Does International Agricultural Trade Matter for Carbon Emissions: A Case Study of the Area Along “the Belt and Road Initiative”

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Abstract. The research problem of this study is to understand how international agricultural trade affects the carbon emissions. To address this, we have conducted an empirical study based on the panel dataset of 48 countries of 5 regions along “the Belt and Road Initiative” over the period 1995-2014. The impacts of agricultural trade openness on the level of carbon emissions per capita has been investigated. Along with the traditional trade openness, a different trade openness measure is used, called as the adjusted agricultural trade potential index. Based on the findings of the paper, we can draw the following conclusion, that is, the adjusted agricultural trade potential index is negatively associated with the carbon emissions.

1. Introduction
Globally, we are witnessing a sharp increase of carbon emission. According to CO2 Emissions from Fuel Combustion: Overview released by International Energy Agency (IEA) in 2018, global CO2 emissions reached 32.79 billion ton in 2017, which has an increase of about 1.5% year-on-year. China, India and the European Union are the main sources of the growth. 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. In 2016, the total agricultural trade volume of the countries along "the Belt and Road Initiative" was US $7.93 trillion, accounting for 51.57% of the total global agricultural trade.

Does international trade of agricultural products matter for carbon emissions? To answer this question, based on approaches of current literature, we intend to estimate the impact of agricultural trade openness on the level of carbon emissions per capita based on panel dataset of 48 countries of the 5 regions along "the Belt and Road Initiative" over the period 1995-2014. This paper uses a different trade openness measure, so called as the agricultural "Trade Potential Index”(TPI).

The article has been organized as follows. The second section establishes the model; The third section introduces the data source; and the fourth section uses both adjusted agricultural TPI and traditional trade openness measure to test the impact of the agricultural trade openness on the level of carbon emissions per capita of the 48 countries of 5 regions along "the Belt and Road Initiative".
Finally, the conclusions and lines of future research are provided.

2. Model Specification
In this paper, referring to Environmental Kuznets Curve (EKC) model[2], three explanatory indicators, such as, income, energy consumption and international trade, are selected as explanatory variables to construct a model for carbon emissions, so as to analyse the impact of international trade of agricultural products on carbon emissions along "the Belt and Road Initiative". The following is a theoretical explanation of each variable.

Dependent variable: carbon emissions per capita. While the use of embodied carbon emissions in some literature is based on the analysis from a process perspective, which may result in discrepancies in results due to different methods of calculation. But analysis based on a country's carbon emissions data is from a result perspective which is more reliable.

Income: agricultural output value per capita. According to the EKC hypothesis, GDP per capita reflects the impact of income on carbon emissions. In other words, the effect of the income level of carbon emissions looks like an inverted-U upon a graph. The decline of carbon emissions is related to the fact there is an increased awareness of the negative consequences of the environmental degradation when the country reaches a high income level[3].

Energy consumption: energy consumption per capita. Fossil fuels are the main source of energy, and high energy consumption can lead to damage of environmental[4]. So, there is a two-way causal relationship between energy consumption and carbon emissions [5].

International agricultural trade openness: Trade potential index (TPI) and traditional trade openness index. Referring to previous literature [6], this paper adjusts the TPI to agricultural trade context, and employs it together with the traditional trade openness index to stand for the degree of openness of international trade of agricultural products.

In a word, the EKC empirical model is set as follows:

$$ CARBON_i^t = f(AGDP_i^t, ENERGY_i^t, ATRAD_i^t) $$

(1)

The above formula can be written in the natural logarithmic form:

$$ \ln CARBON_i^t = \alpha_0 + \alpha_1 \ln AGDP_i^t + \alpha_2 \ln ENERGY_i^t + \alpha_3 ATRAD_i^t + \epsilon^t $$

(2)

In Eq. (2), $\ln CARBON_i^t$ is the natural log form of CO2 emissions per capita of the country i (i=1,2,3,...,48) at time t (t=1995,1996,...,2014), $\ln AGDP_i^t$ is the natural log form of Agricultural output value per capita of the country i at time t, $\ln ENERGY_i^t$ is the natural log form of energy consumption per capita of the country i at time t, and $ATRAD_i^t$ is the agricultural trade openness measures of the country i at time t. The error term is denoted by $\epsilon^t$.

3. Data

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

Even though many researchers have analysed 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

(1) Introduction of agricultural TPI

In Eq. (2), $ATRAD_i^t$ involves two variables, i.e., the agricultural TPI and traditional agricultural trade openness. While the traditional agricultural trade openness is calculated as the Percentage of agricultural production divided by 100; This paper attempts to adjust and apply the trade openness index (TPI) to measure the opening degree of agricultural trade among the countries along the "the
Belt and Road Initiative”. In the classical international trade model, TPI is defined as follows: \( TPI = \left( \frac{\lambda_{ii}^n Y_i}{\lambda_{ii}^{\theta}} \right)^{\frac{1}{1-\theta}} \) [7]. We calculate the share of domestic trade in agricultural products as (one country’s agricultural imports as a percentage of GDP). \( \theta \) stands for trade elasticity, referring to the approach of some literature [8,9], we set the trade elasticity to four.

Overall, during 1995-2014, the TPI level of agricultural products in regions along "the Belt and Road Initiative" was not high, with an average of only 0.07. From Figure 1, we can see that the average TPI level of agricultural products in South Asia is the highest and the rising trend is the most obvious. The average TPI of the Central and Eastern Europe was in the second place, that of the Central Asia and Russia and Mongolia was the second, and that of West Asia and the Central Asia was the lowest. The change of TPI of agricultural products in these four regions during the last 20 years was very small and almost flat. The South-East Asia region suddenly saw a huge increase in 2013, and “the Belt and Road Initiative” that year may have been one of the driving forces behind it.

(2) Data Sources
The data of carbon emissions are from the World Bank Database (WDI), while in Eq.(2), it is denominated in metric tons per capita; The data source of agricultural output is the FAO STAT, while in Eq.(2), it is denominated in current price of US per capita, In Eq.(2), the data of energy consumption are from the World Bank Database (WDI), the unit is Kg of oil equivalent per capita.

![Figure 1. Average Agricultural TPI of 5 Regions Along "the Belt and Road Initiative".](image)

4. Empirical Methodology and Results
As the panel data model has many advantages, such as, it can reflect the changing rules and characteristics of variables in both dimensions of cross-section and time, which is incomparable with the single cross-section data and the time series data. Meanwhile, according to different restrictions on intercept and independent variable coefficient, the panel data model can be divided into three types: the mixed model, the variable intercept model and the variable coefficient model. Among them, the variable intercept model can be divided into fixed effect model and random effect model. In the estimation of panel data model, a key step is unit root test, which is the precondition to avoid the phenomenon of “pseudo regression”.

4.1. the Correlation Test
The main methods of correlation test include correlation coefficient test, Spearman rank correlation
test and Kendall rank correlation test, and so on. In this paper, the correlation coefficient test is used to judge the correlation between coefficients, and then select the variables with lower correlation coefficient as explanatory variables, so as to avoid multi-collinearity between variables, which may result in pseudo-regression due to the high correlation. The results are shown in Table 1.

As can be seen from Table 3, the absolute value of correlation coefficients among all variables are less than 0.7, and the absolute value of correlation coefficients between most of the variables are less than 0.3, so the correlation is weak. The absolute correlation coefficient between energy consumption per capita and carbon emissions per capita, Trade openness of agriculture and agricultural output value per capita are greater than 0.6 and less than 0.7, which are a moderate correlation. Since the natural logarithm is used in the panel data is carried out before regression analysis. And the most commonly used method is the unit root test. There are many ways to do unit root test. In this paper, ADF test, KPS test and PP test are selected. The standard unit root test process should take into three models account, that is, intercepts only, trends and intercepts, and neither trends nor intercepts. Since the natural logarithm is used in the panel unit root test, as long as one of the tests rejects the null hypothesis of the existence of a unit root process, the variable can be regarded to be stable. As a result, from the panel unit root test results in Table 2, we can see that most of the variables in the ADF test, KPS test and PP test reject the null hypothesis, and accept the alternative hypothesis of the non-existence of the unit root process.

4.2. Panel Unit Root Check

The stability of panel data has a great influence on the accuracy of regression results, and the instability of data series will lead to a large deviation of the results. Therefore, the stability test of panel data is carried out before regression analysis. And the most commonly used method is the unit root test. There are many ways to do unit root test. In this paper, ADF test, KPS test and PP test are selected. The standard unit root test process should take into three models account, that is, intercepts only, trends and intercepts, and neither trends nor intercepts. Since the natural logarithm is used in the panel regression analysis, therefore, the panel unit root test is based on the natural logarithmic data series.

| Table 1. the Correlation Matrix. |
| Variables | Ln carbon emission per capita | Ln energy consumption per capita | Ln agriculture output per capita | Agricultural TPI | Trade openness of agriculture |
| Ln carbon emission per capita | 1.00 | | | | |
| Ln energy consumption per capita | 0.68 | 1.00 | | | |
| Ln agriculture output per capita | 0.22 | 0.20 | 1.00 | | |
| Agricultural TPI | -0.27 | -0.30 | -0.25 | 1.00 | |
| Trade openness of agriculture | -0.05 | -0.04 | -0.61 | 0.24 | 1.00 |

In the panel unit root test, as long as one of the tests rejects the null hypothesis of the existence of a unit root process, the variable can be regarded to be stable. As a result, from the panel unit root test results in Table 2, we can see that most of the variables in the ADF test, KPS test and PP test reject the null hypothesis, and accept the alternative hypothesis of the non-existence of the unit root process.

| Table 2. Panel Unit Root Check Results. |
| Regressors | ADF test | KPS test | PP test |
| | I.O. | I.T.I. | N.I.T. | I.O. | I.T.I. | N.I.T. | I.O. | I.T.I. | N.I.T. |
| LnCARBON1 | -4.2347*** | -4.3158*** | -2.3214** | 0.1532*** | 0.0435*** | -4.6305*** | -4.7368*** | -3.0618*** |
| LnENERGY2 | -4.2102*** | -4.2086*** | -0.3455 | 0.0872*** | 0.0721*** | -5.6443*** | -5.6413*** | -0.5163 |
| LnAGROPI | -5.4668*** | -5.5219*** | -0.6244 | 0.1391*** | 0.0610*** | -6.6732*** | -6.6933*** | -1.2002 |
| Agricultural TPI | -6.3541*** | -6.6027*** | -1.8333** | 0.6916*** | 0.1784*** | -7.9118*** | -8.2853*** | -2.5582*** |
| TRADEOPEN | -6.0759*** | -6.0734*** | -5.9626*** | 0.1029** | 0.1023*** | -8.0077*** | -8.0022*** | -8.0470*** |

Notes:”I.O.” stands for “Intercept Only”,”I.T.I.” stands for “Include Trend and Intercept”,”N.I.T.” stands for “Neither Intercept nor trend”. ***, **, and * represents the statistical significance at the 1.5, and 10% levels,
respectively.

On the basis of the correlation test and panel unit root test, panel regression analysis is carried out with Stata 14.0. The results of regression analysis are shown in Table 5. Model 1 is a mixed OLS model. It is found that only the traditional trade openness variable has not passed the significance test, but all of the other variables have passed the significance test. This indicates that the choice and setting of independent variables are basically equitable in this paper. Model 2 is a fixed effect model, which is selected from the mixed OLS model and the fixed effect model by F-test. Model 3 is a GLS random effect model which can correct the heteroscedasticity of random terms. The Hausman test is used to determine whether to adopt the fixed effect model or the random effect model. Finally, the test results accept the random effect model. Model 4 and model 5 are the GLS random effect model after eliminating variables of traditional trade openness and agricultural TPI respectively. Because neither the mixed OLS model nor the GLS stochastic effect estimation takes the existence of spatial interaction effect into account, the mixed OLS and GLS stochastic effect estimation will have a certain degree of estimation deviation under the condition of spatial auto-correlation. Therefore, the method of maximum likelihood estimation (MLE) which considers the random effects is used in the spatial econometric analysis under the condition of clustering robust standard error, so as to obtain the uniform effective estimation of parameters. Model 6 is a MLE random effect. Model 7 is a MLE stochastic effect model which excludes the variable of trade openness. In a word, most of the variables have passed the significance test.

As can be seen from Table 3, the variable of traditional trade openness fails to pass the significance test from model 1 to model 4. Besides, all the other variables have passed the significance test, which shows that the explanatory variables chosen in this paper are basically equitable. The coefficient of agricultural TPI is negative, which indicates that the trade openness of agricultural products along "the Belt and Road Initiative" has a negative impact on carbon emissions. In other words, the higher the degree of trade openness in agricultural products, the less carbon emissions. The possible reason is that, with the increase in the degree of agricultural trade openness, countries have achieved a higher degree of agricultural productivity. On the other hand, a higher degree of trade openness can lead to the structural transformation, which reduces environmental pollution as technology advances. The coefficient of agricultural output per capita is positive and significant at a level of 1%. This indicates that agricultural production has a positive impact on carbon emissions. A similar conclusion is also drawn from the related research on the general GDP per capita and carbon emissions in the countries along "the Belt and Road Initiative"[10].The reason may lie in that the successful popularization of science, technology and industrialization in the field of agriculture makes the productivity and output increase at the same time, which inevitably increases the carbon emissions. The coefficient of energy consumption per capita is positive, which indicates there is a positive effect of energy consumption on carbon emissions.

| Regressors  | Model 1  | Model 2  | Model 3  | Model 4  | Model 5  | Model 6  | Model 7  |
|------------|----------|----------|----------|----------|----------|----------|----------|
| α          | -3.1581*** | -3.1474*** | -3.1581*** | -3.4153*** | -3.0822*** | -3.1581*** | -3.0822*** |
|            | (-18.11)  | (-17.80)  | (-18.11)  | (-22.90)  | (-18.10)  | (-18.15)  | (-18.14)  |
| LnAGRP**   | 0.1621*** | 0.1620*** | 0.1621*** | 0.1717*** | 0.1104*** | 0.1621*** | 0.1104*** |
|            | (3.66)    | (3.62)    | (3.66)    | (3.88)    | (3.11)    | (3.67)    | (3.12)    |
| LnENERGY*  | 1.1120*** | 1.1117*** | 1.1120*** | 1.1445*** | 1.1235*** | 1.1120*** | 1.1235*** |
|            | (26.08)   | (25.83)   | (26.08)   | (27.83)   | (26.57)   | (26.14)   | (26.63)   |
| TRADEOPEN* | 0.0001    | 0.0001    | 0.0001    | 0.0001 (1.56) | 0.0001    | 0.0001*   |
| Agricultural TPI | -16.1352*** | -17.3149*** | -16.1352*** | -14.5456*** | -16.1352*** | -14.5458*** |
|            | (-18.11)  | (-2.86)   | (-2.82)   | (-2.56)   | (-2.83)   | (-18.14)  |

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

5. Conclusions
This research work has tried to shed some light into whether international agricultural trade matters for the carbon emissions on basis of the panel data samples of "the Belt and Road Initiative" from 1995 to 2014 are used. At first, the opening degree of agricultural products trade of 48 countries of 5 regions
along the route are measured by using the adjusted agricultural TPI. And then the impact on carbon emissions is analyzed.

In this paper, the study found that: (1) The general level of the agricultural TPI of 48 countries of 5 regions along the route are not high, as the average value is only 0.07. Among them, the average level in South Asia is the highest with an obvious growing trend. While Central and Eastern Europe takes the second place, Central Asia, Russia and Mongolia are in the third place, West Asia and Central Asia are of the lowest average level of agricultural TPI. (2) From 1995 to 2014, the average carbon emissions of the 5 regions has fluctuated slightly. Among them, carbon emissions in Central and Eastern Europe is significantly higher than that in other regions, with a carbon emission per capita of 85.18 metric tons, which is followed by Western Asia and Middle East, Central Asia and Russia-Mongolia, as well as Southeast Asia. South Asia has the lowest carbon emissions per capita of 0.66 metric tons. (3) There is a negative effect of the agricultural TPI on the carbon emissions, a main policy implication is that to provide the liberalization of international agricultural trade for decreasing the level of carbon emissions and this can also help to solve the problems of global warming.

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 impacts of international agricultural trade on the carbon emissions in each of these countries. Especially, the cases of large countries (e.g., Russia and India) can be considered.

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