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LAND RESOURCES AND AGRICULTURAL EXPORTS NEXUS

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Abstract

Research background: As part of the process of structural transformation that countries go through in their development journey, the relative significance of agriculture as a sector typically shrinks over time. Nonetheless, the agricultural sector maintains its significance in terms of its trade potential and global employment prospects to this day. The extant literature largely neglects the impact of countries' land resources on agricultural trade by emphasizing agricultural farm size and land productivity nexus. This justifies the exploration of the causal nexus between countries' agricultural land resources and their agricultural exports.

Purpose: The study herein aims at investigating the nexus between countries' total agricultural land resources and agricultural exports for 174 selected countries over the period 1991–2019.

Research methodology: Dumitrescu and Hurlin's (2012) test for Granger non-causality for heterogeneous panels is harnessed.

Results: Estimation results evidence the presence of bi-directional causality (feedback) between countries' agricultural land resources and agricultural exports not only in the whole panel (1991–2019) but also in subpanels too (1991–2000, 2001–2010, and 2011–2019). Overall, the results stress the strategic importance of agricultural land as a significant determinant of agricultural exports.

Novelty: Our study takes a unique approach and investigates if there is a cause-and-effect relationship between a country's agricultural land resources and its agricultural exports by relying on the implications of the factor endowment theory of trade.

Keywords: Agricultural Exports, Land Resources, Factor Endowment, Panel Data Analysis

JEL classification: Q17, Q15, F10, C33

Introduction

Despite the continuous and gradual decline in the value-added share of agriculture brought about by the process of structural transformation (Choi *et al.*, 2021; McMillan *et al.*, 2014; Norbu *et al.*, 2021), the agricultural sector still maintains its relevance not only for its strategic importance in rural development and poverty alleviation (Song *et al.*, 2022) but also for its ability to meet the ever increasing demand for sustainable and nutritious food per rising world population (Balogh, Jámbor, 2020). According to FAO (2020), the real value added of the agricultural sector has increased steadily by 73% in the 2000–2019 period and consequently reached 3.5 trillion USD on a global scale. In the same period, the total workforce employed in the agricultural sector was 874 million, corresponding to 27% of the global workforce, making it the sector providing the most employment after the service industry.

Traditionally, as a primary input to the agricultural production process, land is a fixed immobile factor whose physical transferability across countries is not congenial unlike the other factors of production (De Maria, 2019). In this regard, studies on the strategic importance of land in agricultural production and the international trade of agricultural goods has become much more relevant due to the rising world population, increasing urbanization, and growing demand for food, especially on the part of developed and developing countries (Balogh, Jámbor, 2020; Viana *et al.*, 2022). In particular, agricultural land's role in the international trade of agricultural goods has not been adequately touched on.

In the extant literature, the topic is taken up from a rather micro perspective focusing on the nexus between agricultural farm size and land productivity (e.g., Binswanger *et al.*, 1995; Bojnec, Latruffe, 2013; Carter, 1984; Chand *et al.*, 2011; Dorward, 1999; Eastwood *et al.*, 2010; Fan, Chan-Kang, 2005; Lipton, 1993; Noack, Larsen, 2019; Savastano, Scandizzo, 2017; Sen, 1962; Srinivasan, 1972). Nevertheless, we contribute to the extant literature by taking up a different methodological approach and by exploring the existence of causal nexus between countries' total agricultural land resources and their agricultural exports via the panel Granger non-causality test for the 174 selected countries for the period 1991–2019 by drawing on the implications of the factor endowment theory of international trade given the strategic importance of land resources in determining countries' agricultural goods trade.

The paper herein is divided into five sections also encompassing a brief introduction. The first section reviews the extant literature as to determinants of agricultural goods trade. The second section rigorously describes the data and methodology. The third section discusses the estimation of the results pertaining to the heterogeneous panel Granger non-causality test and initial diagnostics. Ultimately, the fourth and last section concludes the paper.

1. Theoretical Background and Literature Review

Several factors, according to international trade theory, have a significant bearing on global agricultural trade; namely, Adam Smith's concept of absolute advantage, David Ricardo's theory of comparative advantage, Hecksher-Ohlin factor endowment differences, and agricultural farm size amongst many others. Adam Smith associates international trade with the increase in welfare on a global scale and states that the path to increased welfare is through cooperation and specialization between countries. According to Smith, the status of a country as an exporter or importer of particular goods in international trade is determined solely by the absolute superiority of the countries in the production of the relevant goods. However, Adam Smith's theory of absolute advantage can partially explain international trade occurring between developed and underdeveloped countries.

David Ricardo broadens the scope of the trade theory by basing international trade on comparative advantages rather than absolute advantages and constructs a more comprehensive theory that also explains trade flows between countries with similar levels of economic development. According to the theory of comparative advantage, different countries have similar production structures and the relative superiority of countries in the production of different goods is the determinant of trade flows. Although Smith (1776) draws attention to costs in the production process, Ricardo (1819) emphasizes productivity differences between trading parties.

Eli Heckscher and Bertil Ohlin explicate that international trade occurs due to the differences in countries' relative factor endowments. According to the factor endowment theory, countries specialize in the production of goods that require the heavy use of the production factors they are abundantly endowed with and consequently export these products whereas they import goods whose production requires the utilization of production factors that they are scarcely endowed with. This naturally implies that goods trade is a substitute for factors trade and thus goods traded across countries should embody these factor differences. A famous study published by Wassily Leontief empirically tested such a prediction for the US in 1953. US labor at the time visibly worked with more capital in comparison to their counterparts elsewhere. Consequently, there was an expectation that the US would be an exporter of capital-intensive goods while being an importer of labor-intensive goods. The results showed otherwise, and this became known as the Leontief Paradox. However, Leontief (1953) utilized two factors of production; namely, capital and labor. Vanek (1959) argues that a given commodity might also be intensive in natural resources and classifying it as either labor or capital-intensive would not be congenial, and consequently land should be part of a countries' factor endowment differences just like capital and labor. To this day, one of the prevailing criticisms of the classical economic theory is that production factors other than labor and capital have largely been neglected. Yet when the relevant literature is critically evaluated, it is noteworthy that the focus of the studies examining the agricultural trade between countries still focuses on labor and capital endowment differentials. Empirical studies on the effect of the countries' land resources, which is one of the basic inputs of the agricultural production process, on their agricultural goods trade remain rather scarce.

Recent studies mainly focus on the effect of the land and labor endowments of the countries on the trade of agricultural products in the context of the determinants or the patterns of the agricultural trade between specific countries or regions. Ya and Pei (2022) analyzed the agricultural trade between China and 58 African countries with the augmented gravity model. The results indicate that the average arable land per capita of African countries has a positive impact on the trade of agricultural products between the two regions. According to Li (2012), China's agricultural foreign trade patterns are shaped by region-specific features within the land and labor endowments. Maslak, Lei, and Xu (2020) draw attention to the fact that despite the abundance of labor endowment, land scarcity creates a significant constraint on China's agricultural products trade. On the other hand, Song *et al.* (2022) find that agricultural land and labor endowments in China negatively affect relative rural poverty.

Bojnec (2013) made a comparative analysis of the land endowment and land market policies of North Macedonia, Turkey, and Croatia. Maravall (2020) examined the relationship between relative land and labor endowment and agricultural concentration in the case of Algeria. Huo (2014) draws attention to the fact that the irrigable agricultural land resources of developing countries significantly impact their competitive advantages in the export of agricultural products. Grzelak, Guth, Matuszczak, Czyżewski, and Brelik (2019) examined the effect of land and labor endowments on the environmental sustainability value of the European Union (EU). Last but not least, Verter (2015) studied the agricultural products trade of sub-Saharan African countries in the context of natural resource endowments. The results mainly indicate that Sub-Saharan African countries are the main exporters of tropical products in global markets due to natural resource endowments, especially their unique climate endowments. However, in terms of primary and processed agricultural products other than tropical products, sub-Saharan African countries have serious trade deficits, especially against developed countries, despite their abundant land and labor endowments. This indicates that many factors, especially capital endowment, level of technology, and access to international markets, in addition to natural resource endowment (i.e., land, water, climate, etc.) are important determinants in agricultural product trade.

The existing literature shows that the land endowments of countries have a significant and positive effect on the trade of agricultural products. However, these studies chiefly try to understand agricultural product trade empirically in the context of the factor endowment theory and adopt a micro approach over a specific country or region sample. Previously conducted studies have not given enough attention to causal relations between agricultural exports and the agricultural land resources of countries given the strategic importance of land resources in determining a countries' agricultural trade.

2. Data and methodology

Panel data sets appear in several different forms. The panel data set utilized in this study has 174[1] countries observed consistently over a 29 year period (i.e., 1991–2019), which is referred to as long and wide with long describing the time dimension and wide referring to the cross-sectional dimension (Hill *et al.*, 2011; Kennedy, 2008). It has a balanced characteristic since the number of time series observations is the same for all the sample constituents.

This paper investigates the causal nexus between countries' total agricultural land resources and agricultural exports via Dumitrescu and Hurlin's (2012) heterogeneous panel Granger non-causality test (DH test, hereinafter). To do so, we first implemented cross-sectional test of dependence to choose the appropriate panel unit root testing approach. After making sure

[1] Select sample constituents make up 91.2% of the value of total world agricultural exports as of 2019.

that the series concerning the variables of the paper herein are stationary as a prerequisite for the DH test, we checked the existence of a causal nexus between the aforementioned variables.

Granger (1969) devised a method for investigating the causal relations between time series. Assume that x_t and y_t are two series that are stationary. Then, the following model can be harnessed to test whether x Granger causes y:

$$y_t = \alpha + \sum_{k=1}^{K} \gamma_k y_{t-k} + \sum_{k=1}^{K} \beta_k x_{t-k} + \varepsilon_t \quad \text{and } t = 1, 2, \ldots, T \tag{1}$$

The basic idea of equation (1) is that if the past values of x significantly determine the current value of y when the past values of y are also included in the model, then x has a causal effect on y. It can be simply tested via an F-test with the null hypothesis as follows:

$$H_0\!:\!\beta_1 = \ldots = \beta_k = 0 \tag{2}$$

if the null hypothesis is rejected, it can be concluded that x Granger causes y. The procedure can be carried out to check if there exists feedback by simply interchanging variables x and y. Dumitrescu and Hurlin (2012) provide an extension formulated to check causality in panel data sets. The underlying regression applied to the variables of the paper herein is as follows:

$$Export_{it} = \alpha_i + \sum_{k=1}^{K} \gamma_{ik} Export_{i,t-k} + \sum_{k=1}^{K} \beta_{ik} Land_{i,t-k} + \varepsilon_{it} \qquad (3)[2]$$

where $\varepsilon_{it} = \mu_i + v_{it}$, while $\mu_i \approx (0, \sigma_\mu^2)$ and $v_i \approx (0, \sigma_v^2)$ are independent of each other and among themselves. μ_i and v_{it} denote time-invariant country-specific fixed effects and time-variant effects, respectively. Export is measured as the natural logarithm of the total value of agricultural exports divided by the natural logarithm of the total labor force employed in agriculture while Land is measured by dividing the natural logarithm of total agricultural land endowment measured in hectares by the natural logarithm of the total agricultural labor. The data pertaining to all variables were collected from the FAOSTAT database for each country. Coefficients are allowed to differ across countries as captured by the attached i subscript but are assumed to be time-invariant. The lag order K is assumed to be identical for all cross-sections and is based herein on the AIC criterion, and the panel must be balanced. As in Granger (1969), the procedure to determine the existence of a causal relation is to test for the significant effects of the past values

[2] It shall herein be mentioned that due to discontinuity in the data series for Belgium and Luxemburg, we merged a respective series for these two countries and treated them as one.

of Land on the present value of the variable Export. Hence, the null hypothesis is formulated as follows:

$$H_0: \beta_{i1} = \beta_{i2} = \cdots = \beta_{ik} = 0 \ and \ \forall_i = 1, 2, \ldots, 174 \quad (4)$$

which translates into no causal relationship for all cross-sectional units. There can be causality for some units but not necessarily for all and the test is applied to a stationary data series using the fixed coefficients in a vector autoregressive (VAR) framework. The DH test[3] has several advantages over the traditional Granger (1969) causality approach. First, the test can easily be implemented irrespective of the co-integrating relations between variables. Second, it can be applied to both balanced and unbalanced panel data. Third, it takes into account the cross-sectional dependence and heterogeneity in the cross-sections of the panel (Dumitrescu, Hurlin, 2012).

3. Results

At the initial stage of our empirical analysis, we examined unit root properties in our data set. According to Pesaran (2007) and Strauss and Yigit (2003), standard panel unit root tests that do not allow for cross-sectional dependence suffer from substantial size distortions and low power if the degree of cross-sectional dependence is large. Therefore, evidence concerning the existence or lack thereof of cross-sectional dependence must be provided before selecting the appropriate panel unit root test.

Table 1. Descriptive Statistics

	Mean	Min	Max	SD
Export (dollars)	1,285.7	0.000012	397,167.5	13,683.2
Land (hectares)	781,397.5	0.0148	1,809,359,356	32,201,677.7
N (# of obs.)	5,046			

Source: the authors' computation via Stata 16 statistical software.

Table 1 displays the descriptive statistics of the variables of this study. It reveals that the data has fair dispersion around the mean, which justifies the further estimation of our data. Table 2 presents the pairwise correlation and it implies that the variables of interest in this study have non-negligible and statistically significant positive correlations, giving us early hints as to the potential

[3] The DH test of panel Granger non-causality can easily be implemented via the *xtgause* command in the Stata statistical software package made available by Lopez and Weber (2017).

nexus between them. Additionally, in the Appendix section, we have mapped the intensity of countries' total land resources and their agricultural exports both expressed in per-labor terms. As is evident from Figure A1 and Figure A2, it seems that the two maps nicely overlap.

Table 2. Pairwise Correlations

Variables		
Export	1.000	
Land	0.076***	1.000

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: the authors' computation via Stata 16 statistical software.

Hoechle (2007) contends that assuming that errors of a panel model are cross-sectionally independent is often inappropriate. Consequently, testing for cross-sectional dependence is important in the estimation of panel data models. Thus, we utilized Pesaran's (2004) cross-sectional dependence (CD) test as it suits panels where a given panel's cross-sectional dimension is greater than its time dimension (i.e., N > T) and is implementable with both balanced and unbalanced panel data sets. As is evident from Table 3, the CD test strongly rejects the null hypothesis of cross-sectional independence, which is also confirmed by Frees' (1995) and Friedman's (1937) test results.

Table 3. Cross-sectional Dependence (CD) Test

Variable	CD statistic	Probability
Pesaran's (2004) CD Test	4.341***	0.000
Friedman's (1937) Test	944.863***	0.000
Frees' (1995) Test	Statistic	Critical values
	24.971[a]	($\alpha = 0.10$) 0.0892
		($\alpha = 0.05$) 0.1160
		($\alpha = 0.01$) 0.1660

Note: *** signals the rejection of the null hypothesis of cross-sectional independence (i.e., $H_0 = corr(\mu_{it}, \mu_{ij}) = 0$ for $i \neq j$).

[a] Frees' statistic is strictly larger than the critical value with at least $\alpha = 0.01$, providing evidence in favor of the presence of cross-sectional dependence in residuals. The test can be estimated via the *xtcsd* post-estimation command in Stata thanks to the contribution of De Hoyos and Sarafidis (2006).

Source: the authors' computation via Stata 16 statistical software.

Since cross-sectional dependence is established in our data, unit root tests that take this into account should be implemented. As pointed out by Hurlin and Mignon (2007), the first generation of panel unit root tests is based upon the rather restrictive cross-sectional independence assumption whereas the alternative tests relax the assumption of cross-sectional independence. These tests are referred to as second-generation unit root tests (Burdisso, Sangiácomo, 2016). Following Paramati, Apergis, and Ummalla (2017) and Salahuddin, Alam, and Ozturk (2016), we have utilized the second-generation panel unit root testing approach by Pesaran (2007). Table 4 shows the results of Pesaran's (2007) cross-sectional augmented panel unit root test (CIPS). The findings demonstrate that the null hypothesis of the unit root process is rejected at the 1% level across the variables of this paper. Thus, it is confirmed that the variables of this study are stationary at levels.[4] Additionally, since slope coefficients are allowed to differ across cross-sectional units of the paper herein under the DH test of panel Granger non-causality framework, Pesaran and Yamagata's (2008) test for slope homogeneity is utilized. Test results, as available in Table 5, rejected the null hypothesis of slope homogeneity for all the variables at the 1% level.[5]

Table 4. Second Generation Panel Unit Root Test Results

Pesaran (2007) Panel Unit Root Test		
variables	export	land
CIPS[1]* (level)	–4.393***	–3.890***
CIPS[2]* (level)	–4.601***	–4.440***
CIPS[3]* (level)	–4.771***	–4.621***

Note: CIPS[1]* refers to the truncated CIPS test with neither constant nor trend. CIPS[2]* denotes the truncated CIPS test with constant. CIPS[3]* denotes the truncated CIPS test with both constant and trend. *** denotes the rejection of the null hypothesis at the 1% level (i.e., $H_0 = \beta_i = 0$ for all i). The results reported herein are at lag 1.

Source: the authors' computation via Stata 16 statistical software.

Table 5. Slope homogeneity test of Pesaran and Yamagata (2008)

	Delta statistic	*p*-value
$\tilde{\Delta}test$	106.628***	0.000
$\tilde{\Delta}adj.test$	116.805***	0.000

Note: H_0: slope coefficients are homogenous. *** indicates a rejection of the null hypothesis of slope homogeneity.

Source: the authors' computation via Stata 16 statistical software.

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4 The presence of a unit root process in our data is further investigated via an alternative second-generation panel unit root testing procedure based on Reese and Westerlund (2016) and Bai and Ng (2004, 2010) and can easily be carried out in Stata via *xtpanicca* package. The results further validated that the series in our data are stationary although not explicitly reported herein due to space considerations.

5 Pesaran and Yamagata's (2008) test for slope homogeneity is tested via the *xthst* command in the Stata statistical software program made available by Bersvendsen and Ditzen (2021).

The estimation results of the DH test of the heterogeneous panel non-causality test are reported in Table 6. For the whole panel (1991–2019), it is evident that Land Granger causes Export, and the reverse also holds, validating the existence of feedback between these two variables. In what follows, we divided the entire sample of the paper into three subpanels and further investigated the causal nexus between the variables of interest. For panel A (1991–2000), it can be seen that there exists a two-way causal relationship between the variables Export and Land. In addition, the two-way causal relationship is also found in Panel B (2001–2010) and Panel C (2011–2019). In summary, findings evidence the presence of feedback between countries' land endowments and their agricultural exports not only in the whole panel but also in the subpanels too.

Table 6. Pairwise Dumitrescu and Hurlin (2012) Panel Granger Non-Causality Test

Whole Sample: 1991–2019 Lags: Akaike information criterion (AIC) Null Hypothesis	Zbar-stat.	Probability
Land does not homogenously cause **Export**	1.18e+07***	0.000
Export does not homogenously cause **Land**	1.57e+08***	0.000
Panel A (1991–2000)[a]	Zbar-stat ($\bar{Z}$)	Prob.
Land does not homogenously cause **Export**	–	0.000
Export does not homogenously cause **Land**	–	0.000
Panel B (2001–2010)	Zbar-stat ($\bar{Z}$)[b]	Prob.
Land does not homogenously cause **Export**	13.349***	0.000
Export does not homogenously cause **Land**	21.007***	0.000
Panel C (2011–2019)	Zbar-stat ($\bar{Z}$)	Prob.
Land does not homogenously cause **Export**	48.545***	0.000
Export does not homogenously cause **Land**	1.59e+05***	0.000

Note: The appropriate lag length is based on the AIC. *** indicates a rejection of the null hypothesis (i.e., absence of causality for all countries in the panel) at the 1% level.

[a] The output in Panel A reports the obtained *p*-values associated with the Z-bar statistic that is computed via the bootstrap procedure with 1,000 reps as suggested by Dumitrescu and Hurlin (2012). However, we were unable to retrieve critical values for the Z-bar statistics in the Stata statistical software package for reasons outside the boundaries of our understanding.

[b] Dumitrescu and Hurlin (2012) explicitly stated that when both N and T are relatively large, the ($\bar{Z}$) statistic should be favored over the $\tilde{Z}$ statistic, as in Paramati, Apergis, and Ummala (2016).

Source: the authors' computation via Stata 16 statistical software.

4. Discussion and conclusion

Amongst the factors of production, land is more or less seen as a fixed factor whose quality can change, but not the quantity. This characteristic that land possesses as an indispensable factor of agricultural production frequently weighs in the concerns as to agricultural production and food crises, and the inequalities in the distribution of fertile agricultural lands amongst countries add up to these concerns. Against this background, the extant literature inquires about the effects of countries' land resources on their agricultural goods trade. Nonetheless, research on the topic has remained relatively scarce and is approached from a micro perspective disproportionately concentrating on the relationship between agricultural farm size and land productivity. Herein, this paper approached the issue from a macro perspective examining the causal nexus, if there are any, between nations' total agricultural land resources and agricultural goods exports for the selected 174 constituents of the sample for the period 1991–2019. Estimation results evidence that there exists a two-way causal relation or feedback mechanism between nations' land endowments and their agricultural exports, as captured by the variables Land and Export respectively, not only in the whole sample period (1991–2019) but also in subperiods (1991–2000, 2001–2010, and 2011–2019). Overall, the results emphasize the importance of agricultural land resources as a significant determinant of agricultural exports, which is in line with the implications of the Heckscher-Ohlin factor endowments theory and with the findings of Akther, Voumik, and Rahman (2022), Devadoss, Ugwanyi, and Ridley (2022), Hamulczuk, Makarchuk, and Sica (2019), and Zhang and Sun (2022). Also, agricultural exports turn out to be a determinant of agricultural land resources, which is implicated within the framework of the export-led growth theory of economic development and is consistent with the results of Carrara and Pesquero (2022), Mkuna (2022), and Toyin (2016).

Before the 20th century, productivity differences in agricultural production between countries were at a more reasonable level, and the quality of the soil and climate conditions were dominant factors in the determination of agricultural productivity. Nevertheless, the shift kicked off with the developments in artificial fertilizers and seed breeding technologies which has leveled up the productivity differentials ever since. And the fact that agriculture is labor-intensive kept the cost difference between countries at a lower level. However, it is palpable that the agricultural sector has taken up a more capital-intensive form over time and the relative importance of the labor factor has decreased in comparison to the past. For that reason, countries that can bring their agricultural production technologies to a more competitive level will also come to the forefront of global agricultural goods trade. Especially, countries with a high average farm enterprise size ought to internalize the capital-intensive production process more quickly. Also, countries with low average agricultural land per farm need to prioritize land reforms to adapt to ongoing technological change, especially in terms of basic agricultural goods that have been subject to frequent international trading,

Notwithstanding, there are limitations of the paper herein that need to be elaborated on and be hopefully addressed by the upcoming studies on the topic. While we take a global view of agricultural goods trade and land resources, we overlook the variations in production and land systems between nations, including factors such as soil quality, fertilizer use, and irrigation availability, which are crucial to agricultural production. Additionally, the time frame could be enlarged to encompass both the outbreak of the COVID-19 pandemic and the emergence of the Russia-Ukraine armed conflict as these black-swan events have widespread ramifications across agricultural markets on a global scale.

Appendix

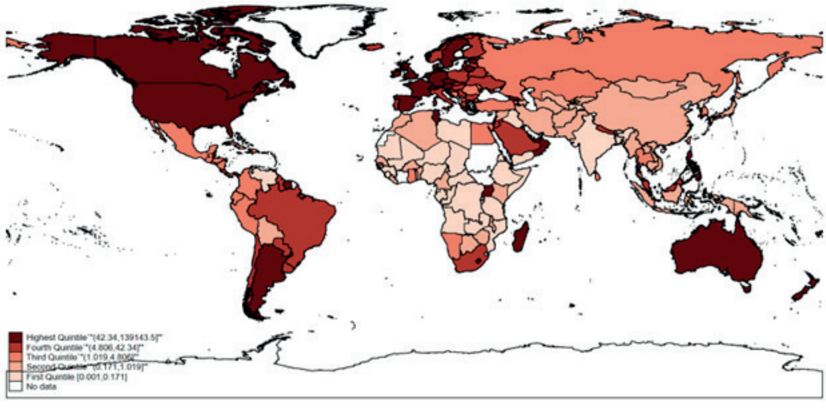

Figure A1. Mapping the intensity of agricultural exports per agricultural labor across sample countries in 2019. The series is divided into 5 equal parts, each of which is represented by respective quintiles

Source: The authors' own creation via Stata 16.

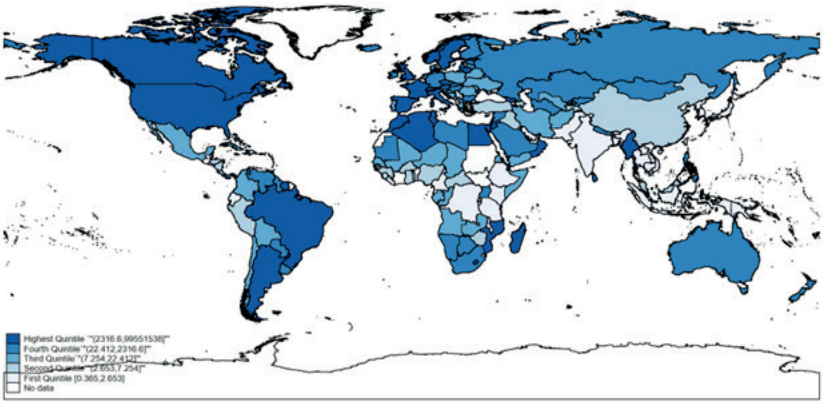

Figure A2. Mapping the intensity of agricultural land per agricultural labor across sample countries in 2019. The series is divided into 5 equal parts, each of which is represented by respective quintiles

Source: The authors' own computation via Stata 16.

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