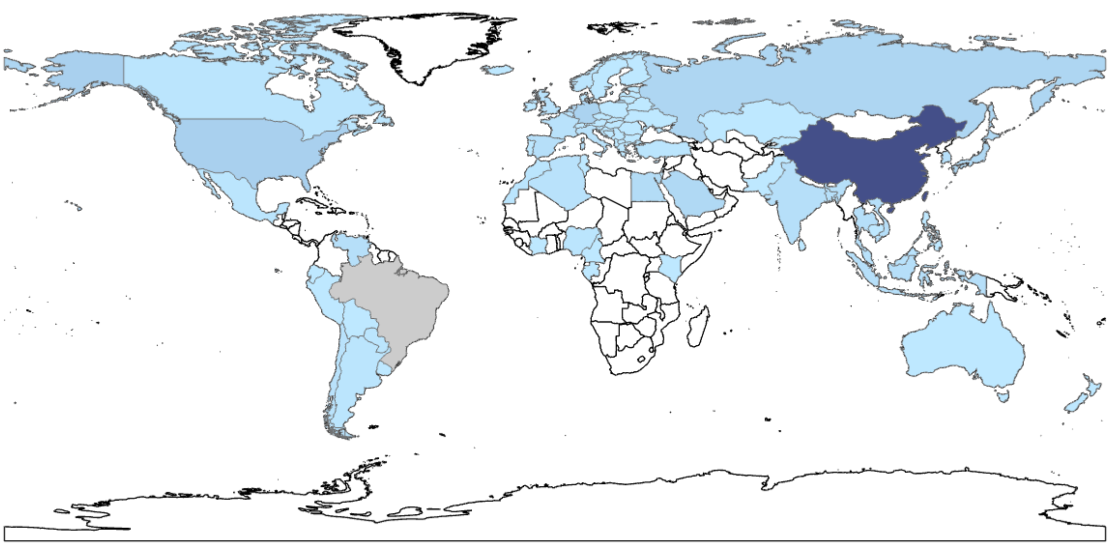


Note. These data are from the CHELEM - International Trade Database.

Figure 4. The Selected Sample of Brazil Trading Partners



(a) 1996 to 2000



(b) 2014 to 2018

Note. The graduated color scheme is the same for panels (a) and (b) showing the change in trade intensity among partner countries for the first and last five years of the sample period. The included partner countries are: Albania, Algeria, Argentina, Australia, Austria, Bangladesh, Belarus, Belgium, Bolivia, Bosnia & Herzegovina, Brunei, Bulgaria, Cambodia, Canada, Chile, China, Colombia, Côte d'Ivoire, Czechia, Denmark, Ecuador, Egypt, Estonia, Finland, France, Gabon, Germany, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Kazakhstan, Kenya, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Morocco, Netherlands, New Zealand, Nigeria, North Macedonia, Norway, Pakistan, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Serbia & Montenegro, Singapore, Slovakia, Slovenia, South Korea, Spain, Sri Lanka, Sweden, Switzerland, Taiwan, Thailand, Tunisia, Turkey, Ukraine, United Kingdom, United States, Uruguay, Venezuela, and Vietnam.

Table 1. Summary Statistics

Variable	Varies: importer	Varies: time	Number of Obs.	Unit	Mean	Std. dev.	Min	Max
Agricultural Export Value	yes	yes	1886	USD (Constant 2010)	7.1M	18.3M	56	389M
Gross Domestic Product of Brazil	no	yes	1886	USD (Constant 2010)	1.93B	357M	1.41B	2.42B
Gross Domestic Product of j	yes	yes	1882	USD (Constant 2010)	692B	1.87T	2.61B	18T
Distance	yes	no	1909	Kilometer	10,190	4,163	1,463	18,832
Bilateral real exchange rate	yes	yes	1909	Per 1 Br. Real	297.1	2,659.27	0.0013	106,340.4
Producer support estimate of Brazil	no	yes	1826	USD (Constant 2010)	154M	65.8M	21,191	241M
Total paved road length of Brazil	no	yes	1909	Kilometer	160,838	22,922	149,000	219,089
Total railways length of Brazil	no	yes	1909	Kilometer	29,617	537	28,874	30,621
Sold agricultural machinery of Brazil	no	yes	1909	Level	40,961	16,746	12,431	77,594
Agricultural land share of Brazil	no	yes	1909	Percentage	27.65	0.37	27.27	28.34
Agricultural land share of j	yes	yes	1892	Percentage	40.27	20.84	0.93	85.49
Fertilizer use of Brazil	no	yes	1909	Metric Tons	10.2M	3.4M	5.02M	16.4M
Pesticide use of Brazil	no	yes	1909	Metric Tons	260,779	103,257	101,622	395,646
Producer Price Index of Brazil	no	yes	1909	Index	57.04	28.50	21	105.81
Institutional quality of Brazil	no	yes	1909	Index	52.02	4.10	42.18	58.23
Openness to trade of j	yes	yes	1866	Index	74.33	13.76	0	95
Preferential Trade Agreement	yes	yes	1909	Binary	0.23	0.42	0	1
Adjacency	yes	no	1909	Binary	0.08	0.28	0	1
Ocean accessibility	yes	no	1909	Binary	0.07	0.26	0	1

Table 2. Gravity Model Empirical Results

Dependent Variable: ln(ag. export value)	Model A: Basic Gravity	Model B: No time-invariant variables	Model C: Parsimonious model	Model D: Parsimonious model
Independent Variables	OLS	Fixed Effects (Driscoll-Kraay std. errors)	Random Effects	Fixed Effects (Driscoll-Kraay std. errors)
ln(Brazil gross domestic product)	**.73***** (.16)	**.29***** (.08)	**.26***** (.09)	**.26*****(.07)
ln(importer gross domestic product)	**.91***** (.02)	**.86***** (.05)	**.91***** (.09)	**.94***** (.05)
ln(distance)	**-.68***** (.06)		-.47 (.35)	
ln(bilateral real exchange rate)		-.02 (.03)	.02 (.06)	.0002 (0.30)
ln(Brazil producer support estimate)		-.0003 (.01)	.006 (.01)	.0064 (.01)
ln(Brazil paved road length)		**.85**** (.40)	**.89*** (.50)	**.76**** (.36)
ln(Brazil railway length)		1.39 (1.30)	**2.6**** (1.09)	**2.45*** (1.28)
lagged ln(Brazil ag. machinery sales)		.06 (.09)	**.19***** (.07)	**.19*** (.11)
Brazil ag. land share		**-.68***** (.20)	**-.41**** (.16)	**-.42**** (.15)
Importer ag. land share		**.04***** (.01)		
ln(Brazil fertilizer use)		.03 (.10)		
ln(Brazil pesticide use)		.09 (.22)		
Brazil producer price index		**.006**** (.002)		
Brazil institutional quality		.006*** (.007)	-.002 (.01)	-.002 (.01)
Importer openness to trade		.001 (.002)	.001 (.01)	.002 (.002)
Preferential trade agreement		**.62***** (.15)	**.43*** (.23)	**.51***** (.16)
Adjacency			.10 (.63)	
Importer ocean accessibility			-.39 (.91)	
Constant	**-24***** (4,55)	-22 (14.32)	**-36***** (10.8)	**-38***** (12.4)
Adjusted R2	.61	0.56 (Within)	0.64	0.54 (Within)
Number of Observations	1882	1851	1865	1865

*Note. Robust standard errors are in parenthesis. ***/**/* represents statistical significance at 1%, 5%, and 10% level, respectively.*