FDI and China's Carbon Dioxide Emissions: 1978–2008

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Abstract This research examines the impact of foreign investment dependence on carbon dioxide emissions between 1978-2008 in China. In a time series regression analysis, the anthor finds that foreign capital penetration has a significant negative effect on the growth of CO_2 emissions, which is due to the spill-over effect. It does not mean that FDI does no harm to us. Chinese are aware that foreign capitals of pollution-intensive industries have poured into China. We must be strict with the inflow of foreign capital. Exports aggravate the pressure on CO_2 emissions. It is the evidence of "Pollution Haven". Economic growth, however, has no systematic effect. The author finds negative effect of domestic investment and agriculture shares on total CO_2 emissions over the same period.
Key words FDI; Carbon dioxide emissions; Pollution haven; EKC

1 Introduction

It is a well-known fact that foreign direct investment (FDI) flows have increased dramatically over the last three decades. In the 90s, the growth of FDI flows trebled the growth in international trade. Since 2004, the global FDI has risen to $1833 billion in 2007 with the annual growth of 30%.It is also undoubted that governments across the world, in developing and developed countries alike, are trying to attract multinational enterprises (MNEs) to locate in their country, using generous financial and fiscal incentives. In this paper, we focus the analysis on contemporary China. Its sheer size is of significance to the whole world and its stellar growth has been attributed to enormous FDI inflow among others. Under the financial crisis, the global FDI flows dropped 14% in 2008. While foreign direct capital inflows to China is $9239.5 billion, with the growth of 23.58% in the same period.

It is no doubt that FDI had positive impacts on output growth. And certainly FDI had negative effects on host countries especially those who have poor environment regulations. As for China, Whether the FDI inflows had negative impacts on Chinese environment? Particularly, How does FDI influence China's carbon emissions? In this paper, I focus the analysis on FDI and carbon emissions of China.

2 Global Climate Change and Carbon Emissions

International Climate Conference in Copenhagen seized the global concern. Climate change and carbon emissions have become the most concerned issue.

Earth's surface temperature is the outcome of energy flows that are dynamic, sensitively re-adjusting to a fluid balance of forces. The incoming warmth from the sun and the internal heat from the molten core beneath the mantle are continuously being radiated out into space, and the difference between these rates of warming and cooling creates the surface temperatures we must cope with. The atmosphere ultimately governs this race between heating and cooling by acting as a "valve" regulating the rate of heat loss from infrared radiation into space, and the size of this valve is mainly due to CO_2. CO_2 captures heat, acting like a gaseous blanket over the planet. Although heat still works its way out through this chemical blanket, the blanket slows its progress enough to retard cooling and raise the global surface temperature. If it were not for naturally occurring levels of atmospheric CO_2 in the past, the surface temperature of our planet would be below freezing (–18c), liquid water would not exist, and life as we know it impossible.

It is a delicate balance. Evidence from the fossil record and Antarctic ice cores reveal that levels of atmospheric CO_2 have risen inversely with periods of glaciation for at least the past 100,000 years. These same ice cores show that levels of atmospheric CO_2 have risen 27% during the period 1800-1990.The increase in levels of CO_2 since 1800 is almost certainly due to human activity—massive deforestation during the 19th Century added to in the 20th by the burning of fossil fuels. Today all automobiles, planes, and ships burning fossil fuels emit CO_2, along with all coal or oil fired electric generators. Hence almost all of the machinery used in modern production contributes to CO_2 emissions.

The Intergovernmental Panel on Climate Change has reached consensus that global warming is already well along. Temperatures in the northern hemisphere have shot up dramatically since 1900, well

above their average for the previous five centuries. Glacial ice-packs are retreating at unprecedented rates, while plants and butterflies have been documented moving higher up mountains and further north.

Warming implies a general movement toward the poles of the climates appropriate for the major food crops (wheat, rice, and maize). For the majority of plants not under human cultivation, the polar shift in climate may outrun their ability to migrate, leading to their extinction along with the life forms dependent on them. Melting ice suggests rising sea levels, which satellite data now confirm. The remaining glacial ice, if fully melted, would add another 250 feet. While we are yet far from that point, a rise of only one or two feet would permanently flood the currently arable land around the Nile, and has been estimated to be able to cut agricultural production globally by as much as 20 percent. Further, rising sea levels pose the potential for flooding important ports and coastal cities, as well as entire pacific island nations. Finally, climate models predict more frequent storms having higher wind-speeds with increased warming, implying corresponding increases in deaths and infrastructural damage. Because the global population is growing, and most of that population lives near rivers and seacoasts, the mortality figures could become truly staggering, as well as the costs of repair.

3 Literature Review

Views varied on the relationship between FDI and environment. The core of the controversy is "Pollution haven". In Baumol's opinion, the developing countries would become the concentration of world's pollution if they implement low environment standards. If we consider environment as a factor of production, those countries who have poor environment standards are rich in environment factor, those who have strong environment standards are poor. Developed countries usually have stronger environment restriction than developing countries, then high polluting industries shift to developing countries, and they become "Pollution haven".

Peter Grimes and Jeffrey Kentor(2003) examine the impact of foreign investment dependence on carbon dioxide emissions between 1980 and 1996. In a cross-national panel regression analysis of 66 less developed countries, they find that foreign capital penetration in 1980 has a significant positive effect on the growth of CO_2 emissions between 1980 and 1996. Domestic investment, however, has no systematic effect. They suggest several reasons for these findings. Foreign investment is more concentrated in those industries that require more energy. Second, transnational corporations may relocate highly polluting industries to countries with fewer environmental controls. Third, the movement of inputs and outputs resulting from the global dispersion of production over the past 30 years is likely to be more energy-expensive in countries with poorer infrastructure. Finally, power generation in the countries receiving foreign investment is considerably less efficient than within the countries of the core.

Some researches find that FDI are good for environment, such as Letehumanan, R.and Kodamat F (2000), Eskeland and Harrison(2002). They examined that FDI promote the technology progress as well as improve environment welfare by introducing environment-friendly technology and products. And they find that foreign companies of pollution-intensive industries concerned more about environment than domestic companies.

Chinese scholars also had many studies on relationship between FDI and environment. Sha and Shi (2006) examined the impact of foreign investment dependence on ecological environment between 1980 and 1996 and find negative impact. Wu (2007) found that FDI is worsening our environment by using the panel data from 30 provinces. Liang(2005) analyzed the panel data from 260 cities between 1996~2003 and revealed that FDI alleviated carbon emissions. Liu, Pan and Chen(2006) found that export had significant positive impact on environment, while FDI had significant negative impact on the environment, using the panel data from 28 provinces between 1990~2003. Deng and Song(2008) found that FDI improved environment quality while trade deteriorate it. Using time series model and panel data, they concluded that a U-shaped relationship between GDP and pollution is found which is different with EKC hypothesis.

4 Methodology

4.1 A baseline model and data descriptions

In discussing how FDI influence carbon emissions of China, this article does not make a simple regression between FDI and CO_2 emissions data. CO_2 emissions related to other variables as well as FDI. If we do not consider these variables, mostly will omit the important variables and come to model set error and suspect conclusions. So this article includes FDI, GDP/GDP per capital, export, domestic

investment, and agriculture as independent variables. Learn from Peter Grimes and Jeffrey Kentor (2003)'s model, this model takes the following logarithmic form:

$$LnCO_{2t}=\beta_0+\beta_1 Ft+\beta_2 AGRIt+\beta_3 EXt+\beta_4 GDIt+\beta_5 LnGDPt \quad (1)$$

$$LnCO_{2t}=\gamma_0+\gamma_1 Ft+\gamma_2 AGRIt+\gamma_3 EXt+\gamma_4 GDIt+\gamma_5 LnAGDPt \quad (2)$$

Where F=FDI/GDP, FDI are exchanged into RMB according to the current exchanged rate. Coefficients β_1 and γ_1 indicate the effect of FDI on CO_2 emissions;

AGRI= Agriculture/GDP, controls for the structure of China economy. Agricultural production typically generates less CO_2 than the industrial sector of the economy. So Coefficientsβ_2 and γ_2 are expected to be negative;

EX=Trade / GDP, it is included as a control for the level of integration in the world-economy. Coefficients β_3 andγ_3 indicate the effect on CO_2 emissions; we expect β_3 and γ_3 to be positive;

GDI=Gross Domestic Investment / Fixed assets investment, Coefficients β_4 andγ_4 indicate the effect of Domestic Investment on CO_2 emissions.;

GDP and GDP per capita (natural log) are measures of a country's wealth and, therefore, indicators of level of development. Coefficients β_5 and γ_5 indicate the effect of economic growth on CO_2 emissions.

All the above variables are measured at 1978 prices. The dada are taken from The China Statistical Yearbooks, Fifty years compilation of statistical information of new China. Time spans 1978 – 2008.

The dependent variable is the level of CO_2 emissions in *t* year, which has been logged (Ln) to correct the extreme skewness of this measure. We use absolute levels rather than CO_2 / GDP, because we are interested in assessing the impact of foreign capital penetration on the environment.

4.2 Measurement of CO_2 emissions

CO_2 emissions can be divided into natural and artificial discharge. Artificial emission is caused by human activity, including fossil fuel consumption, biomass burning, etc. CO_2 emissions from fossil fuel burning account for over 95% of the total CO_2 emissions. This article estimates China's total carbon emissions with the following decomposition formula:

$$c = \sum_1 Si \times Fi \times E$$

Where E is the total consumption of primary energy in China. Fi stands for the carbon intensity of the ith energy. Si presents the share of the ith energy in the total energy. Fi is shown in Table 1. This article takes the average as CO_2 emission coefficients for China. Data of primary energy consumption and proportion of each form of energy in the total energy come from The China Statistical Yearbooks, Fifty years compilation of statistical information of new China, and The China Energy Statistical Yearbook.

Table 1 CO_2 Emission Coefficients for China

Source	Coal	Oil	Natural gas
U.S. Department of Energy	0.702	0.478	0.389
Japanese Energy Economics Institute	0.756	0.586	0.449
State Science and Technology	0.726	0.583	0.409
NDRC Energy Institute	0.7476	0.5825	0.4435
Average	0.7329	0.5574	0.4226

4.3 Results

This article employs the OLS method to run the time series data regressions of model 1 and 2. Table 3 reports the estimations results. We know that most non-stationary time series using OLS regression analysis of time series may produce "spurious regression" problem.

In order to test for stationarity in the time series of the dependent and independent variables, the most common stationarity test, namely the augmented Dickey-Fuller test (ADF test), was applied. The aim of this procedure is to test for characteristics of the time series with $LnCO_{2t}$ as the dependent variable and Ft,AGRIt,Ext,GDIt,LnGDPt and LnAGDPt as the explanatory variables. Without presenting the details of the econometric estimations, it can be concluded that the hypothesis (H_0) of non-stationarity for the time series of the dependent variable $LnCO_{2t}$ in levels cannot be rejected at any reasonable level of significance. However, if we apply the ADF test in order to explore the stationarity of the first difference of the time series, we have to reject H_0 at the 1% level of significance.

First, we apply the ADF test to $LnCO_{2t}$ for the period from 1978 to 2008. The estimation implies that the time series is non-stationary in levels but stationary in its second difference. Furthermore, we

test the variables Ft, AGRIt, Ext, GDIt, LnGDPt and LnAGDPt for stationarity. Without going too much into detail here, the explanatory variables of Ft, Ext, LnGDPt and LnAGDPt are proved to be non-stationary in levels but stationary in their second differences (I(2)). The variable AGRIt is stationary in levels. The variable GDIt is stationary in its first difference.

Since the time series of our models is non-stationary. OLS regression analysis of these time series may produce "spurious regression" problem. We need to test the residuals resulting from estimating equation for stationarity. If the residuals are stationary, which denotes that cointegration relationship exists between variables, time series are cointegrated, and OLS estimation is appropriate. Otherwise, we need to make smooth processing of the non-stationary time series.

The residuals resulting from estimation of Eq.(1) are tested for stationarity with the ADF test, as shown in Table 2. We reject the hypothesis of a unit root in residuals at the 1% level of significance. The ADF test statistic is -5.364965 which is smaller than the critical value of -2.669359 at the 1% level of significance. Therefore OLS is the right estimation method and the estimating results of model 1 are meaningful.

Table 2 ADF Unit Root Test on Residuals

		t-statistic
ADF test statistic		-5.364965
Test critical values	1% level	-2.669359
	5% level	-1.956406
	10% level	-1.608495

Table 3 reports the estimations results. The estimated coefficient for F indicates that one percent increase in FDI/GDP contributes to 4.26 percent decrease in carbon emissions. The estimated AGRI coefficient is consistent with a priori expectation: significant and negative, an increase in agriculture share contributes to decrease in carbon emissions. The estimated EX coefficient is significantly positive, indicating that one percent increase in export dependence contributes to 2.61 percent increase in carbon emissions, which is consistent with most of the previous findings. The estimated coefficient for GDI is significant and negative. In other words, domestic investment contributes to decrease in carbon emissions. The estimated Log(AGDP) coefficient is insignificant, indicating that GDP per capital does not necessarily influence carbon emissions.

The residuals resulting from estimation of Model 2 are tested for stationarity with the ADF test.. We reject the hypothesis of a unit root in residuals at the 1% level of significance. Therefore OLS is the right estimation method and the estimating results of model 2 are meaningful.

As shown in table 3, coefficients of variables in model 2 are almost the same with model 1. We find that economic growth, whether in the form of GDP or GDP per capital, does not necessarily influence carbon emissions. In model 2, FDI has significantly negative effect on carbon emissions. Also, growth in agriculture and domestic investment contributes to decrease in carbon emissions. The estimated export coefficient is positive and significant, increase in export aggravating carbon emissions.

Table 3 The Estimated Coefficients of OLS Regressions

		C	F	AGRI	EX	GDI	log(AGDP)	log(GDP)
Model 1	Coefficients	13.27	-4.26	-2.47	2.61	-2.59		0.06
	T statistic	6.92	-3.25	-2.93	10.19	-3.02		0.49
	P value	0.00	0.004	0.0085	0.00	0.007		0.625
Model 2	Coefficients	13.41	-4.26	-2.47	2.61	-2.59	0.06	
	T statistic	8.09	-3.25	-2.93	10.19	-3.02	0.49	
	P value	0.00	0.004	0.0085	0.00	0.007	0.625	
	R^2=0.99, A-R^2=0.98, D-W=2.16							

5 Conclusions

The main conclusion of our analysis is FDI inflows alleviate the pressure of carbon dioxide emissions in China, which is due to FDI technology spillover. FDI brings not only money but also technology. Overall, foreign production technology and processes from developed countries are better than the current domestic level, the use of foreign technology some extent improved our environmental problems. FDI inflows to some extent improve the quality of the environment in our country, but this does not mean that China's FDI inflows is of no harm, it should be noted that a large number of the FDI inflows to the pollution-intensive industries. Therefore, China should develop more rigorous environmental access system, and the selective use of foreign investment.

Exports aggravate the pressure on CO_2 emissions. We know China export commodities at a relatively low cost, and China exerts export tax rebates, financial policies to encourage exports, Therefore, trade interests are shared both at home and abroad, the but pollution remains home alone. China's exports are mostly intensive and resource consuming products. We need to make use of economic instruments to internalize environmental costs, reduce or eliminate export tax rebates to the pollution-intensive and resource consuming products. As for the inevitable environmental pollution, we should collect environmental taxes, develop emissions trading, adopt the permit system and other fiscal and financial system to raise environmental standards, in order to guide the implementation of clean production, promote industrial upgrading, change industrial structure, and to avoid "pollution havens" in China.

Share of agriculture in the economy contributes to the CO_2 emission reduction. The results again demonstrate the importance of agricultural production. Agricultural development can not only solve the food problem, but also alleviate the pressure on resources and environment. China is vast in territory, every region does not have to follow the road of industrialization. In accordance with the strategy of sustainable development, some major agricultural regions may focus more resources on the development of agriculture.

Effect of Either GDP per capita or total GDP on CO_2 emissions is insignificant. Economic growth, however, does not automatically solve the environmental problems.

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