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The Relationship between International Inbound Tourism Income and CO_2 Emissions: Based on ARDL-ECM Approach

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Abstract: This paper establishes an autoregressive distributed lag (ARDL) model and use bond test to analyze the relationship between International Inbound Tourism Income and CO_2 emissions. Based on the evidence data from 1995 to 2018, the paper derived three results. First, International Inbound Tourism and CO_2 emissions have cointegration. Second, the long trip income and catering service income of international inbound tourism have positive effects on CO_2 emissions in long-run. Third, long trip income and catering service income of international inbound tourism would dynamically fluctuate CO_2 emissions in short run.

1. Introduction

1.1. Research background and motivation

Carbon dioxide (CO_2) is the most common greenhouse gas （GHG)and the main factor of climate change[1]. In recent years, carbon dioxide emissions have caught a worldwide attention. In 1997, 84 countries signed the Kyoto Protocol, agreeing to stabilize the concentration of greenhouse gases at an appropriate level. In 2016, 178 State parties committed to achieve carbon neutral under the Paris Agreement, which would keep global temperature rise within 2 degrees Celsius, or even 1.5 degrees Celsius.

Since China’s reform and opening up, China vigorously developed its inbound tourism industry. Inbound tourism not only brings foreign exchange earnings but also enhances international recognition. After China State Council proposed to establish tourism industry as a "strategic pillar industry” of the national economy in the "Opinions on Accelerating the Development of the Tourism Industry", tourism industry has become a critical component of China's national economy[2]. By 2016, China's inbound tourism generated $120 billion foreign exchange income, which made China the world's third-largest international inbound travel destination. Inbound tourism income contributed 14.3% of the country's tourism production value.

Although tourism industry consumes less fossil energy compared with metallurgy industries, it is by no means "zero-emission". Tourism industry highly relies on transportation and inevitably leads to the pollutants emissions such as carbon dioxide. According to the UN World Tourism Organization's Glasgow Declaration on Climate Action in April 2022, tourism-related carbon dioxide emissions increased by at least 60% from 2005 to 2016[3]. The long-distance and long-duration based inbound tour induced an increasing energy dependency with China's inbound tourism market continuously expanding.

To achieve carbon neutral and keep a high-quality economy development, analyzing long-term and short-term relationship of China between international inbound tourism income and carbon emissions plays a crucial role.

1.2. Research objectives

To fill the gap of under research on the relationship between international inbound tourism and carbon emissions, we use ARDL-ECM Approach to evaluate long-run and short-run relationships between international inbound tourism and CO_2 emissions. To make a better understanding of how these two variables interacted, the foreign exchange earnings from international tourism and CO_2 emissions was selected to represent international inbound tourism and carbon emissions respectively. As noted, ARDL-ECM model would be applied to test whether there indeed exist cointegration and long-term and short-term relationship between international inbound tourism and carbon emissions.

The paper is organized as follows. Section 2 provides a short overview over previous works on carbon emissions, tourism and tourism economy. The ARDL-ECM framework is introduced in section 3. The data set and the estimation results are presented in section 4. In section 5 makes a conclusion and summarizes the main findings of this paper

2. Literature review

Environmental degradation due to climate change is a critical issue on a global scale. As international tour becoming more common and its economic value constantly rising, numerous studies investigated the relationships between tourism, economic growth, and carbon emissions in order to find a possible means of preventing further damage.

Tourism is found to have a considerable beneficial influence in connection to economic growth. Tourism brought lots of employment, most of which are lower-skilled wage workers[4]. According to other researches, self-employment or family businesses typically provide jobs in the tourism industry, particularly in the lodging and restaurant services [5]. Also, tourism would bring demand for different means of transits. The demand of transit encourages trade and tourism, which in turn support economic expansion[6].

Previous studies concluded that tourism has a significant correlation with carbon emissions. As early as 1997, Tamirisa used the input-output method to analyze the energy consumption in the spatial scope of tourism[7]. In 2002, the study used a "bottom-up" approach to break down the carbon emissions of tourism into transportation, accommodation and sightseeing [8,9]. In 2012, Max et al. measured the impact of foreign tourists on local carbon emissions. The impact of tourism growth on carbon emissions is clear[10].

Earlier studies investigated the relationships between economic growth and carbon emissions. They primarily studied the environmental Kuznets curve (EKC) hypothesis in order to analyze the long-term equilibrium correlations between GDP per capita, energy consumption, and GHG emissions. The inverted-U link between a nation's income and its level of carbon emissions served as the foundation for the EKC hypothesis[11]. It was noted that the amount of greenhouse gas emissions in high-income countries would rise in line with their income levels. Grossman and Krueger applied the EKC hypothesis in investigating the relationship between per capita income and environmental indicators[8,9]. However, their result was against the EKC hypothesis. Besides Grossman and

Krueger, there are many other studies concentrated on the similar topic. Some of the studies concluded that there exists a relationship between CO_2 and GDP per capita income [12].

There are two conclusions on tourism economic growth caused carbon dioxide emissions according to the different research target regions. Some studies found that tourism growth has a positive relationship with carbon dioxide emissions in long run [13]. Zhao et al. suggested that tourism growth caused regional carbon dioxide emissions increase[14]. Other studies researched on the small and undeveloped regions pointed out tourism growth reduced carbon dioxide emissions[15]. Akadiri et al. got the similar result based on small island data[16].

Some studies demonstrated that there exists a long-term equilibrium between tourism income and CO_2 emissions [17]. Some studies concluded that leisure and vacation have a significant impact on CO_2 emissions in both short-term and long-term dimensions [18]. Growth in time of inbound tour may have consequences for increasing consumption per person of transportation in the given city and across different cities. Which would also increase the CO_2 emissions.

In recent years, a large number of studies proposed that in order to realize the “dual carbon goal”, it is necessary to transform the present energy structure of tourism and leisure vacation into low-carbon energy structure [19]. According to specialties of tourism growth in different regions, CO_2 emissions can be reduced by decomposing the factors of tourism economic growth[20]. However, there are little existing literatures discussed CO_2 emissions caused by inbound tourism economy growth. Most of which focused on the relationships between regional tourism economy growth and carbon emissions. Thus, this paper evaluates the China’s nexus between international inbound tourism income and carbon emissions by utilizing the ARDL-ECM method. The scientific contribution of this work lies in expanding the scope of low-carbon tourism economy and enriching the contents of sustainable development of China's tourism economy.

3. Research methodology

3.1. Economic model and variables selection

According to China Yearbook of Statistics International Tourism Foreign Exchange Income Table, foreign exchange income from international inbound tourism is mainly derives from long-distance transportation, excursions, accommodation, catering, merchandise sales, transportation within the city. The proportion of long-distance traffic is around 50%. It can be seen from previous research that China's highway transportation and railroad transit have significant carbon emissions [21]. Essentially, GHG emissions occur as long as vehicles using non-renewable energy as power sources. Since the main focus is on the impact of inbound tourism on CO_2 emissions, it is straightforward to select factors that have direct relations with the foreign exchange earnings of inbound tourism and CO2 emissions. Long-distance transportation, catering, sightseeing, and urban transportation will be selected as variables in this paper.

The relationship between CO_2 and foreign exchange earnings from international inbound tourism is as follows:

$$RCO_{2_t} = \beta_0 + \beta_1 lnLT_t + \beta_2 lnMl_t + \beta_3 lnTr_t + \beta_4 lnTu_t + \varepsilon_t \quad (1)$$

where RCO_{2_t} is the rate of change of China’s carbon emissions performance in t period, due to the long-time span and long-term trend of carbon emissions, we use rate of change as study object; LT_t is foreign exchange income of long-distance transportation during period t. To measure the impact on inbound economy on CO_2 emissions, we convert the unit to RMB and exclude exchange rate fluctuations in foreign exchange. $lnLT_t$ is the natural logarithm for LT_t; Ml_t, Tr_t, Tu_t represents catering income of international inbound tourism during t period, urban transportation income of international inbound tourism during the t period, sightseeing income of international inbound tourism during t period, respectively, all of what unit convert to RMB; $lnMl_t, lnTr_t, lnTu_t$ is natural logarithms for Ml_t, Tr_t, Tu_t respectively; εt is the random perturbation term.

This paper would select time variable data. In order to avoid spurious regression, it is necessary to cointegrate the variables in equation (1) to ensure that there is a long-term stability relationship between the variables before OLS regression.

3.2. ARDL model and bounded cointegration test

Besides the Autoregressive-Distributed Lag Bounds Test which developed by Pesaran et al. [22]is a cointegration test for dealing with models that involve time series with mixed orders of integration, the Engle Granger two-step method for cointegration test and Johansen Cointegration Test are commonly used as well. Engle Granger two-step test is for cointegration between two time series, not usually used in multi-variables situation. Sahar et al. used Johansen cointegration for frequency response functions contaminated with nonstationary colored noise for structural damage detection[23]. However, when the sample is small with large unit intervals, the Johansen and Engle-Granger tests produce inaccuracy that would make cointegration results unreliable. Choosing ARDL bounds test has the following reasons. First, the data sample is small. Secondly, the ARDL model results on the problems inherent in variables are not affected, so it may increase the reliability of estimates. Thirdly, ARDL bounds test is available for variable first-order integration or zero-order integration.

There are two procedures to do the ARDL bounds test and the ARDL model estimate. The first step is to estimate the basic errors of ARDL model and do the significance test for lag length which makes determine the long-term covariance between variables possible. The second step is to Choosing an appropriate lag length for the ARDL model and estimate the ARDL model and judge the long-term relationship between inbound tourism income and CO_2 emissions.

The ARDL $(p, q, \dots, q)$ model are showed below:

$$y_t = c_0 + c_1 t + \sum_{i=1}^{p} \emptyset_i y_{t-1} + \sum_{i=0}^{q} \beta_i' x_{t-i} + u_t, \tag{2}$$

Where $p \geq 1, q \geq 0$. Based on the ARDL model framework which is showed as equation (2), the following model is constructed to investigate the main problem of inbound tourism income and CO_2 emissions.

$$RCO_{2t} = C_0 + \sum_{i=1}^{p_0} \beta_i RCO_{2t-i} + \sum_{j=0}^{p} \Phi_j' X_{t-j} + \varepsilon_t \tag{3}$$

Where C_0 is a constant. $X_t' =$ ($lnLT_t, lnMl_t, lnTu_t, lnTr_t$). p is the vector of lag length for explanatory variables which can be expressed as $p = (p_0, p_1, p_2, p_3, p_4)$. p_0, p_1, p_2, p_3, p_4 are the lag length for $lnLT_t, lnMl_t, lnTu_t, lnTr_t$ respectively. ε_t is the random error of the model.

4. Experimental design

4.1. Data

In view of the data availability, this paper selected annual data on foreign exchange income from international inbound tourism and China's CO_2 emissions from 1995 to 2018 as research samples and applied autoregressive distributed lag model on the research of how international inbound tourism income would impact on CO_2 emissions. The data CO_2 emissions would be calculated by the following method:

The quantity of CO_2 emission = energy (containing carbon) consumption ×Carbon conversion coefficient× CO_2 gasification coefficient

Carbon-containing energy generally means that coal, oil, natural gas and other energy that will release CO_2 in the process of consumption. Carbon conversion coefficient is 0.67 which is given by China's National Development and Reform Commission research institute. CO_2 gasification coefficient is a standard value which means in the process of carbon oxidization the mass ratio of prior carbon to carbon dioxide is a standard value 3.67.

The data mainly come from the digital research center of Peking University, China Urban Statistical Yearbook, China Energy Statistical Yearbook, China Environmental Statistical Yearbook, prefecture-level Municipal Statistical Bulletin, EPS database, carbon emission Accounts & Datasets, ect. Moreover, the data of variables related to foreign exchange are converted to the prices in RMB according to the exchange rate in each corresponding years so as to eliminate the influence of exchange rate fluctuation.

4.2. Stationary test

Before performing the boundary test, it should ensure the variables are stationary. Also, the variable should be zero order or first order difference stationary so that can make F test for cointegration are efficacy.

The ADF unit root test results of each variable are as follows:

Table 1 Augmented-Dickey-Fuller unit root test for sample data.

ordinary variables					
	(1)	(2)	(3)	(4)	(5)
	RCO_2	$lnLT$	$lnMl$	$lnTu$	$lnTr$
AIC	-1.7571	-0.82	-3.1387	-3.2697^{*}	-1.5158
First order of variables					
	ΔRCO_2	$\Delta lnLT$	$\Delta lnMl$	$\Delta lnTu$	$\Delta lnTr$
AIC	-2.7348^{*}	-3.976^{***}	-2.8792^{*}	-	-3.8534^{***}

Note: *,* *,* ** respectively denotes rejection of the null hypothesis that there is a unit root at a significant level of 10%, 5%, 1%.

Column (4) of Table 1 shows the ADF result of inbound tourism sightseeing income is original stationary, other variables are stationary at first order difference. All variables are zero order or first order difference stationary which are satisfy to do the ARDL bounds test.

4.3. ARDL bounds test

There are two steps for ARDL bounds test.

Firstly, Estimate UECM which is a generic function used to construct Unrestricted Error Correction Models (UECM). Establish for Equation (3).

$$\Delta RCO_{2_t} = C + \sum_{i=1}^{p-1} \beta_i \Delta RCO_{2_{t-i}} + \sum_{j=0}^{p-1} \Phi_j' \Delta X_{t-j} + \gamma_0 RCO_{2_{t-i}} + \gamma_1 X_{t-1} + \varepsilon_t \quad (4)$$

Where ΔRCO_{2_t} is the first order difference of RCO_{2_t}; ΔX_t is the first order difference of X_t; ε_t is normal random error term; $\gamma_1{}' = (\gamma_{11}, \gamma_{12}, \gamma_{13}, \gamma_{14})$, let $\gamma = \binom{\gamma_0}{\gamma_1}$.

The following hypothesis for coefficients vector γ is proposed. $H_0: \gamma = 0$; $H_1: \gamma \neq 0$. If the null hypothesis is rejected, it indicates that there is a long-term cointegration relationship between the variables, and short-term relationship analysis can be carried out next. The following shows the results of lag length for ARDL model in software R.

Table 2. Rank of lag length by AIC standard for ARDL model

p	p_0	p_1	p_2	p_3	p_4	AIC
1	1	1	1	2	0	-86.3286
2	1	1	2	2	0	-85.0372
3	1	2	1	2	0	-84.4801
4	1	1	1	2	1	-77.7399

From Table 2, it can be seen that the best choice for ARDL lag length by AIC standard is p=(1,1,1,2,0).

Secondly, do the ARDL bonds test for equation (4). Table 3 displays the results of ARDL bonds test on variables with the optimal lag order is selected above.

Table 3. Bond test for no cointegration of ARDL-ECM model

hypothesis	$H_0: \gamma=0;\ H_1: \gamma \neq 0$
F-value	9.537
P value	1e-06

From Table 3 it should reject null hypothesis of no cointegration existing under 1% Significant Level. Therefore, it can be judged that there is a long-term equilibrium relationship between international inbound Long-distance transportation income, catering income, sightseeing income, urban transportation income and the growth of carbon dioxide emission.

4.4. Model estimation

Table 4 ARDL estimate results (Long-run equilibrium Relationships)

	(1)	(2)	(3)	(4)
variables	coefficient	Standard error	t-value	P value
C_0	0.008644	0.010266	0.842	0.41772
$RCO_{2_{t-1}}$	0.156357	0.151246	1.034	0.32343
$lnLT_t$	0.035435	0.038486	0.921	0.37694
$lnLT_{t-1}$	-0.154730	0.044642	-3.466	0.00528 **
$lnMl_t$	0.033452	0.046356	0.722	0.48558
$lnMl_{t-1}$	0.128935	0.041010	3.144	0.00934 **
$lnTu_t$	-0.021200	0.032499	-0.652	0.52758
$lnTu_{t-1}$	0.051745	0.026881	1.925	0.08047.
$lnTu_{t-2}$	-0.075403	0.021772	-3.463	0.00530 **
$lnTr_t$	-0.033121	0.036136	-0.917	0.37903

Note: *,* *,* ** respectively denotes a significant level of 10%, 5%, 1%.

From column (1) of Table 4, it can be seen that international inbound tourism income from Long-distance transportation, catering, and the first order differenced sightseeing have positive impacts on CO_2 emission growth in long run. In other word, increase in international inbound tourism income from Long-distance transportation and catering to some extent would lead to an increase in CO2 emission. This conclusion is generally consistent with past research and analysis. In the long run, international inbound tourism revenue is negatively correlated with the first-order lag of long-distance transportation and the second-order lag of sightseeing. This may due to the fact that most of the carbon emissions by long-distance transportation and sightseeing directly collected the data in current statistic period without taking natural carbon sequestration effect into account. In the next statistic year, the sequestrated carbon may release CO_2 which will be recorded in the next statistic period. This mismatch would induce the statistical data of CO_2 smaller. Thus, a negative equilibrium relationship exist in increase of carbon dioxide emissions in the current period.

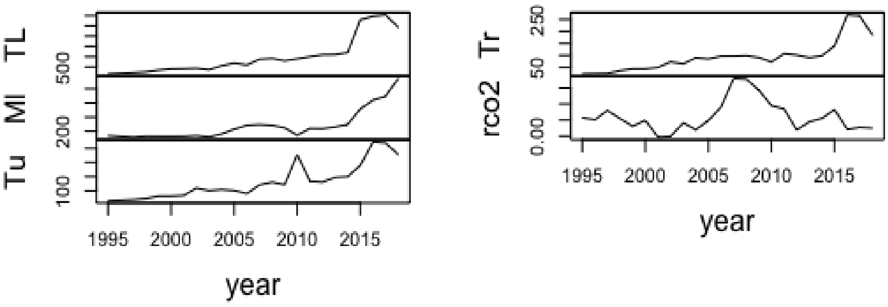

Fig. 1 Trend plot of CO_2 emission growth and international inbound tourism income in long-run

Since CO_2 emissions are caused by multi-factors, long-distance transportation, catering and urban transportation of international inbound tourism can bring a part of the impacts, but their influences are not enough to be determinate. However, with the improvement of international openness, the income of international inbound tourism has increased along with an upward trend of carbon dioxide emissions growth. From figure 1, the trend is disturbed in the period from 2008 worldwide economic crisis to Paris agreement has been signed. After when it can be seen there developed a new long-term equilibrium. Figure 2 further reflects long-term equilibrium trend of the carbon dioxide change rate and the fitted ARDL model.

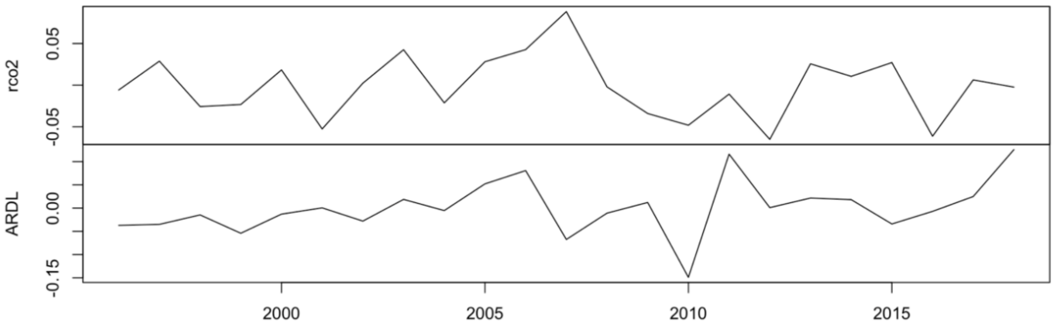

Fig.2 The carbon dioxide growth is fitted to the ARDL model

Table 5 ARDL-UECM estimate results (Long-term equilibrium correlation short-term dynamic relationship)

	(1)	(2)	(3)	(4)
variables	coefficient	Standard error	t-value	P value
C	0.008644	0.010266	0.842	0.417723
$RCO_{2_{t-1}}$	-0.843643	0.151246	-5.578	0.000166 ***
$lnLT_{t-1}$	-0.119295	0.063495	-1.879	0.087013 .
$lnMl_{t-1}$	0.162386	0.054223	2.995	0.012193 *
$lnTu_{t-1}$	-0.044859	0.062960	-0.712	0.490999
$lnTr_t$	-0.033121	0.038956	-1.027	0.399032
$\Delta lnLT_t$	0.035435	0.038486	0.921	0.376943
$\Delta lnMl_t$	0.033452	0.046356	0.722	0.485581
$\Delta lnTu_t$	-0.021200	0.032499	-0.652	0.527578
$\Delta lnLT_{t-1}$	0.075403	0.021772	3.463	0.005302 **

Note: *,* *,* ** respectively denotes a significant level of 10%, 5%, 1%.

Column (4) of table 5 shows that Short-term dynamic relationships related to long-term equilibrium trend of $RCO_{2_{t-1}}, lnLT_{t-1}, lnMl_{t-1}, \Delta lnLT_{t-1}$ are significant. Which states that CO_2 emission growth rate and international inbound long-distance income in current period have negative impacts on CO_2 emission growth rate in the next period. This may account for carbon emissions statistic records in short time interval and some natural consumption of carbon is also recorded, so the result of short time dynamic relationships would lead to the deviations. These two deviations can make the statistical data of International inbound tourism catering income and the first order lag in long-distance travel income become larger. Thus, it can be seen that International inbound tourism of catering income and first order lag in long-distance travel income have positive effects on the growth rate of CO_2 emissions.

Table 6 Short-term multiplier effect

term	average relative difference (coefficient)
"estimate"	1.039894
"t.statistic"	0.7100229
"p.value"	0.132387

Table 6 reflects the short-term dynamic results of the modified model. The modified model with a coefficient of 1,039894 which means the modified model has an average relative difference with 1.039894, namely, error Correction. Furthermore, table 6 shows that the P-value is 0.1323, which is significant at 15% confidence level but not significant at 10%. Stated differently, the dynamic disturbance effect can be regarded as having a positive correction effect of 3.9893% on the long-term trend deviation at the 15% confidence level. In particular, the long-term equilibrium is positively changed by the short-term dynamic relation disruption between international inbound revenue and CO_2emissions. As previously demonstrated, the longer run equilibrium model with a smaller statistic in the current period can compensate for part of the mistake caused by the greater statistical data of CO_2.

5. Conclusions and policy implications

5.1. Conclusions

With the data International Tourism Income and CO_2 emissions from 1995 to 2018, this study evaluates the International Tourism economy and carbon emission performance. Then, this paper employs OLS, ARDL bonds test model, ARDL-ECM and ARDL-UECM model to empirically investigate the effect of International Tourism economy on carbon emission performance and its long-term equilibrium and short-term dynamic mechanism. The main conclusions are as follows.

Firstly, in the long run, the increase of international inbound long-distance transportation income and catering income have positive relationships with carbon dioxide emission growth.

Secondly, there is a negative long-term equilibrium between the long-distance transportation income of international inbound tourism in the first order lag, catering income of international inbound tourism in the second order lag and CO_2 emissions growth. That might result by fact that carbon emissions from fossil energy are measured in current period, but the natural sequestration effect is not calculated, so statistically there is a negative impact on carbon emissions in the next period.

Thirdly, the short-term dynamic relationship. The increase of carbon dioxide in the current period and the increase of long-distance international inbound tourism income would decrease change rate of carbon dioxide emissions in the next period. The deviation of international inbound tourism catering income and long-distance travel income in first order lag have positive impacts on the growth rate of carbon dioxide emissions. Which indicate that in the short term, international inbound long-distance transportation income and catering income have short-term dynamic impacts on carbon dioxide emissions.

5.2. Policy advice

Carbon dioxide emission is an unavoidable topic in the world. China as one of WTO countries, has a large number of international inbound tourists every year. Under the scenario of increasing foreign exchange income, China still needs to give priority to the pace of low-carbon development. First of all, it is wise to continue to promote the use of new energy transportation, especially for long-distance transportation. What's more, it could increase the efficiency of long-distance transportation by reservation system of route planning without losing the economic income. Furthermore, the freedom of carbon trading market should be improved and the carbon sequestration data should be recorded in the trading market as well, so as to measure various carbon emission sources more accurately and effectively.

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