A Test of the Relationship between Air Pollution and Exports: The Case of China

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ABSTRACT: This study estimates the effects of exports on air pollution in China. To avoid endogeneity issues, we use an instrumental variable strategy, which relies on the exogenous shock to export brought about by the Great Recession and the fact that most exports from China are produced in coastal provinces. In our empirical work, we employ data collected by the National Bureau of Statistics of the People's Republic of China. Sulfur dioxide, nitrogen dioxide and smoke & dust at the province level over 13 years from 2003 to 2015 are used to measure air pollution, and are related to measures of provincial exports such as export intensity (exports as a fraction of GDP). The econometric model utilizes a two-stage IV regression. In the first stage, export intensity is instrumented using the exogenous variation from the Great Recession and coastal location. Then the predicted export intensity from the first stage is used as the regressor in the second stage regression explaining air pollution. For all three air pollutants, the results show that pollution decreases more for coastal provinces following the Great Recession than it does for inland provinces. Hence, air pollution improves as export intensity declines.

JEL Codes: F18, O13, O53, Q53
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1. INTRODUCTION

Over the past few decades, the world has witnessed the "Chinese miracle" – the tremendous speed of economic growth in China. Since the start of the economic reforms in December 1978, China has experienced an average annual GDP growth rate of 8.62 percent per capita from 1979 to 2015, compared to an average annual GDP growth rate of 3.23 percent per capita from 1961 to 1978. Following the accession to the World Trade Origination in December 2001, China has reached an even higher average annual GDP growth rate of 9.17 percent per capita from 2002 to 2015, while the average annual GDP growth rate for the world was only 1.61 percent per capita during this period.[1]

During this incredible economic growth, exports have played a significant role (Heshmati & Sun, 2012; Qiao, 1998; Chen & Feng, 2000). Between 2003 and 2015, about 16.8 percent of China's GDP growth is due to growth in exports. Many countries around the globe now import goods that are "Made in China". However, every coin has two sides. The incredibly rapid economic growth has been accompanied by notoriously serious pollution problem. More recently, as people in China have grown wealthier and public awareness of the importance of health has increased, environmental pollution issues have come into focus. For example, due to the increasingly severe air pollution in China since 2013, people and the news media have been paying particular attention to air quality.

Research on issues related to the Chinese economy has always been important. However, very few studies have been done regarding the effects of exports on air pollution in China. There have been many studies in the literate that particularly look into the relationship between trade

[1] Data source: World Development Indicators, February 1, 2017 version.

and pollution (e.g. Frankel & Rose, 2005; Managi et al., 2009). In those studies, theory and methods have been developed to assess the impact of trade on the environment, but so far no study has exploited the natural experiment arising from declining global demand for Chinese exports during the Great Recession in 2007-2008 to identify the effect of exports on air pollution in Chinese provinces.

There has been a heated debate whether exports have improved or worsened the air quality in China. For one thing, a significant percentage of the products exported from China are produced in heavy polluting industries. According to Levinson (2008), the pollution haven hypothesis points out that polluting industries will relocate to jurisdictions with less stringent environmental regulations, and China has been encouraging these types of industries. On the other hand, there are some strict environmental regulations associated with production for export, which may improve the environmental situation. According to the environmental Kuznets curve hypothesis, a nation's environmental quality will first decrease and then improve with the level of economic development. Taking both views into account, this study aims at finding out what are the real effects of exports on air pollution in China.

The two main challenges in this line of research on China are (1) the availability of reliable pollution data, and (2) plausibly exogenous variation in trade (exports or imports) to credibly identify its effects on pollution. To overcome these difficulties, our study uses a reliable data source on pollution statistics in China from the National Bureau of Statistics of the People's Republic of China. From the data set, the quantity of sulfur dioxide, nitrogen dioxide and smoke & dust of each province in China over years are collected. We use all 3 measures of air pollution. Meanwhile, levels of GDP and exports of each province in China over the same time period are used to construct a measure of export intensity, which is our dependent variable of interest.

Further, the main contribution of our study is the use of quasi-experiment, the Great Recession of 2007-2008, to identify the impact of exports on local pollution in China. We interact the plausibly exogenous decline in demand for Chinese exports after the Great Recession with the geographic location (coastal vs. inland) of the province where the exports were produced to show that after the Great Recession, coastal provinces, where export production is concentrated because of proximity to navigable water, experienced a larger decline in exports and pollution.

A key difference of this study from existing work is the careful focus on the estimating strategy – we do not simply correlate export intensity and pollution across Chinese provinces over time but estimate the difference in the impact of export intensity brought about by the Great Recession before and after 2008 between coastal and inland provinces. In our empirical analysis, the first stage regression shows that the Great Recession brought about a decline in export intensity (exports as a share of provincial GDP), especially for coastal provinces. In the second stage, we estimate the reduced-form regression, using the Great Recession and coastal location to infer that provinces along the coast, where disproportionately higher production of exports occurs, experienced a greater decline in air pollution following the great recession. The regression results reveal this for all the three pollutants, sulfur dioxide, nitrogen dioxide and smoke & dust.

The paper proceeds as follows: the second section will review the literature, the third section describes the data and the econometric model, including descriptive statistics, the fourth section presents the results, and conclusions as well as future extensions of our research are in the last section.

2. LITERATURE REVIEW

Frankel and Rose (2005) estimate the effects of trade on the environment by sorting out the causality. They specifically consider the endogeneity of trade and use exogenous geographic determinants of trade as instrumental variables and also control for income and other relevant factors. They utilize data from the three 1990 measures of air pollution we discussed, all measured as concentrations in micrograms per cubic meter, and they find that trade tends to reduce three measures of air pollution: statistical significance is high for concentrations of sulfur dioxide, moderate for nitrogen dioxide, and lacking for particulate matter. They conclude that there is little evidence supporting the detrimental effects of trade on the environment, and trade appears to have a beneficial effect on some measures of environmental quality. Their work focuses on the same issue as this study, but they perform a cross country analysis, whereas this study particularly looks at China alone and our instrumental variable strategy, unlike theirs, is time-variant. Additionally, their conclusions contradict the regression results from our analysis. This may be because we focus on one country or because our instrumental variable strategy is time-variant. Also, we focus on exports, while they assess the impact of trade, exports and imports combined.

Managi et al. (2009) also ask if trade openness improves environmental quality. They treat trade and income as endogenous and estimate the overall impact of trade openness on environmental quality. They make use of instrumental variables with data from 80 countries from 1970 to 2000. They find that whether trade had a beneficial effect on the environment depends on the pollutant and the country. To be more specific, they conclude that trade would benefit the environment in OECD countries, while it had detrimental effects on sulfur dioxide and carbon dioxide emissions in non-OECD countries, which is consistent with the results from our study. In addition, they find that the impact was larger in the long term after the dynamic adjustment process, while it was smaller in the short term. Their research considers the same question as our paper, but they have done a cross-country analysis whereas we specifically focus on China.

Another related paper is Dean et al. (2009). Their analysis tests if foreign investors are attracted to weak environmental regulations in the case of China. They test for the pollution haven hypothesis by estimating the determinants of location choice for equity joint ventures in China. Beginning with a theoretical framework of firm production and abatement decisions, they derive and estimate a location choice model using data on a sample of equity joint ventures projects, Chinese effective levies on water pollution and Chinese industrial pollution intensity. They find that equity joint ventures in highly-polluting industries funded through Hong Kong, Macao and Taiwan were related to weak environmental standards, whereas equity joint ventures funded from non-ethnically Chinese sources were not significantly related to weak standards, regardless of the pollution intensity of the industry. Their findings are consistent with pollution haven behavior, but not by investors from high income countries, and only in industries that were highly polluting.

One potential issue with their analysis is the way they measure the stringency of pollution regulation across provinces, which is by the amount of fines paid for pollution. The authors take the fine rate for pollution in a given province as given, i.e. exogenous. However, in reality the situation could be complicated. For one thing, the fine will increase as the quantity of pollution increases. The authors did not show specifically how the fine was calculated in their paper, so it is not clear whether the authors took the possible changes of fine rate into consideration. For another thing, it is very likely that the fine and quantity of pollution are jointly determinate. For a firm in one province, if the fine rate increases, the firm could work to reduce pollution; meanwhile, if the quantity of pollution is too high, the government could increase the fine rate to induce a lower pollution level. Besides, the fine rate for pollution is very much negotiable in China. For instance, in many provinces, the government is very willing to reduce fine and tax for pollution to attract new firms, even the highly polluting ones, in order to promote economic growth as well as to lower unemployment rate. Taking this problem into account, the instrumental variables employed in Dean et al. (2009) may have undesirable properties.

3. DATA AND ECONOMETRIC MODEL

3.1 Data

For this study, the data is collected from the National Bureau of Statistics of the People's Republic of China. The dataset is a panel across the 31 provinces of mainland China from 2003 to 2015, 13 years in all. Trade openness is represented by the real value of export and import using 2000 constant prices. [2] To measure air pollution in China, we use concentrations of sulfur

[2] According to the instruction from the dataset, the data for international trade are collected by the General Administration of Customs of the People's Republic of China based on the rules from the United Nations. There is one thing particularly to clarify about the export. In the original dataset, there are two separate measures of export, one is by the location of exporters and the other one is by the place of origin in China. Unfortunately, there is no clear definition or instruction of each measure. Thus, both measures of data are tried in the model, and there is no significant difference in the results, so the measure by the location of exporters is used in this study.

dioxide, nitrogen dioxide, and smoke & dust. [3] For sulfur dioxide[4], soot[5] and nitrogen dioxide[6], the emissions data are available for both industry and household consumption, and the total emissions could be obtained by adding up the two. For dust, the data are available only as

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[3] According to the instruction from the dataset, the data for pollutions are collected by the Ministry of Environmental Protection, including pollutants discharged by industrial companies and household from urban areas. Data from major industrial companies are collected by comprehensive surveys, while data for other companies are estimated, so the total number of industrial pollutions is obtained by adding up the two. Data for pollutions from household consumption are estimated based on relevant statistics and technical parameters.

[4] According to the instruction from the dataset, SO_2 Emitted from Industrial Activities refers to the amount of sulfur dioxide emitted from fuel consumption or production by industrial companies for a given period. It is calculated by:
SO_2 emitted from industrial activities = SO_2 emitted from fuel consumption + SO_2 emitted from production

According to the instruction from the dataset, SO_2 Emitted from Non-Industrial Activities is calculated based on the amount of coal used by households as well as other non-industrial activities and the amount of sulfur contained in the coal. The formula is given by:
SO_2 emitted from non-industrial activities = the amount of coal used by households and other non-industrial activities * sulfur content * 0.8 * 2

[5] According to the instruction from the dataset, Industrial Soot Emission refers to the amount of soot contained in the smoke that is emitted during the fuel consumption from industrial companies. Non-Industrial Soot Emission refers to the net volume of soot emitted during the fuel consumption from all of the social and economic activities as well as public facility operations other than industrial activities. It is calculated based on the amount of coal used by households and other non-industrial activities.

[6] The data for Nitrogen Dioxide are incomplete in the National Bureau of Statistics of the People's Republic of China, so the data are collected from a user on bbs.pinggu.org (a Chinese website for sharing economic data regarding China), the name of whose is not specified in the website. From the National Bureau of Statistics of the People's Republic of China, the data for Nitrogen Dioxide are available only from 2011 to 2015. For the years available, the data published by the user are exactly the same as the ones from the National Bureau of Statistics of the People's Republic of China; for the years that are not available, the data published by the user are consistent with the rest and have already been verified by some other users. Thus, the data for Nitrogen Dioxide used in this study could be treated as reliable.

industry emissions. [7] Smoke & dust is obtained by adding up soot and dust. [8] In addition, one variable is included to measure location, which is whether the province is coastal. If a province is coastal, the variable Coast would be equal to 1, otherwise, it equals 0. Furthermore, the variable GreRec is equal to 1 after the Great Recession (2009 and later) and 0 before.[9] We also construct a measure of total consumption in China by adding up GDP and imports net of exports.

3.2 Descriptive Statistics

As is shown in Table 2, for both sulfur dioxide and smoke & dust, the mean is higher for each category before the Great Recession than it is after the Great Recession. By contrast, for nitrogen dioxide, the mean is higher after the Great Recession than before for both total emissions and the industry emissions, and the means for all years lie in between. For trade openness and growth, the mean for export, import and GDP is higher after the Great Recession. For the ratio of exports over GDP, the mean is higher before the Great Recession than it is after.

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[7] According to the instruction from the dataset, Industrial Dust Emission refers to the volume of dust emitted from the production of industrial companies that is suspended in the air for a given period, including dust from refractory material of steel factories, dust from coke-screening systems and sintering machines of coke plants, dust from lime kilns and dust from cement production by construction material plants, but soot and dust emitted from power plants are not included.

[8] Since this study is looking into the effects of export on the air pollution in China, and the majority of the related air pollution comes from production, so the ideal situation is to measure air pollution by the industry emission. However, the availability of data from industry emission is less than the overall case. Then, the correlation between the industry emission and the overall case is checked and the results are shown in Table-3. Since the industry emission and the overall case are very highly correlated, the regression should be as good to use the overall emission as a measure of air pollution to make better use of the data available.

[9] As for the year 2008, it does not matter in which group to put it. Both ways have been attempted, and there is no significant difference in the regression results.

In addition, as is reflected in Figure-1, Chinese GDP was growing steadily over the sample period except that the growth rate was lower from 2008 to 2009. Also, exports and imports were growing steadily except from 2008 to 2009, during which time both decreased. The trends in the ratios of export over GDP, export over total consumption and import over total consumption are presented in Figure-2. The three ratios were all increasing before 2007 and started to drop in 2008, then reached their minimum in 2009. After 2009, they were increasing slowly again but started to decrease slightly after 2012.

3.3 Econometric Model

How is air pollution influenced by exports from China? To answer this question, one can use the panel data described in the previous section and the following econometric equation:

$$\text{Air Pollution}_{it} = \alpha_0 + \alpha_1 * \text{Export/GDP}_{it} + \text{Year}_t + \text{Province}_i + \varepsilon_{it} \quad (1)$$

The dependent variable, $\text{Air Pollution}_{it}$, denotes air pollution in province *i* in year *t*, and it is measured by emissions of sulfur dioxide, or nitrogen dioxide, or smoke & dust. Export intensity is measured by the ratio of exports over GDP in a given province and year. It is important to normalize exports by GDP because pollution is expected to rise with GDP even the ration does not change. If China has comparative advantage in heavy polluting industries, i.e. the industrial composition of exports is skewed towards sectors that are heavy polluters, then an increase in provincial exports as a share of GDP will bring about greater amount of pollution. To control for time-invariant province-specific characteristics, we include province fixed effects, and year dummies control for aggregate economy-side shocks that affect all industries. The main coefficient of interest is α_1, which estimated the effect of increased export intensity on provincial-level pollution. One potential problem with regression equation (1) above is endogeneity in the form of omitted variable, hidden in the error term, that may affect both export intensity and pollution simultaneously. To alleviate endogeneity concerns, we implement an instrumental variable strategy which relies on the interplay between the temporal export demand shock brought about by the Great Recession of 2007-2008 which sharply reduced global demand for Chinese exports, and the geographic variation of provincial location that afford provinces along the Chinese coastline an exporter advantage. To this end, we estimate the following reduced-form econometric model:

$$\text{Air Pollution}_{it} = \alpha_0 + \alpha_1 * \text{Great Recession}_t * \text{Coastal\_Province}_i + \text{Year}_t + \text{Province}_i + \varepsilon_{it} \quad (2)$$

The Great Recession of 2007-2008 started in the United States and Europe and it affected China subsequently, as well. It led to a severe job loss and thus a drop in consumption in the United States as well as Europe. Meanwhile, exports from China are mainly targeting these western countries. Therefore, as a result of the decrease in consumption in western countries, exports from China declined following the recession. Furthermore, most of the exporting oriented business in China are clustered in the coastal provinces because of easy access to ports on navigable water. Hence, the greatest negative impact of the decline in export demined was experienced in coastal provinces.

The first-stage regression that corresponds to our IV strategy is given by the following econometric equation:

$$\text{Export/GDP}_{it} = \alpha_0 + \alpha_1 * \text{Great Recession}_t * \text{Coastal\_Province}_i + \text{Year}_t + \text{Province}_i + \varepsilon_{it} \quad (3)$$

This model, provides evidence of the impact of the Great Recession on export intensity in coastal provinces (compared to inland ones).

4. RESULTS

Provinces with different trade linkages are affected differently by the Great Recession. As is shown in Table 4, for each regressor, every coefficient is negative. To be more specific, after the Great Recession, export decreased by 22.28 percent more for coastal provinces than inland ones, imports decreased by 11.66 percent more for coastal provinces than inland ones, and GDP decreased by 7.87 percent more in coastal provinces than inland ones. Also, after the Great Recession, the ratio of export over GDP, i.e., the export intensity, decreased by about 10 percent more for coastal provinces than inland ones, the ratio of export over total consumption decreased by 11.66 percent more for coastal provinces than inland ones, and the ratio of import over total consumption decreased by 8.06 percent more for coastal provinces than inland ones. [10] As for statistical significance, generally speaking, the significance level is higher when the dependent variable is a ratio. When regressed on the instrumental variable, the ratio of export over GDP, which is the export intensity, and the ratio of export over total consumption are significant at the 1 percent level; the ratio of import over total consumption and the log of GDP are significant at the 5 percent level; the log of export is significant at the 10 percent level and the log of import is not statistically significant.

Next, we present results from the reduced form model (2) and the 2-satge model, where we first predict exports using equation (3) and then used the predicted values for export intensity

[10] In the regression, there is a continuous variable on the left-hand side, while a dummy variable is on the right-hand side, so the coefficient needs to be interpret as exp(x)-1.

in place of the actual export intensity in equation (1). The detailed results are shown in Table 5, Table 7 and Table 9.

First, here come the regression results for sulfur dioxide, as is presented in Table 5. The estimates indicate that increased export intensity brought about greater sulfur dioxide emissions. In particular, the results suggest that when export intensity grows by 10 percent, emissions of sulfur dioxide increase by about 20 percent. The endogenous regression in column (1), on the other hand, suggests that the impact is less than half as small, and not statistically significant.

The regression results for nitrogen dioxide are very similar. According to Table 7, when export intensity grows by 10 percent, provincial emissions of nitrogen dioxide increase by about 25 percent. The IV results here is also larger than the OLS estimate (impact of about 15 percent) in column (1), but both are statistically significant. Finally, the regression results for smoke & dust, reported in Table 9, are smaller and statistically insignificant. In particular, a 10 percent increase in export intensity leads to only about a 5 percent increase in emissions of smoke & dust. Note that in this case, the OLS estimate is actually negative, but also imprecisely estimated.

In sum, the empirical evidence suggests that increased export intensity in China leads to greater pollution, at least when it comes to sulfur dioxide and nitrogen dioxide.

5. CONCLUSION

This study estimates the effects of exports on air pollution in China. The incredible economic growth in China was accompanied by severe pollution. Since exports have been playing an essential role for growth in China, it is natural to ask if air pollution China is affected by exports. To answer this question, we use provincial-level panel data on emissions of sulfur dioxide, nitrogen dioxide, and smoke & dust to empirically assess if they increase with export intensity. The instrumental variable strategy we employ, uses the temporal variation in export demand for Chinese manufacturing goods brought about by the Great Recession and geographic variation in provincial location (on the coast vs. inland) that affords coastal areas an exporter advantage to provide an estimate of the effect of exports on pollution. We find that a decrease in export intensity decreases emissions of both sulfur dioxide and nitrogen dioxide, implying that greater export intensity leads to higher pollution levels in China.

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TABLE-1 DEFINITION OF VARIABLES

Variable	Definition
SO	Total sulfur dioxide, measured by million ton, log form is used in the regression, and the log form is measured by ton.
SO_Indus	Sulfur dioxide emitted by industry, measured by million ton, log form is used in the regression, and the log form is measured by ton.
SD	Smoke & Dust, measured by million ton, log form is used in the regression, and the log form is measured by ton.
NO	Total Nitrogen Dioxide, measured by million ton, log form is used in the regression, and the log form is measured by ton.
NO_Indus	Nitrogen Dioxide emitted by industry, measured by million ton, log form is used in the regression, and the log form is measured by ton.
Exp	Export, measured in constant 2000 trillion Yuan, log form is used in the regression.
Imp	Import, measured in constant 2000 trillion Yuan, log form is used in the regression.
GDP	GDP, measured in constant 2000 trillion Yuan, log form is used in the regression.
ExpInt	Export Intensity, equals export over GDP.
Coas	Coastal, equals 1 if a province is coastal and equals 0 if a province is inland.
GreRec	Great Recession, equals 1 if it is 2009 and after, and equals 0 if it is 2008 and before.
GreRec_Coa	Equals GreRec times Coas.
ExpInt_Coa	Equals ExpInt times Coas.
TotCons	Total Consumption, equals GDP plus Imp minus Exp.
Ex_Co_Ra	Export Consumption Ratio, equals Exp over TotCons.
Im_Co_Ra	Import Consumption Ratio, equals Imp over TotCons.

TABLE-2 DESCRIPTIVE STATISTICS

	Overall (2003-2015)		After Great Recession (2009-2015)		Before Great Recession (2003-2008)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Total Sulfur Dioxide (Million Ton)	0.718	0.453	0.673	0.415	0.771	0.488
Sulfur Dioxide by Industry (Million Ton)	0.643	0.412	0.602	0.370	0.657	0.425
Smoke and Dust (Million Ton)	0.518	0.384	0.448	0.327	0.600	0.429
Total Nitrogen Dioxide (Million Ton)	0.620	0.424	0.666	0.435	0.515	0.382
Nitrogen Dioxide by Industry (Million Ton)	0.456	0.330	0.493	0.336	0.392	0.311
Export (Real 2000 Trillion Yuan)	0.254	0.493	0.299	0.549	0.202	0.413
Import (Real 2000 Trillion Yuan)	0.216	0.402	0.255	0.447	0.170	0.339
GDP (Real 2000 Trillion Yuan)	1.036	0.955	1.361	1.086	0.656	0.582
Export/GDP	0.168	0.193	0.149	0.161	0.189	0.222
Coastal	0.355	0.479	0.355	0.480	0.355	0.480

TABLE-3 CORRELATION BETWEEN DIFFERENT POLLUTION

	Sulfur Dioxide	Sulfur Dioxide by Industry	Nitrogen Dioxide	Nitrogen Dioxide by Industry	Smoke and Dust
Sulfur Dioxide	1				
Sulfur Dioxide by Industry	0.9833	1			
Nitrogen Dioxide	0.7788	0.8226	1		
Nitrogen Dioxide by Industry	0.7985	0.8334	0.9837	1	
Smoke and Dust	0.7896	0.7859	0.5824	0.6163	1

TABLE-4 THE IMPACT OF THE GREAT RECESSION ON EXPORTS, IMPORTS AND GDP IN COASTAL PROVINCES

	ln(Export) (Real 2000 Yuan)	ln(Import) (Real 2000 Yuan)	ln(GDP) (Real 2000 Yuan)	Export/GDP	Export/Total Consumption	Import/Total Consumption
Great Recession* Coastal	-0.252*	-0.124	-0.082**	-0.100***	-0.124***	-0.084**
	(0.130)	(0.124)	(0.040)	(0.030)	(0.034)	(0.032)
Province FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	403	403	403	403	403	403

Robust standard errors clustered by provinces are in parentheses.

*** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level

TABLE-5 THE IMPACT OF THE GREAT RECESSION ON SULFUR DIOXIDE EMISSIONS IN COASTAL PROVINCES

	ln(Sulfur Dioxide) (Endogenous Regression)	ln(Sulfur Dioxide) (Ton) (IV Regression)	Export/GDP (1st Stage of the IV)	ln(Sulfur Dioxide) (Ton) (Reduced Form)
Great Recession*Coastal			-0.100*** (0.032)	-0.200* (0.108)
Export/GDP	0.898 (0.563)	2.004* (1.065)		
Province FEs	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Observations	403	403	403	403

Robust standard errors clustered by provinces are in parentheses.

*** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level

TABLE-6 THE IMPACT OF THE GREAT RECESSION ON SULFUR DIOXIDE EMISSIONS IN COASTAL PROVINCES

	Sulfur Dioxide (Million Ton) (Endogenous Regression)	Sulfur Dioxide (Million Ton) (IV Regression)	Export/GDP (1st Stage of the IV)	Sulfur Dioxide (Million Ton) (Reduced Form)
Great Recession*Coastal			-0.100*** (0.032)	-0.113** (0.051)
Export/GDP	0.074 (0.253)	1.136* (0.614)		
Province FEs	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Observations	403	403	403	403

Robust standard errors clustered by provinces are in parentheses.

*** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level

TABLE-7 THE IMPACT OF THE GREAT RECESSION ON NITROGEN DIOXIDE EMISSIONS IN COASTAL PROVINCES

	ln(Nitrogen Dioxide) (Ton) (Endogenous Regression)	ln(Nitrogen Dioxide) (Ton) (IV Regression)	Export/GDP (1st Stage of the IV)	ln(Nitrogen Dioxide) (Ton) (Reduced Form)
Great Recession*Coastal			-0.100*** (0.032)	-0.259** (0.102)
Export/GDP	1.459*** (0.534)	2.444*** (0.920)		
Province FEs	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Observations	306	306	403	306

Robust standard errors clustered by provinces are in parentheses.

*** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level

TABLE-8 THE IMPACT OF THE GREAT RECESSION ON NITROGEN DIOXIDE EMISSIONS IN COASTAL PROVINCES

	Nitrogen Dioxide (Million Ton) (Endogenous Regression)	Nitrogen Dioxide (Million Ton) (IV Regression)	Export/GDP (1st Stage of the IV)	Nitrogen Dioxide (Million Ton) (Reduced Form)
Great Recession*Coastal			-0.100*** (0.032)	-0.082 (0.051)
Export/GDP	0.457* (0.232)	0.752* (0.392)		
Province FEs	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Observations	310	310	403	310

Robust standard errors clustered by provinces are in parentheses.

*** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level

TABLE-9 THE IMPACT OF THE GREAT RECESSION ON SMOKE & DUST EMISSIONS IN COASTAL PROVINCES

	ln(Smoke & Dust) (Ton) (Endogenous Regression)	ln(Smoke & Dust) (Ton) (IV Regression)	Export/GDP (1st Stage of the IV)	ln(Smoke & Dust) (Ton) (Reduced Form)
Great Recession*Coastal			-0.100***	-0.053
			(0.032)	(0.123)
Export/GDP	-0.173	0.528		
	(0.695)	(1.178)		
Province FEs	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Observations	403	403	403	403

Robust standard errors clustered by provinces are in parentheses.

*** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level

TABLE-10 THE IMPACT OF THE GREAT RECESSION ON SMOKE & DUST EMISSIONS IN COASTAL PROVINCES

	Smoke & Dust (Million Ton) (Endogenous Regression)	Smoke & Dust (Million Ton) (IV Regression)	Export/GDP (1st Stage of the IV)	Smoke & Dust (Million Ton) (Reduced Form)
Great Recession*Coastal			-0.100*** (0.032)	0.034 (0.070)
Export/GDP	-0.373 (0.222)	-0.343 (0.638)		
Province FEs	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Observations	403	403	403	403

Robust standard errors clustered by provinces are in parentheses.

*** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level

FIGURE-1 TREND OF GDP, EXPORT AND IMPORT

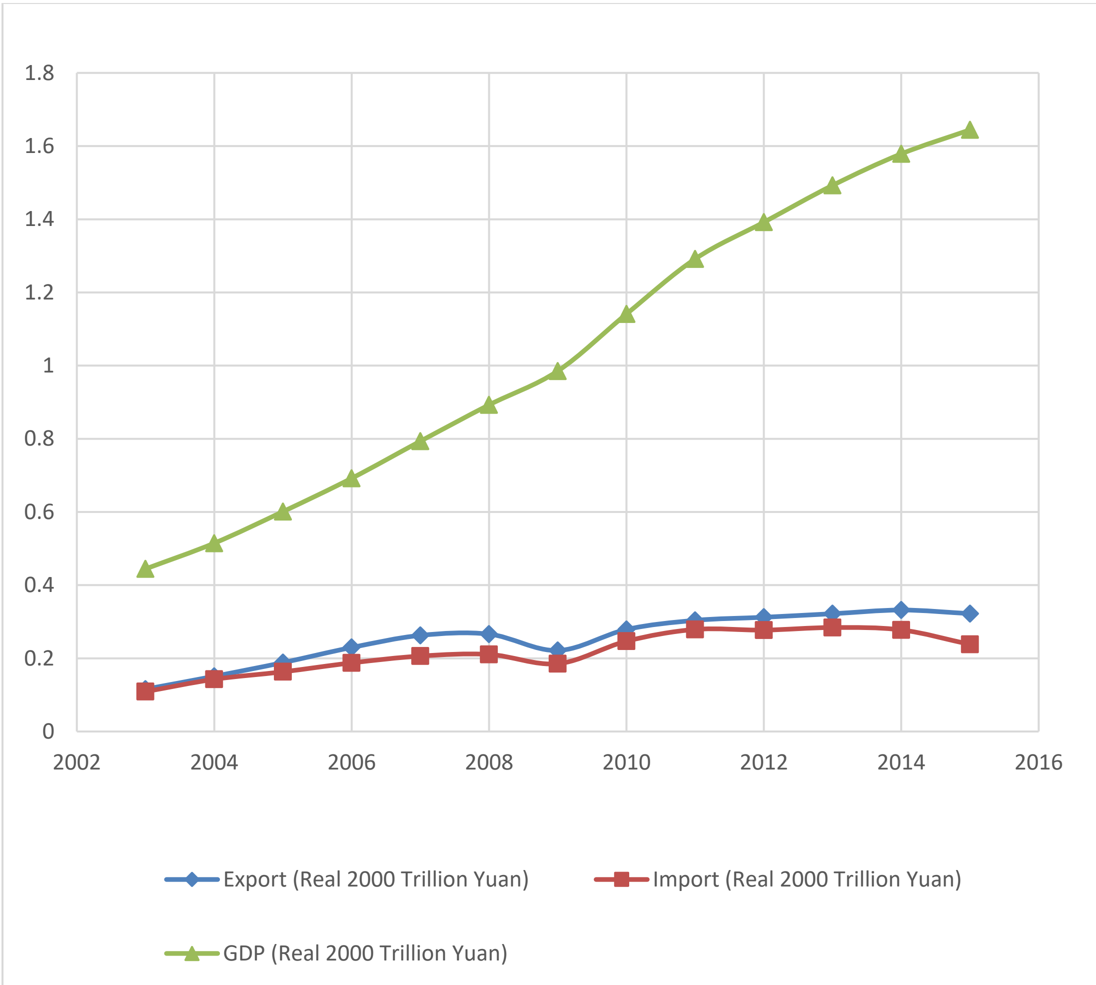


FIGURE-2 TREND OF EXPORT OVER GDP, EXPORT OVER TOTAL CONSUMPTIONA AND IMPORT OVER TOTAL CONSUMPTION

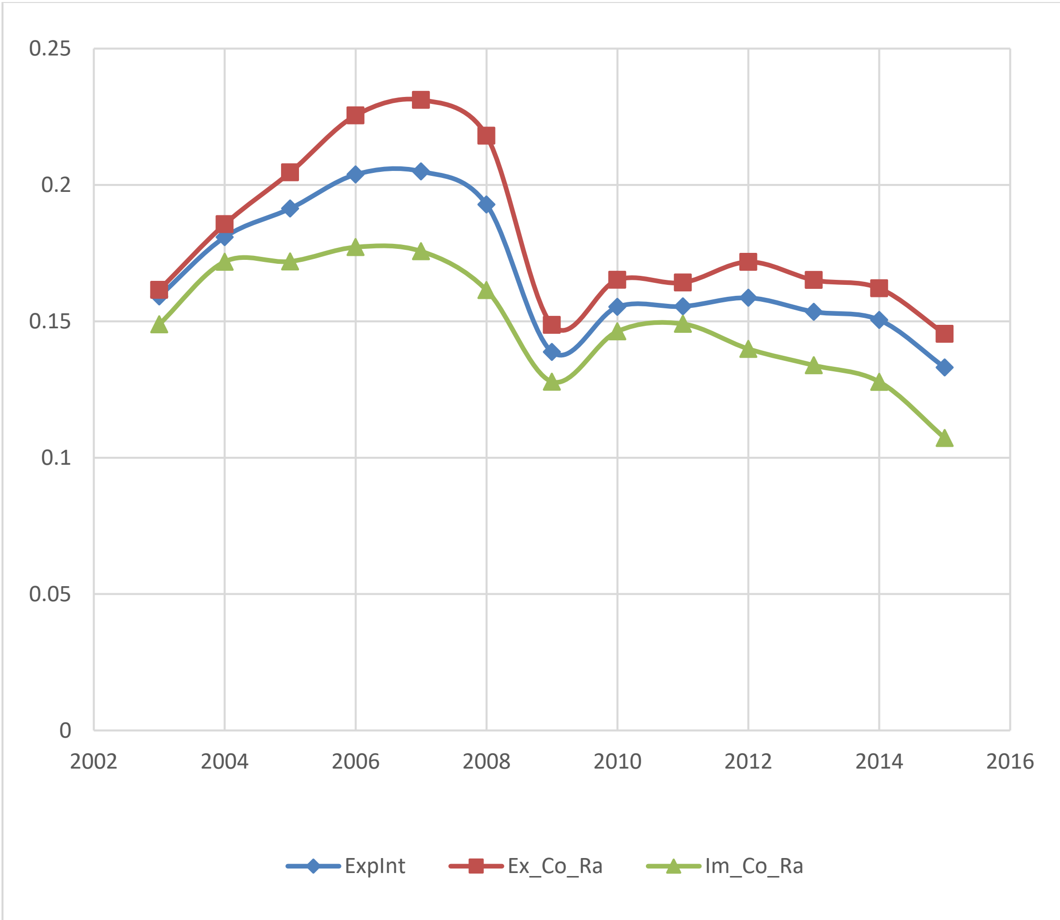
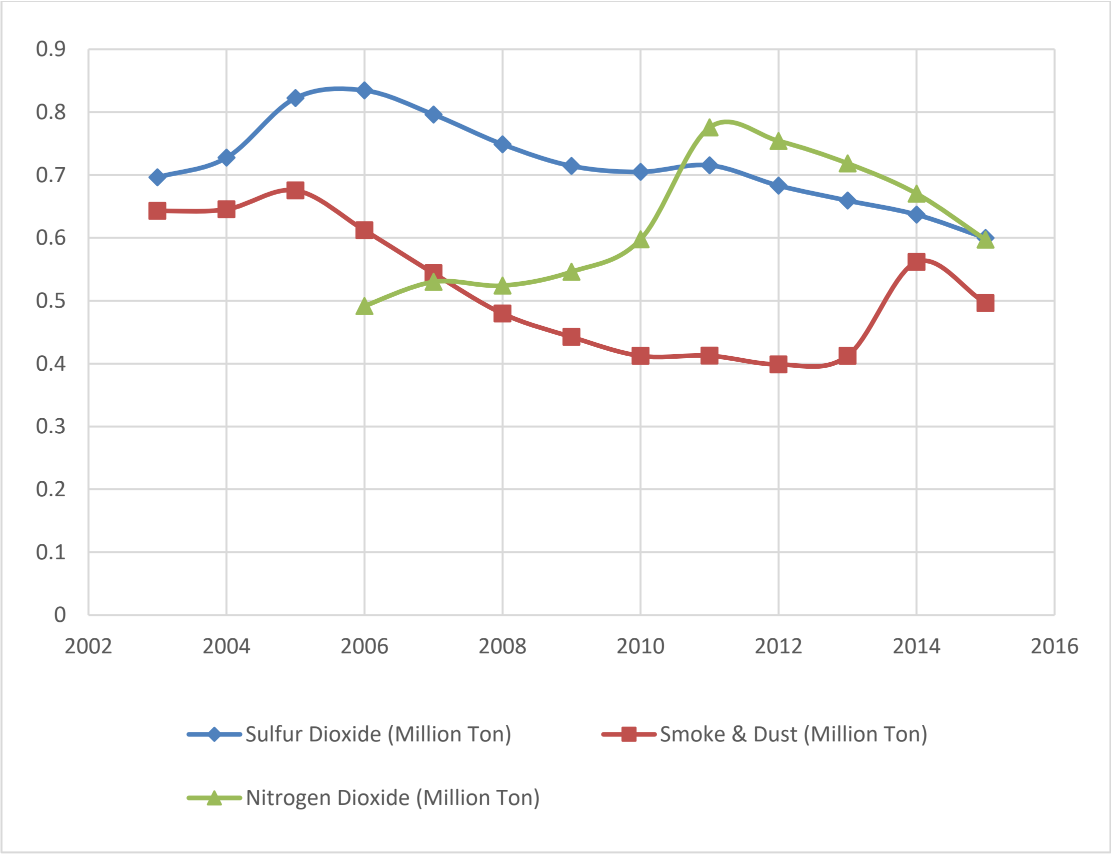


FIGURE-3 TREND OF AIR POLLUTION



PICTURE-1 MAP OF CHINA WITH PROVINCE OUTLINES