Study on the Impact of Carbon Emissions on International Agricultural Trade of Countries Along “the Belt and Road Initiative” with China

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Abstract. The main aim of this study is to investigate the impact of carbon emissions on international agricultural trade. To address this, a stochastic frontier specification of the gravity model is adopted to examine the driving forces of the change in agricultural import and export between 48 countries of 5 regions along “the Belt and Road Initiative” and China with an emphasis on carbon emissions. Based on the findings of the paper, we can draw the following conclusion, first, there is a positive influence of carbon emissions in international agricultural trade. Second, the situation varies among the five regions.

1. Introduction
In 2016, the total agricultural trade volume of the countries along "the Belt and Road Initiative" and China amounted to US $ 0.73 trillion, accounting for 9.25% of the total agricultural trade in this region. Since China has been working on economic and trade cooperation between China and countries along "the Belt and Road Initiative" in respect of many sectors including agriculture. In May 2017, China Ministry of Agriculture and Rural Affairs, the National Development and Reform Commission, the Ministry of Commerce and the Ministry of Foreign Affairs jointly released Vision and Actions on Jointly Promoting Agricultural Cooperation of the Belt and Road Initiative. It is in this vein that the volume of agricultural trade within this region will continue to expand in a large degree, especially when taking the fierce Sino-US agricultural trade friction into account.

With more and more energy consumed in production activities, agriculture has become the second largest source of the greenhouse gases. The development of science and technology in the sector of agriculture leads to the progress of the productivity and output, as well as the rising carbon emissions. International trade has led to increase of carbon emissions [1]. Therefore, carbon emissions brought by international trade have been paid more and more attention, among them, that of agricultural products is a hot issue to be researched.

The article has been organized as follows. The second section specifies the gravity model; The third section introduces the data sources; the fourth section uses the scholastic frontier method to test the impact of the driving forces of the agricultural trade between the 48 countries of 5 regions along "the Belt and Road Initiative" with China. Finally, the conclusions and lines of future research are provided.
2. Model Specification

The Gravy model is the most commonly used method to analyze the determinants of international trade[2,3,4]. Since the traditional gravity model is based on the assumption of friction-free trade as well as the iceberg cost, the influence of multilateral resistance factors on trade are ignored, which may lead to errors in the research results[5,6]. Hence, some literature have introduced the stochastic frontier method (SFA) into the gravity model[6,7]. Compared with the estimating method of the traditional gravity model, stochastic frontier method can analyze the effect of artificial trade inefficiency, so it is more inclusive. While in the beginning period of the stochastic frontier method, the trade inefficiency term is generally assumed as a time-invariant model (TIM), which does not change with time. Battese and Coelli [8] proposed that the term of trade inefficiency should change with time. In this way, a time-varying model (TVDM) is proposed, which is more consistent with the trade reality.

Due to the existence of trade resistance, there is a certain difference between the actual trade volume and the maximum possible trade volume, and the trade efficiency reflects the degree of difference between the actual trade value and the maximum probable trade value. So, it is important to investigate the non-efficiency item of the gravity model. At first, considering the geographical situation of the area along "the Belt and Road Initiative" is very complex, which objectively results in the inconvenience of the transportation across the region. Therefore, the logistics performance cannot be ignored in the impact on the efficiency of international trade of agricultural products. Besides, since the deepening of market-oriented reform and the of openness to the outside world are conducive to reducing trade costs, such as, transaction-oriented costs, policy-oriented costs, as well as institutional costs, as a result, the trade efficiency can get improved. Considering WTO only accept those countries who has been recognized as a market country as its member. In this sense, this paper takes whether be the membership of WTO as an indicator of the institution quality.

Based on the above analysis, referring to Battese and Coelli’s model [9], two stochastic frontier estimation gravity models with carbon emission factors are constructed in this paper, as shown in formula (1) and (2).

\[
\ln AIMP_j = \beta_0 + \beta_1 \ln AGDP^j + \beta_2 \ln POP^j + \beta_3 \ln DIST_{ij} + \beta_4 BORD_{ij} + \beta_5 \ln CARBON^j + \beta_6 \ln AVITY^j + \beta_7 \ln ER_{ij} + \nu_{ij} - u_{ij}
\]

(1)

\[
\ln AEXP_j = \beta_0 + \beta_1 \ln AGDP^j + \beta_2 \ln POP^j + \beta_3 \ln DIST_{ij} + \beta_4 BORD_{ij} + \beta_5 \ln CARBON^j + \beta_6 \ln AVITY^j + \beta_7 \ln ER_{ij} + \nu_{ij} - u_{ij}
\]

(2)

In Eq. (1),(2), \(\ln AGDP^j\) is the natural log form of agricultural gross output value for country j at time t, and \(\ln CARBON^j\) represents the natural log form of total carbon emissions for country j at time t; \(\ln AIMP_j\) is the natural log form of import amount of agricultural products from China by countries j (j= 1, 2, 3,..., 48) during t period (t=1995, 1996,..., 2014); \(\ln AEXP_j\) is the natural log form of export amount of agricultural products to China from countries j during t period; \(\ln POP^j\) is population of countries j during t period; \(\ln DIST_{ij}\) is the distance from capital of country j to Beijing; \(BORD_{ij}\) denotes whether the territory of country j has the common border with China; \(\ln AVITY^j\) denotes the labor productivity of agricultural sector of country j; \(\ln ER_{ij}\) is exchange rate of country j against RMB; The error term is denoted by \(\nu_{ij}\), which obeys the normal distribution, that is, \(\nu_{ij} \sim N(0,\sigma^2)\) ; \(u_{ij} \geq 0\) is trade inefficiency item, which obeys the semi-normal distribution;
\( \text{cov}(v_j, u_j) = 0 \) means they're independent of each other.

The trade inefficiency model is set as:

\[
\mu'^{ij} = \kappa_0 + \kappa_1 LE^{ij} + \kappa_2 WTO^{ij} + \omega^{ij}
\]

(3)

In Eq. (3), \( LE^{ij} \) is the comprehensive logistics efficiency of country \( j \); \( WTO^{ij} \) denotes whether country \( j \) is the member nation of WTO; the random error term is denoted by \( \omega^{ij} \).

3. Data

3.1. Geographical Scope of Countries Along “the Belt and Road Initiative”

Even though many researchers have analyzed the geographical scope and put forward the corresponding definition, “the Belt and Road Initiative” is an open international economic cooperation network with no precise space scope defined yet. Usually, 65 countries are involved. However, taking the data into account, in this paper, the geographical scope of the study is set as 48 countries of 5 regions. There are central Asia, Russia and Mongolia area, southeast Asia area, south Asia area, central and eastern Europe area, as well as western Asia and the middle east area.

3.2. Data Sources

The data of carbon emissions are from the World Bank Database (WDI). They are denominated in metric tons; The data source of agricultural output is the FAO STAT, it is denominated in current price of USD per capita, it is denominated in current price of USD. the agricultural import, export data between the countries along "the Belt and Road Initiative" and China are from the United Nations Trade Database (UN COMTRADE), The selection criteria are BEC 1. Food and Beverage, denominated in current price of USD; The data of population are from the World Bank database (WDI); The data source of both of distance and common border are from the French Centre for prospective Studies and International Studies (CEPII) Database. the data of agricultural productivity are calculated by the authors according to the database of FAO, the specific calculation formula is "Gross agricultural product/the Number of agricultural employment"; The data of exchange rate are from the database of International Monetary Fund (IMF). In Eq. (3), the data of LE are from the World Bank Database (WDI); WTO is a dummy variable, it stands for whether country \( j \) is the WTO member. If yes, denotes 1, otherwise 0. the data of WTO are from the official website of WTO.

4. Empirical Methodology and Results

Since Maximum Likelihood Estimation (MLE) not only has good consistency and improves the accuracy of estimation, but also has asymptotic normality and asymptotic efficiency under large samples. Therefore, we use Stata 14.0 software to estimate the maximum likelihood of the gravity model (1), (2) and the trade inefficiency model (3).

4.1. Test of the Gravity Model

First of all, we check the existence and time variability of \( \mu'^{ij} \). Because the stochastic frontier method (SFA) is highly dependent on the function form of the model, which requires a strict match between the sample data set and the function form of the model. Therefore, this paper first tests the validity of the model, that is, to verify the existence of \( \mu'^{ij} \). The generalized likelihood ratio test (LR test) is employed to verify the form of the trade function as well as the null hypothesis of nonexistence of the trade efficiency in the stochastic frontier model. The null hypothesis is \( H_0 \), \( L(H_0) \) is the logarithmic likelihood value of the model with constraints, and the alternative assumption is \( H_1 \), \( L(H_1) \) is the logarithmic likelihood value of the model without constraints.

Secondly, the explanatory variables in the stochastic frontier gravity model are tested in turn. The null hypothesis that there is no trade inefficiency is significantly rejected, which indicates that the
choice of the model is necessary. Secondly, the null hypothesis that trade inefficiency does not change with time is significantly rejected, which means that the time-varying stochastic frontier gravity model is appropriate. Thirdly, the null hypothesis that there is no common boundary variable as well as exchange rate variable cannot be rejected in two models. Finally, both null hypothesis that there is no agricultural gross output variable in the importing model, and there is no population variable in the exporting model cannot be rejected. In addition, the null hypothesis of all other explanatory variables has been rejected, indicating that the stochastic frontier gravity model presented is basically reasonable. According to the above-mentioned tests, the final models of importing and exporting trade can be determined as formulas (4) and (5) respectively.

\[
\ln AGIMP_{ij} = \beta_0 + \beta_1 \ln POP_{ij} + \beta_2 \ln DIST_{ij} + \beta_3 \ln CARBON_{ij} + v'_{ij} - u'_{ij} \\
+ \beta_4 \ln AVITY_{ij} + \nu_{ij}
\]

\[
\ln AGEXP_{ij} = \beta_0 + \beta_1 \ln AGDP_{ij} + \beta_2 \ln DIST_{ij} + \beta_3 \ln CARBON_{ij} + v'_{ij} - u'_{ij}
\]

4.2. Regressions and Results of the Gravity Model

Based on results of the applicability test, the time-varying model (TVDM) is used to estimate the gravity model for the import and export of agricultural products between 48 countries along "the Belt and Road Initiative" and China from 1995 to 2014. The results are shown in Table 1.

| Variables  | Import Coefficient | t value | Export Coefficient | t value |
|------------|-------------------|---------|-------------------|--------|
| \(\beta_0\) | -63.3353***       | -16.77  | -34.1529***       | -17.79 |
| LnAGDP\(_j\) | 0.3868***        | 3.40    | 0.1371***         | 4.12   |
| LnPOP\(_j\) | 4.8869***        | 16.64   | 3.0790***         | 19.61  |
| LnDIST\(_j\) | 0.9345***        | 10.46   | 0.6104***         | 15.78  |
| LnCARBON\(_j\) | 2.7318***      | 6.25    | 2.5935***         | 15.78  |
| \(\delta^2\) | 57.1403***       | 31.19   | 55.9661***        | 10.5358 |
| \(\gamma\)  | 0.9855***        | 3.01    | 0.9921***         | 6.34   |
| \(u\)       | -5.9387***       | -13.66  | -25.2578***       | -3.19  |
| \(\eta\)    | 4.2185***        | 11.610  | 4.8314***         | 5.93   |

Log likelihood value: -2477.1912 -1850.7131
LR Statistics: 219.63 218.54

Notes: *** , **, and * represents the statistical significance at the 1,5, and 10% levels, respectively.

First of all, \(\eta\) of the results of the two time-varying models are positive, which shows that the time-varying model proposed is well-grounded and the term of trade inefficiency is time-varying. Moreover, the efficiency of bilateral agricultural trade has shown a dynamic increasing trend, which is caused by China’s adoption of various substantial measures to promote "the Belt and Road Initiative". Second, \(\gamma\) of the two models are 0.9855 and 0.9921 respectively, it indicates that the trade inefficiency term is the dominant in the overall complex disturbance term, which is the main reason why the actual trade is difficult to approach the level of trade potential. We can see that in the models, the correlation coefficients of carbon emissions are positive, which are 0.9345 and 0.6104 respectively, and both are significant at the level of 1%. The reason may be as follows, on one hand, for the importing countries, which have shown a strong complementarity in international trade of agricultural products with China[10], so while more carbon are emitted to produce agricultural products that they specialize in, they still need to import other kinds of agricultural products from China to meet the diversified...
demand of the domestic market. On the other hand, for the exporting countries, the increase in carbon emissions means that they might have planted and processed a large quantity of agricultural products to export.

Second, in the models, the correlation coefficients of agricultural productivity are positive, which are 2.7318 and 2.5935 respectively. Both of them are significant at the level of 1%. This is in line with the theoretical expectations, indicating that with the progress of agricultural productivity in countries along "the Belt and Road Initiative", the trade flows of agricultural products between them and China are increasing. For the exporting countries, the improvement of productivity has contributed to an increase in output, resulting in an increase in exporting. For those importing countries, the rise of the average productivity does not mean the advance of that of each of the agricultural sector. Among them, the intra product division of labor brought about by the vertical division of labor is a typical example.

Third, in the importing model, the correlation coefficient of population is positive, because larger population requires a larger quantity of and more diversified agricultural products, hence more import. Fourth, agricultural output value has a positive impact on exporting, as higher output value can lead to more export of agricultural products. At last, distance between the capitals and Beijing has shown a positive impact on both import and export, which indicates that the main agricultural trade counterparts are far away from China.

4.3. Regression and Results of Trade Inefficiency Model
The test of existence of the inefficiency term and the time-varying test of the inefficiency term are made for the trade inefficiency model. The null hypothesis is as follows: \( \gamma = \mu = \eta = 0 \) (\( \mu = 0 \), That is, \( k_0 = k_1 = k_2 = 0 \) in the trade inefficiency model), Time-varying trade inefficiencies should be considered. Both of the null hypothesis are rejected. The trade inefficiency model is then estimated. As we can see from table 2, the results show that the signal to the noise ratio \( \gamma \) values are 0.9060 and 0.9220, respectively, indicating that the models are reasonable. Besides, the coefficients of logistics performance and WTO membership are significantly negative, which are consistent with the theoretical assumption, which indicates that the improvement of logistics performance and the entry into WTO will contribute to the advance of the trade efficiency of agricultural products between the countries along "the Belt and Road Initiative" and China.

| Variables | Import | | Export |
|-----------|--------|------|-------|
|           | coefficient | t value | coefficient | t value |
| \( K_0 \) | -9.1555*** | -11.75 | -14.6088*** | -33.86 |
| \( LE^1_j \) | -2.9470*** | -9.61 | -1.3318*** | -8.41 |
| \( WTO^3_j \) | -1.6147*** | -5.34 | -0.8733*** | -5.20 |
| \( \delta^2 \) | 65.4072*** | 29.24 | 28.2663*** | 8.59 |
| \( \eta \) | 2.1970*** | 5.47 | 2.4542*** | 4.23 |
| \( r \) | 0.8999*** | 3.42 | 0.9208*** | 3.87 |
| Log likelihood | -2625.3318 | | -2080.3959 | |
| LR statistics | 98.65 | | 68.03 | |

Notes: ***, **, and * represents the statistical significance at the 1, 5, and 10% levels, respectively.

4.4. Analysis of Different Regions
On basis on the computing data results of the impact of carbon emissions on international trade of agricultural products between 5 regions along "the Belt and Road Initiative" and China we can find that, at first, the carbon emissions of South Asia have the most significant positive impact on its agricultural trade with China, which means that the agricultural import and export with China are grow in a large degree as carbon emissions increases in the region. Secondly, the positive effects of carbon emissions in Southeast Asia on international trade of agricultural products with China are less than 0.5,
which indicates that with the increase of carbon emissions in Southeast Asia, import and export trade of agricultural products with China is also on the rise. Thirdly, carbon emissions of Central Asia, Russia and Mongolia also have a positive impact on their agricultural trade with China. Among them, the impact on import is more prominent, and that on export is relatively smaller. Fourthly, carbon emissions of Western Asia and Middle East have a positive effect in their agricultural import with China, but a negative effect in export which means that with the increase in carbon emissions in the region, import of agricultural products between them and China grew, while export decreased; Finally, the impact of carbon emissions on Central and Eastern Europe region on agricultural trade with China is not significant at all.

5. Conclusions

In this paper, the study found that:(1) As for the stochastic frontier method used to estimate gravity model of import and export of agricultural products between countries along the route and China, the correlation coefficients of carbon emissions are significantly positive. This indicates that the rise in carbon emissions of countries along the route lead to an increase their agricultural imports and exports with China. A main policy implication may be that the agricultural production in this region causes more carbon emissions, therefore, low-carbon agricultural growth patterns should be promoted in the region.(2)Among these countries, the coefficient of Central and Eastern Europe region is significantly negative, but the coefficient of South Asia, Southeast Asia, Central Asia, Russia and Mongolia are significantly positive. However, carbon emissions in West Asia and Middle East has a positive effect on import of agricultural products with China, with a negative effect on export. A main policy implication is that different trade policies for international agricultural products with China should be formulated for different countries and regions. Meanwhile, China should formulate different policies for different regions to reduce carbon emissions from agricultural production and international trade.

Given that our findings are only limited to the panel dataset of 48 countries of 5 regions along "the Belt and Road Initiative", future papers on the subject can use the approach to examine the influence of carbon emissions on international agricultural trade in each of these countries.

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References

[1] Yao, Q.-H.; Han, M.-Y. Study on embodied carbon flow along the "Belt and Road Initiative". J. Geogr. Sci., 2018, 28,68-79.
[2] Tinbergen, J. Shaping the world economy, Twentieth Century Fund, New York,1962.
[3] Rauch, J. Networks versus market in international trade. J. Int. Econ.,1999,48,7-37.
[4] Sheng, B.; Liao, M.-Z. China's Trade flow and Export potential: a study of Gravity Model. J. World Econ.,2004,2,3-12.
[5] Anderson, J.E.; Wincoop, E.V. Gravity with gravitas: a solution to the border puzzle. Am. Econ. Rev.,2003,93,170-192.
[6] Armstrong, S. Measuring trade and trade potential. A survey. Asia Pacific Econ. Papers.No.368. https://openresearch-repository.anu.edu.au/bitstream/1885/39320/14/01_Armstrong_Measuring_Trade_2007.pdf.
[7] Kalirajan, K. Regional cooperation and bilateral trade flows: an empirical measurement
of resistance. J. Int. Trade, 2007, 21, 85-107.

[8] Battese, G.E.; Coelli, T. J. Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India. J. Prod. Anal., 1992, 3, 153-169.

[9] Battese, G.E.; Coelli, T.J. A model for technical inefficiency effects in a stochastic frontier production function for panel data. Empir. Econ., 1995, 20, 325-332.

[10] Waugh, M.E.; Ravikumar, B. Measuring openness to trade. J. Econ Dyn Control, 2016, 72, 29-41.