Was Entry into the WTO Worth It?

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Abstract

The benefit of trade liberalization may be compromised if the major growth of export comes from heavily polluting industries. This paper studies the effect of trade liberalization on environment and health, and also evaluates the overall welfare consequences of trade liberalization. The paper shows that during the period of 2000 and 2005 in China, 1 per cent decrease in tariff in polluting industries faced by Chinese exporters will increase the total standardized mortality in Chinese cities by 0.11 percent. If we take into account both the income growth and mortality penalty, the overall welfare gain of trade liberalization in this period will be 6 percent smaller than the one calculated with income gains only.

Keywords: Trade liberalization, tariff reduction, pollution, health, welfare evaluation.

1 Introduction

Is trade liberalization indeed as beneficial as we used to think? If the income growth comes from polluting industries mainly, will the health cost from increased pollution offset the benefit from the growth of income? There is a vast body of literature (Acemoglu et al. [2005], Frankel and Romer [1999]) showing that trade can lead to higher income and enhance economic growth. On the other hand, there is little empirical evidence on the environmental consequence of international trade. However, the environmental concern is especially important for developing countries. Poorer countries gain in income as well as the richer countries from trade (Dollar and Kraay [2004], Greenaway et al. [2002]) as long as there exist comparative advantages in terms of productivity either from technology or factor endowment. However, the poorer country’s comparative advantage usually lies in the polluting industries because of laxer environmental regulations (Broner et al. [2012]). If this is the case, the shift of polluting

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industry from richer country to poorer country can cause environmental degradation of the poorer country, which will impose welfare penalty on them. In this light, we are overestimating the gains from trade for developing countries by leaving out the environmental and health cost of potentially dirty industrial growth.

Empirically, does trade liberalization really worsen the environment of developing countries? If we account for both income growth and environmental and health costs, will the overall welfare gains from trade be different from the measure with income only? China made great efforts to become a member of the WTO, but was the effort worth it? In order to answer these questions, I will investigate the growth in exports of Chinese cities and corresponding health outcomes after the WTO entry. Although China as a whole experience this trade liberalization, the effect can differ across cities. Cities may specialize in various kinds of industries based on comparative advantages: some in more polluting industries, and some in less polluting ones. Even if two cities might have the similar overall export value growth, but the one specializing in more polluting industries might suffer more from increased pollution. In the long run, the ramification might show up in terms of mortality rates.

However, there are several challenges when studying the environmental consequences of trade liberalization. The first challenge is that in developing countries like China, reliable environmental data is not available. There are two ways that I deal with this problem in the paper: First, I develop a method to divide industry into polluting and less polluting ones, and then use the variation of export in polluting industries of different cities. Second, I extract satellite data by NASA on aerosol optical depth to infer pollution concentration level on the ground.

The second challenge is that export growth of cities can be correlated with many characteristics of the city, especially local government policy. For example, rich cities might both discourage the development of dirty industries, and invest more in public health system. Thus, the effect of increased export in polluting industries on health may be confounded by other factors. In order to solve this problem, I will use induced tariff reduction of the WTO entry as the promoter of the export growth. Chinese exporters will face lower import tariff imposed by partner countries who are WTO members because of WTO requirement, and this change has little to do with local economic policies and health policies.

This study is related to several streams of literature. First strand of literature is related to different aspects of distributional effect of trade liberalization. Topalova [2010] studies the regional effect of trade liberalization in terms of poverty alleviation in India. Kovak [2013] uses matched employer-employee data to study the firm dynamics in Brazil. Autor et al. [2013] studies how the shock of Chinese exports affects local labor markets of the U.S. However, most papers in this literature focus solely on economic outcomes. Antweiler et al. [2001] decomposes the trade effect on pollution into scale, technique, and composition effects and then tests the theory using cross-country data on sulfur dioxide concentrations. Copeland and Taylor [2004] builds a unified framework of economic growth, international trade and environmental consequences. However,
both theoretical and empirical work in this literature remain in cross-country analysis without overall welfare evaluation. In addition, my paper is closely related to Becker et al. [2005] about welfare measure with quantity and quality of life. Instead of cross country comparison, I will do the analysis on city level, eliminating more uncontrolled region heterogeneity, and also incorporate dynamics in the model. Finally, my research contributes to the literature studying the effect of pollution on health. Chay and Greenstone [2003] uses the economic downturn in the U.S. at the beginning of 1980s to get exogenous changes of pollution levels, and studies the effect of total particulate matters on infant mortality rate. Arceo et al. [2015] uses daily data of pollution and infant mortality in the Mexico City to provide evidence of health cost of pollution in a developing country context. Chen et al. [2013] uses the regression discontinuity generated by collective winter heating system in China to study the effect of sustained air pollution on life expectancy. In the literature, by omitting the income effect of industrial activities, the effect of pollution on health may not be corrected measured.

My contribution to the literature lies in the following aspects. First, using cross-city variation in industrial composition, I can evaluate differential effects of trade liberalization on city pollution. Second, by netting out the beneficial effect of income growth on health, I will get a cleaner assessment of pollution on health. Third, by combining the effect of trade on income, pollution and health, I will construct a new measure of the net gains from trade.

The paper is organized as follows. In Section 1, I will introduce the background of China’s entry into the WTO, and explain why this is a unique experiment to study the effect of trade liberalization on income and health. Section 2 will focus on data and measurement issues, and then present summary of statistics of key variables used in the regression analysis. Section 3 will introduce the empirical model and the regression results. I will describe a simple theoretical model and the corresponding back-in-the-envelop calculation in Section 4. The last section concludes.

2 Background

After entry into the WTO in 2001, exports from China were boosted because of both reduced tariff and lift of non-tariff barriers such as import quota (Khandelwal et al. [2013]). During the phase-in period of WTO entry of 2001 to 2005, the tariff faced by Chinese exporters decreased by 0.22 percentage point on average. However, the change in tariff is not balanced across industries. If we define goods like “ores, slag and ash” and “rubber” as more polluting goods and goods like “musical instrument” and “food” as less polluting ones, we can compare the change of tariff between the two categories. In Figure 6, we can see that on average, import tariff was higher in non-polluting industries than in polluting industries in the period of 2000 to 2010, and both tariffs decreased over time. In Figure 2, we can see that during the period of 2000 and 2005, there is larger shift of distribution of tariff for polluting goods: overall polluting goods have
bigger decrease in log of tariff. If we do similar classification of industries, we can construct distribution of tariffs faced by cities, in both polluting and non-polluting industries. We can see in Figure 3, when we aggregate tariffs on city level, both polluting and non-polluting tariffs decreased, but the distribution of tariffs in polluting industries shifts more to the left. ¹

[Figure 1 about here.]

[Figure 2 about here.]

[Figure 3 about here.]

As shown in Figure 4, in response to the tariff reduction, China experienced significant export growth after entry into the WTO. In addition, polluting industries and less-polluting industries did not experience the same rate of growth. Industries like steel and chemical manufacturing had an average annual growth rate of 0.22 and 0.33. At the same time, relatively clean industry like food and beverage, and tobacco grew only by 0.18 and 0.13, respectively.²

[Figure 4 about here.]

Although China as a whole experienced the reduction in tariff and growth in export, the effect might be different across cities. Among the active exporting cities, the industrial structures are very different. In cities like Guangzhou in Guangdong Province for example, in 2000, the major industry of export is “Manufacture of Leather, Fur, Feather and Related Products”, comprising of about 20% of total exports of the city. However, in cities like Langfang in Hebei Province, the major industry in terms of export value is “Manufacture of Metal Products” as 22%³ of total exports.(For trends, see Figure 5.) It is not hard to imagine that faced with open-up to a larger world market, if these cities continued to specialize in the industry where they had comparative advantage in production, the pollution generated from boosted exports would be very different for different cities.

[Figure 5 about here.]

In Figure 4, we can observe that there are similar trends in export growth and overall economic growth. However, the price that cities pay for high growth in exports in polluting industries is not negligible. Starting from 2012, haze weather in Beijing stimulated heated discussion about environmental situations in China. News reports featuring the gloomy weather and environmental regulation issues of China appeared in both Chinese and international media⁴. Early

¹For detailed information on how to construct the tariff by industry and city, and how to classify industries into polluting and less polluting ones, see Section 3.
²Author’s calculation using World Integrated Trade Solutions (WITS) data
³Author’s calculation using Chinese Industrial Enterprise Survey (IES) data
2015, a documentary movie called *Under the Dome* also promoted discussions all over China about the cause, the results and the possible solutions to the urgent environmental problem. In terms of health outcomes, using the two cities I mentioned before as examples, total standardized mortality rates in *Guangzhou* were 4.8 per thousand and 3.3 per thousand in 2000 and 2010, respectively, and were 6.1 per thousand and 4.8 per thousand for *Langfang* in 2000 and 2010, respectively⁵.

Yet, there has been little work on this specific issue of China. One important problem is the data constraint. In 2000, only 41 major Chinese cities (among total of 340 cities) had reports of air quality index on the website of Chinese Environment Protection Bureau; 85 cities in 2010, and only in 2014 the number increased to 289. In addition, it is an open secret that local Chinese government manipulates the reading of monitors for career concerns (see GhanemGhanem and Zhang [2014]). With no credible data, it is hard to study the adverse effect of air pollution.

There are two ways to partially solve the problem. First, the trade liberalization and large geographical and economical variation across Chinese cities provide a unique chance to get estimates of the effect of pollution on health bypassing the measurement of pollution itself, and also empirically study the overall gains from trade with both income and health outcomes. With entry into WTO, the tariff faced by Chinese exported decreased because countries within WTO need to have most-favored nation tariffs. This tariff change on the one hand is imposed by WTO rules(setting upper bounds), and on the other hand is the choice of countries other than China. Thus, the tariff reduction has little to do with local China economic conditions and production patterns. Then, using the coal consumption by industry information, I can divide industries as polluting and non-polluting industries, and the differential growth in different industrial exports will generate different pollution emission level across cities mechanically. In this light, I bypass the problem direct pollution concentration measurement. Second, I will use the aerosol optical depth data by NASA to get estimates of air pollution levels, and show the direct effect of trade on pollution to highlight the mechanism of how trade affects health.

### 3 Data and Measurement

Data used in this study comes from various sources. I will describe in this section both the data sources and how I constructed various measures used in the analysis.

#### 3.1 Data

The major measurement of health outcome is mortality rate. I have two years of data: population and number of death by age group and city from 2000 China Population Census, and 2005 1% Population Survey. The census of 2000 covers

⁵Author’s calculation using Population Census data in 2000 and 2010.
the whole population in mainland China in 340 cities of 31 provinces, surveyed during the period of 1999.11.1-2000.10.31. For 2005, the survey was conducted using stratified, multistage clustered probability proportional to size sampling methods during the period of 2004.11.1-2005.10.31. The survey also covers all cities in mainland China, but the data is not available for all provinces. I could only get city-level measures for 136 cities in 16 provinces.

The tariff information by 2-digit Harmonized System Code is from World Integrated Trade Solution (WITS). I have weighted effectively applied import tariffs for 96 products exported from China, reported by the importing countries, from 2000 to 2010. In the next section I will talk in detail about how I construct the tariff by product, industry and city.

I also use firm-level industry data in 2000-2008 from the Database of Chinese Industrial Enterprises Survey (IES) collected by the National Bureau of Statistics of China. The database contains the information of all state-owned industrial enterprises and the privately-owned ones whose sales revenues are above 5 million RMB annually. The information includes the basic information (address, legal entity, capital ownership, industry code, etc.), financial information (total sales, export, assets, tax, etc.) and product information (primary product, secondary product, etc.). The information useful for this paper is city code, industry code, total sales revenue and total export value. The sample size is 162,883 in 2000 and 268,330 in 2005.

For city characteristics, variables including GDP, population, sulfur dioxide emission, are from City Statistics Yearbook of 2000 and 2005.

Also, for classification of polluting v.s. non-polluting industry, I need to use coal consumption by industry. The national coal consumption of 41 industries is from the website of National Bureau of Statistics of China.

The last data set is NASA’s MODIS data set. “The MODIS Aerosol Product monitors the ambient aerosol optical thickness over the ocean globally and over a portion of continents.” There are several papers using the aerosol optical thickness to infer the ambient pollution level, and the method has been proved useful general both globally and in China in particular (Gutierrez [2010], Long et al. [2014], Wang et al. [2007], Foster et al. [2009]). The data I use is Terra Atmosphere Level 2 Products, in MODIS Collection 5.1. The variable name for aerosol depth is Optical_Depth_Land_And_Ocean, and longitude and latitude are used to match the satellite data with cities.

3.2 Measurement

3.2.1 Mortality rate

The major outcome variable used is the standardized total mortality. The formula for calculating the age-standardized mortality rate in city $i$ is as follows:

$$Mortality_{i}^{std} = \sum_{g} MR_{gi} PS_{g}$$

6http://modis-atmos.gsfc.nasa.gov/MOD04_L2/index.html
where $MR_{gi}$ is the mortality rate in age group $g$ in county $i$ and $PS_g$ is the share of population in age group $g$ in the whole country.

In order to have comparable mortality rates over time, I use age structure in 2000 to standardize the mortality rates in 2005.

3.2.2 Tariff

The second important problem is how to construct weighted tariff by product, by industry and by city.

The tariff is reported by WITS, with 96 product categories, and by partner countries. For example, in 2000, China exported to 68 countries, and in 2008, the number of partner countries increased to 114. For each product, I generate the average tariff faced by Chinese exporters for each product by weighting the tariff of each importing country by the share of export out to the total export value of the product by China.

For example, for aluminum, if the total export value of China in 2005 is 100 units, and Country A imports 40 units and Country B imports 60 units. The import tariff of Country A of aluminum from China is 2.3 and that of Country B is 1.3. Then the tariff faced by Chinese aluminum exporters is $2.3 \times 40\% + 1.3 \times 60\%$.

However, the import value and import tariff are not independent. For example, it is very likely that countries that imports a lot will impose lower import tariff. Because later I will argue that reduced tariff will induce higher export volumes on the supply side without affecting the demand side, this correlation is troublesome. Thus I will use the trade volumes in the baseline year (1999) as weights. Using the same example, if out of the 100 units, if Country A imports 40 units and Country B 60 units in 2005, and 20 and 80 units in 1999, I will calculate the tariff in 2005 as $2.3 \times 20\% + 1.3 \times 80\%$ instead of $2.3 \times 40\% + 1.3 \times 60\%$.

After constructing the weighted average of tariff faced by Chinese exporters by product category, I construct the weighted average of tariff by industry. The problem here is that trade product category is classified using 2-digit HS code, focusing on product characteristics mainly, while industry classification is done using 4-digit U.S. Standardized Industrial Classification (SIC) code, which takes into account the production procedure. I use the data and code provided in Pierce and Schott [2009] to match HS code with SIC code. The second problem is that the Chinese Industrial Enterprise Survey uses a Chinese version of SIC code, which is slightly different from the U.S. SIC code. Thus I will do a manual matching between the two sets of industry code. Details about the matching is shown in Appendix A. After doing the matching between product and industry classification, I construct the tariff faced by an industry in the following way: Suppose that Industry 1 has 3 HS categories, then the tariff faced by Industry 1 is the mean of the tariffs in the 3 HS categories.

After constructing the weighted average of tariff faced by Chinese exporters by product category, I construct the weighted average of tariff by city. Suppose that City C has two industries, and the total export value is 100 dollars. Out of the 100 dollars, 30 dollars are from Industry 1, and 70 dollars are from Industry
2. The tariff for products in Industry 1 is 1.2 and the one for Industry 2 is 1.1. Then the tariff faced by the city is 1.2*30%+ 1.1*70%.

Later, I also need to construct the tariff faced by a city in polluting and non-polluting industries separately. The logic is the same as in the previous paragraph, but the key is to classify industries into polluting v.s. non-polluting ones. I will discuss the method in the next section.

3.2.3 Division of polluting v.s. non-polluting industries

Following Hanlon and Tian [2015], I classify the industries into polluting and non-polluting ones using industry code. This classification is according to an official document of Chinese government. In the document issued by Chinese Environment Protection Bureau ([2003] No.10) named About Inspection of Environmental Qualification of Companies that are Applying for Listing and Refinancing, the heavy-polluting industries are: metallurgical, chemical, petrochemical, coal, thermal power, building materials, paper, brewing, pharmaceutical, fermentation, textile, leather and mining. Moreover, using the coal consumption by industry data and industrial output (values from IES), I calculated the coal use by industry in the unit of ton/1000 yuan. We can see in Table 1, most of industries ranking high on the coal consumption list are also defined as polluting industry in my classification. Electric, gas and sanitary services ranks the top in the coal consumption list, but it is not a exporting industry, so it does not show up in IES data.

[Table 1 about here.]

For summary statistics, please see in Appendix B.

4 Empirical model

4.1 Export supply elasticity

First step is to check export supply elasticity. In other words, I will check if tariff faced by exporters will decrease by 1%, how much more the exporters will export. The empirical regression is as follows:

$$\ln(export)_{it} = \alpha_1 + \alpha_2 \ln(tariff)_{it} + X_t + Y_i + \epsilon_{it}$$

where $i$ represents product, and $t$ represents time. $X_t$ represents time trend and $Y_i$ represents product fixed effects.

Also, when I aggregated industries in each city, I will have the tariff and export information across cities, in all industries, polluting industries and non-polluting industries. Thus, $i$ in the previous model will present city instead of product.

In Table 2, in the first column, I use the tariff and export value information of 96 products over the period of 2000-2010. Column (2)-(4) are city level regressions, where I regression log of export value in all industries, polluting
industries and non-polluting industries on log of tariffs, respectively. In Column (1), I control for product fixed effect and year trend, while in later three columns, I control for city fixed effect and year trend. We can see that product level export supply elasticity is about 0.08, while city level export supply elasticity ranges from 0.17 to 0.65. One explanation for the difference in these two kinds of elasticity is that cities are more flexible in terms of adjusting the export in response to tariff changes because cities are heterogeneous. Suppose that some cities are very good at producing Product 1 while other cities are not very good at producing it. Also when the price of Product 1 increases in the international market (e.g. import tariff of other countries decreases), cities that are good at producing Product 1 increases production a lot, while cities that are not good at producing Product 1 do not response a lot. Then on average the country as a whole do not response as much as individual cities.

4.2 Exogeneity of tariff change

Although the tariffs faced by Chinese exporters are set by the importing countries, it is still useful to check whether tariff change is correlated other variables such as past export volumes. The logic here is that if industries with high growth rate will have greater reduction of tariff, then then future growth of export in this industry is not only the result of reduced tariff.

In order to check the potential endogeneity of tariff change, I use the data from 2001 to 2010 to check whether past industry export growth is correlated with change in tariff. Specifically, I will estimate the following model:

$$\Delta \text{tariff}_{it} = \alpha_1 + \alpha_2 \text{Lagged } \Delta \text{ export}_{it} + X_t + Y_i + \epsilon_{it}$$

where $i$ represents product and $t$ presents year. $X_t$ represents time trend and $Y_i$ represents product fixed effects. I use three specifications in Table 3 to check the whether past industrial growth is correlated with future tariff reduction.

In Column (1), I have growth rate of export tariff by product and year as the dependent variable, and lagged growth rate of export by product and year as the independent variable, controlling for product fixed effect and year trend. In Column (2), I use log variables instead of growth rate. In Column (3), I use change in log variables instead of growth rate. From all three columns, we can see that past export performance is not a good predictor of future tariff change. Thus, it is not likely that endogeneity of tariff change is a big concern in my context.
4.3 Main specification

4.3.1 OLS, IV and Reduced form regression

What is the effect of reduction of tariff on mortality rate? The main regression is

$$\log (\text{MR})_{it} = \alpha_1 + \alpha_2 \log (\text{Export value in pollut. ind.})_{it} + \beta Z_{it} + X_t + Y_i + \epsilon_{it}$$  (1)

where $i$ indicates city and $t$ indicates time. $Z_{it}$ includes other control variables such as log of per capita GDP, log of population, log of share of export as part of total industrial output, dummy for northern provinces. $X_t$ represents year fixed effect and $Y_i$ represents city fixed effects.

In order to have exogenous variation in the export value, I will use log of tariff to instrument log of export. Finally, I will show reduced-form regression as the follows:

$$\log (\text{MR})_{it} = \alpha_1 + \alpha_2 \log (\text{Tariff in pollut. ind.})_{it} + \beta Z_{it} + X_t + Y_i + \epsilon_{it}$$  (2)

where $Z_{it}, X_t, Y_i$ are similar as in the previous equation.

The result is as follows. In Table 4 Column(1)-Column(4), dependent variable is log of age standardized mortality. In all columns, log of per capita GDP, log of population, log of share of export out of total output and year dummy for 2005 are controlled. In Column (1), I control for dummy for northern provinces. In Column (2)-(4), I control for city fixed effect instead. In Column (1)-Column(2), I control for log of exports in polluting industries. In Column(3), I instrument log of export in polluting industries with log of tariff in polluting industries. In Column(4), I control for log of tariff directly.

We can see that Column (1) and (3) have similar results. When we have increase in exports in polluting industries, mortality rate increases. In Column (2) the coefficient for log of exports in polluting industries is not significant, meaning that the instrumenting for export is very important. In Column (4), we can see that when we have 1 percent decrease in tariff in polluting industries, there will be 0.11 percent increase in total mortality rate.

[Table 4 about here.]

4.3.2 Mechanism

In this section I want to provide more evidence about the mechanism of the effect. Specifically, I will regress sulfur dioxide emission and air quality index on tariff of polluting industries.

In Table 5, Column (1) and (2), the dependent variable is log of sulfur dioxide emission, and in Column (3) and (4), the dependent variable is log of air quality index. I do not control for city fixed effect in Column (1) and (3), and control them in (2) and (4). The result shows that without city fixed effects, decrease in tariff in polluting industries will result in increase in SO2 emission and worsened air quality.
However, neither of these two measures for pollution is ideal. I will try to use satellite data to help strengthen this part.

[Table 5 about here.]

4.4 Robustness check

4.4.1 Placebo test: whether tariff change in non-polluting industry affects mortality rate.

Is this really pollution industry that is driving the result, or trade in generate has the health consequence? In order to answer this question, I will do a placebo test to see whether tariff change in non-polluting industries has similar effect as that in polluting industry.

For Table 6, it has exactly the same specification as in Table 4, just with non-polluting industries instead of polluting industries. We can see that increase in log of export in non-polluting industries has insignificant beneficial effect on health, and it is also consistent with the reduced form regression. Thus, we are more confident that pollution indeed matters.

[Table 6 about here.]

4.4.2 Include year 2008

In the main specification, I just include Year 2000 and Year 2005, due to data availability. Population Census data for 2010 is also available; however, the IES data ends in 2008. In this section, I will add Year 2008 into the regression, using mortality rate of 2010 as proxy for mortality rate in 2008. In other words, I will have measurement error in the outcome variable in 2008. There are 252 cities in the 2008 data.

In Table 7, we can see that the result is quite robust when we add one more year. Effects of export in polluting industries is significant and of similar scalar no matter we control for northern province dummy (Column 1), city fixed effect (Column 2) or use tariff as instrument (Column 3). For reduced form regression (Column 4), the effect of tariff on mortality rate is not significant any more, but the size is very close to the one in the main regression.

[Table 7 about here.]

5 Theoretical model and welfare analysis

5.1 Theoretical model

Here the model will follow Kovak [2013] and Topalova [2010].
5.2 Welfare analysis

Following Becker et al. [2005], I will do a simply welfare analysis. Suppose that overall welfare

\[ V(y, S) = A(s)u(y)/r \]

where \( A(s) \) is probability of survival, \( u(y) \) is utility from consumption and \( r \) is the interest rate. The utility function takes the form of

\[ u(y) = \frac{y^{1-1/\gamma}}{1-1/\gamma} \]

Using the same parameter values as in Becker et al. [2005], I will take \( \gamma = 1.25 \) and \( r = 0.03 \).

Now, I will calculate the income and survival rate in autarky, in trade with non-polluting goods only and in trade with both polluting and non-polluting goods. First, I run a simple regression to see the effect of trade liberalization on per capita GDP.

\[
\log(\text{gdp pc})_{it} = \alpha_1 + \alpha_2 \log(\text{Tariff in all inds})_{it} + \alpha_3 \log(\text{pop.}) + \beta X_t + \epsilon_{it}
\]

Where I control for tariff change, log of population and year fixed effects. The coefficient estimates are 10, -0.28, 0.51 for \( \alpha_1 \), \( \alpha_2 \), \( \alpha_3 \) and \( \beta \) respectively. The average log of tariff is 1.4 in 2000, thus suppose that the tariff rate would be the same if the absence of WTO membership approval, thus the log of GDP per capita would be 9.36 if the absence of trade liberalization (log of population in 2005 is 5.9). The mean log of per capita GDP in 2005 is 9.40. Thus, I use 9.36 as the one with trade liberalization.

Second, using main regression in Column 4, Table 4, I will calculate log of mortality rate in three cases: without trade liberalization, with trade liberalization but without pollution growth, and with trade liberalization and with pollution growth. The difference in the three cases lies in the value of log of per capita income and log of polluting tariff. The mean log of tariff in polluting industry is 1.4 in 2000 and 1.2 in 2005. From Table 8, we can see that log mortality rate is 1.49 in the first case, 1.48 in the second case, and 1.58 in the third case.

With the per capita GDP and mortality rate, the welfare in the three cases are shown in Table 9. The welfare gains from trade liberalization would be 8.6 in the absence of pollution growth, and 8.1 when there is pollution effect. Overall, omitting environmental consequence of trade will lead to overestimation of welfare gains from trade.
6 Conclusion

In this paper, I use coal consumption by industry to divide industries into polluting and non-polluting ones, and investigate the effect of trade growth on mortality. The result shows that 1 percent decrease in tariff in polluting industries faced by Chinese exporters will increase total mortality rate by 0.11 percent. If we only account for income growth, the welfare gains from trade will be 8.6, while if we account for both income growth and mortality increase, the welfare gains will be 8.1. In this light, environmental and health concerns is an important aspect when we consider trade policies.

References


Table 1: Average rank of coal use by industry (ton/1000 yuan)

<table>
<thead>
<tr>
<th>Industry Name</th>
<th>Rank of Coal Use (ton/1000 yuan)</th>
<th>Whether defined as Polluting Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric, Gas and Sanitary Services</td>
<td>25.38</td>
<td>No</td>
</tr>
<tr>
<td>Coal Mining</td>
<td>24.38</td>
<td>Yes</td>
</tr>
<tr>
<td>Stone, Clay, Glass, and Concrete Products</td>
<td>23.13</td>
<td>Yes</td>
</tr>
<tr>
<td>Agricultural Production - Crops</td>
<td>22.67</td>
<td>No</td>
</tr>
<tr>
<td>Petroleum Refining and Related Industries</td>
<td>22.25</td>
<td>Yes</td>
</tr>
<tr>
<td>Primary Metal Industries</td>
<td>20.13</td>
<td>No</td>
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<tr>
<td>Mining and Quarrying of Nonmetallic Minerals, Except Fuels</td>
<td>20</td>
<td>Yes</td>
</tr>
<tr>
<td>Paper and Allied Products</td>
<td>19.5</td>
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<tr>
<td>Chemicals and Allied Products</td>
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<td>Yes</td>
</tr>
<tr>
<td>Lumber and Wood Products, Except Furniture</td>
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<td>No</td>
</tr>
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<td>Food and Kindred Products</td>
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<td>No</td>
</tr>
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<td>Textile Mill Products</td>
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<td>Metal Mining</td>
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<td>Yes</td>
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<tr>
<td>Rubber and Miscellaneous Plastic Products</td>
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<td>Yes</td>
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<td>Oil and Gas Extraction</td>
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<td>8.25</td>
<td>No</td>
</tr>
<tr>
<td>Fabricated Metal Prdcts, Except Machinery &amp; Transport Eqpmnt</td>
<td>8.25</td>
<td>No</td>
</tr>
<tr>
<td>Apparel, Finished Prdcts from Fabrics &amp; Similar Materials</td>
<td>7.13</td>
<td>No</td>
</tr>
<tr>
<td>Tobacco Products</td>
<td>7</td>
<td>No</td>
</tr>
<tr>
<td>Industrial and Commercial Machinery and Computer Equipment</td>
<td>6.5</td>
<td>No</td>
</tr>
<tr>
<td>Furniture and Fixtures</td>
<td>6.13</td>
<td>No</td>
</tr>
<tr>
<td>Printing, Publishing and Allied Industries</td>
<td>5.63</td>
<td>No</td>
</tr>
<tr>
<td>Leather and Leather Products</td>
<td>3.5</td>
<td>Yes</td>
</tr>
<tr>
<td>Electronic, Elecrcl Eqpmnt &amp; Cmpnts, Exct Computer Eqpmnt</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>Meas/Anlyz/Cntrl Instrmnts; Photo/Med/Opt Gds; Watches/Clocks</td>
<td>1</td>
<td>No</td>
</tr>
</tbody>
</table>

Note: Coal consumption by industry is from National Bureau of Statistics of China website. Export sales revenues are from Chinese Industrial Enterprise Survey (IES). The list here is by 2 digit Standardized Industrial Classification (SIC) code. The rank is calculated for years of 2000, 2001, 2002, 2003, 2005, 2006, 2007 and 2008, and then I take the average over the 8 years’ ranks.
Table 2: How does export respond to tariff change?

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(export)</td>
<td>All products</td>
<td>City All Ind.</td>
<td>City Poll. Ind.</td>
<td>City Non-Poll. Ind.</td>
</tr>
<tr>
<td>ln(tariff)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.0773*</td>
<td>-0.653**</td>
<td>-0.521**</td>
<td>-0.173</td>
</tr>
<tr>
<td></td>
<td>(0.0455)</td>
<td>(0.285)</td>
<td>(0.264)</td>
<td>(0.350)</td>
</tr>
<tr>
<td>Constant</td>
<td>-301.2***</td>
<td>-308.6***</td>
<td>-245.5***</td>
<td>-463.9***</td>
</tr>
<tr>
<td></td>
<td>(8.780)</td>
<td>(39.02)</td>
<td>(40.12)</td>
<td>(46.14)</td>
</tr>
<tr>
<td>Obs.</td>
<td>1,027</td>
<td>685</td>
<td>659</td>
<td>646</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.963</td>
<td>0.946</td>
<td>0.916</td>
<td>0.943</td>
</tr>
<tr>
<td>Prod FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>City FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: Robust standard errors in parentheses, *** p ≤ 0.01, ** p ≤ 0.05, * p ≤ 0.1. Column (1) uses the tariff and export information of 96 products over the period of 2000-2010. Column (2) uses the tariff and export information of all industries in cities in year 2000, 2005 and 2008. Column (3) includes only the polluting industries, and Column (4) includes only the non-polluting industries.
Table 3: Do lagged export levels predict change in tariff?

<table>
<thead>
<tr>
<th>Lagged export</th>
<th>(1) Growth rate of tariff</th>
<th>(2) Log of tariff</th>
<th>(3) Change in log of tariff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth rate</td>
<td>0.0766</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log</td>
<td>(0.361)</td>
<td>-0.0393</td>
<td></td>
</tr>
<tr>
<td>Change in log</td>
<td></td>
<td></td>
<td>0.0299</td>
</tr>
<tr>
<td>Constant</td>
<td>-83.99</td>
<td>46.65**</td>
<td>-28.53**</td>
</tr>
<tr>
<td></td>
<td>(54.81)</td>
<td>(21.03)</td>
<td>(13.82)</td>
</tr>
<tr>
<td>Observations</td>
<td>864</td>
<td>959</td>
<td>863</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.121</td>
<td>0.913</td>
<td>0.044</td>
</tr>
<tr>
<td>Prod FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: Robust standard errors in parentheses. *** p ≤ 0.01, ** p ≤ 0.05, * p ≤ 0.1. Column (1) regresses growth rate of tariff on lagged export growth rate. Column (2) regresses log of tariff on lagged log of export. Column (3) regresses change in log of tariff on lagged change in log.
Table 4: Does tariff and export change in polluting industry affect mortality? OLS, 2SLS and reduced form regression, 2000 and 2005

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>OLS</td>
<td>2SLS</td>
<td>RF</td>
</tr>
<tr>
<td>Log(mortality)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log(export plln.)</td>
<td>0.0162**</td>
<td>-0.00153</td>
<td>0.0210**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00710)</td>
<td>(0.0251)</td>
<td>(0.00813)</td>
<td></td>
</tr>
<tr>
<td>Log(p.c. GDP)</td>
<td>-0.178***</td>
<td>-0.0291</td>
<td>-0.182***</td>
<td>-0.0328</td>
</tr>
<tr>
<td></td>
<td>(0.0215)</td>
<td>(0.112)</td>
<td>(0.0221)</td>
<td>(0.120)</td>
</tr>
<tr>
<td>Log(population)</td>
<td>-0.0384**</td>
<td>-0.277</td>
<td>-0.0420***</td>
<td>-0.337</td>
</tr>
<tr>
<td></td>
<td>(0.0158)</td>
<td>(0.275)</td>
<td>(0.0160)</td>
<td>(0.272)</td>
</tr>
<tr>
<td>Log(export share)</td>
<td>-0.0372***</td>
<td>-0.0262</td>
<td>-0.0470***</td>
<td>-0.0420**</td>
</tr>
<tr>
<td></td>
<td>(0.00899)</td>
<td>(0.0315)</td>
<td>(0.00914)</td>
<td>(0.0208)</td>
</tr>
<tr>
<td>Dummy for 2005</td>
<td>-0.101***</td>
<td>-0.162*</td>
<td>-0.105***</td>
<td>-0.184**</td>
</tr>
<tr>
<td></td>
<td>(0.0179)</td>
<td>(0.0917)</td>
<td>(0.0179)</td>
<td>(0.0907)</td>
</tr>
<tr>
<td>Dummy for northern</td>
<td>0.0379**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>provinces</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0152)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log(tariff) in plln. ind.</td>
<td></td>
<td></td>
<td>-0.106*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0601)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>3.224***</td>
<td>3.462</td>
<td>3.203***</td>
<td>4.003*</td>
</tr>
<tr>
<td></td>
<td>(0.214)</td>
<td>(2.338)</td>
<td>(0.214)</td>
<td>(2.229)</td>
</tr>
<tr>
<td>Observations</td>
<td>367</td>
<td>367</td>
<td>367</td>
<td>367</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.507</td>
<td>0.897</td>
<td>0.499</td>
<td>0.900</td>
</tr>
<tr>
<td>City FE</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: Robust standard errors in parentheses. *** p≤0.01, ** p≤0.05, * p≤0.1. Column (1) uses log of export in polluting industries and controlled for dummy for northern provinces. Column (2) is the same as Column(1) except that city fixed effect is controlled instead of northern dummy. Column (3) uses log of tariff in polluting industries as instrument for log of export values, and Column (4) uses log of tariff in polluting industries directly.
Table 5: Do tariff changes in polluting industries affect SO2 emission?

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log(tariff)</td>
<td>-0.973***</td>
<td>-0.312</td>
</tr>
<tr>
<td></td>
<td>(0.241)</td>
<td>(0.640)</td>
</tr>
<tr>
<td>Log(p.c. GDP)</td>
<td>0.733***</td>
<td>0.169</td>
</tr>
<tr>
<td></td>
<td>(0.125)</td>
<td>(1.025)</td>
</tr>
<tr>
<td>Log(population)</td>
<td>0.806***</td>
<td>1.454</td>
</tr>
<tr>
<td></td>
<td>(0.118)</td>
<td>(2.031)</td>
</tr>
<tr>
<td>Dummy for 2005</td>
<td>-1.762***</td>
<td>-1.160*</td>
</tr>
<tr>
<td></td>
<td>(0.166)</td>
<td>(0.669)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.992</td>
<td>1.154</td>
</tr>
<tr>
<td></td>
<td>(1.332)</td>
<td>(15.28)</td>
</tr>
<tr>
<td>Observations</td>
<td>362</td>
<td>362</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.261</td>
<td>0.888</td>
</tr>
<tr>
<td>City FE</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Year FE</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: Robust standard errors in parentheses.*** p≤0.01, ** p≤0.05, * p≤0.1. The dependent variable is log of sulfur dioxide emission. Column (1) is without city fixed effect, and Column (2) has city fixed effect.
Table 6: Placebo test: Does tariff and export change in non-polluting industry affect mortality? OLS, 2SLS and reduced form regression, 2000 and 2005

<table>
<thead>
<tr>
<th>Log(mortality)</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>OLS</td>
<td>2SLS</td>
<td>RF</td>
</tr>
<tr>
<td>Log(export non-plln.)</td>
<td>-0.0125**</td>
<td>-0.0393</td>
<td>-0.0115</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00583)</td>
<td>(0.0282)</td>
<td>(0.00702)</td>
<td></td>
</tr>
<tr>
<td>Log(p.c. GDP)</td>
<td>-0.133***</td>
<td>-0.0238</td>
<td>-0.131***</td>
<td>-0.0765</td>
</tr>
<tr>
<td></td>
<td>(0.0200)</td>
<td>(0.148)</td>
<td>(0.0219)</td>
<td>(0.143)</td>
</tr>
<tr>
<td>Log(population)</td>
<td>-0.00596</td>
<td>-1.302*</td>
<td>-0.00604</td>
<td>-1.448**</td>
</tr>
<tr>
<td></td>
<td>(0.0169)</td>
<td>(0.702)</td>
<td>(0.0184)</td>
<td>(0.681)</td>
</tr>
<tr>
<td>Log(export share)</td>
<td>-0.00593</td>
<td>0.0203</td>
<td>-0.0132</td>
<td>-0.0351</td>
</tr>
<tr>
<td></td>
<td>(0.0103)</td>
<td>(0.0399)</td>
<td>(0.0107)</td>
<td>(0.0221)</td>
</tr>
<tr>
<td>Dummy for 2005</td>
<td>-0.0931***</td>
<td>-0.0821</td>
<td>-0.0975***</td>
<td>-0.0793</td>
</tr>
<tr>
<td></td>
<td>(0.0186)</td>
<td>(0.117)</td>
<td>(0.0185)</td>
<td>(0.106)</td>
</tr>
<tr>
<td>Dummy for northern provinces</td>
<td>0.0386**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0156)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log(tariff) in non-plln. ind.</td>
<td>0.0875</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0960)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>3.079***</td>
<td>11.25**</td>
<td>3.040***</td>
<td>12.01**</td>
</tr>
<tr>
<td></td>
<td>(0.222)</td>
<td>(5.645)</td>
<td>(0.229)</td>
<td>(5.543)</td>
</tr>
<tr>
<td>Observations</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.488</td>
<td>0.908</td>
<td>0.480</td>
<td>0.905</td>
</tr>
<tr>
<td>City FE</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: Robust standard errors in parentheses. *** p≤0.01, ** p≤0.05, * p≤0.1. Column (1) uses log of export in non-polluting industries and controlled for dummy for northern provinces. Column (2) is the same as Column(1)except that city fixed effect is controlled instead of northern dummy. Column (3) uses log of tariff in non-polluting industries as instrument for log of export values, and Column (4) uses log of tariff in non-polluting industries directly.
<table>
<thead>
<tr>
<th>Log(mortality)</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log(export plln.)</td>
<td>0.0237***</td>
<td>0.0150**</td>
<td>0.0300***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00543)</td>
<td>(0.00726)</td>
<td>(0.00682)</td>
<td></td>
</tr>
</tbody>
</table>
| Log(p.c. GDP) | -0.190*** | -0.0773** | -0.192*** | -0.0630*  
|                | (0.0157) | (0.0382) | (0.0173) | (0.0375) |
| Log(population) | -0.0350*** | -0.0481 | -0.0395*** | -0.0486  
|                | (0.0118) | (0.0966) | (0.0127) | (0.0969) |
| Log(export share) | -0.0391*** | -0.0273** | -0.0520*** | -0.0139  
|                | (0.00726) | (0.0109) | (0.00787) | (0.00906) |
| Dummy for 2005 | -0.101*** | -0.162*** | -0.107*** | -0.160***  
|                | (0.0179) | (0.0294) | (0.0180) | (0.0295) |
| Dummy for 2008 | -0.155*** | -0.265*** | -0.164*** | -0.266***  
|                | (0.0175) | (0.0448) | (0.0176) | (0.0453) |
| Dummy for northern provinces | 0.0479*** |  
|                | (0.0119) |  
| Log(tariff plln.) |  
|                | -0.0154 |  
|                | (0.0152) |  
| Constant | 3.197*** | 2.147** | 3.146*** | 2.272***  
|                | (0.154) | (0.876) | (0.157) | (0.877) |
| Observations | 611 | 611 | 611 | 611  
| R-squared | 0.648 | 0.895 | 0.638 | 0.894  
| City FE | No | Yes | Yes | Yes  
| Year FE | Yes | Yes | Yes | Yes  

Robust standard errors in parentheses, *** p≤0.01, ** p≤0.05, * p≤0.1
Note: Column (1) uses log of export in polluting industries and controlled for dummy for northern provinces. Column (2) is the same as Column (1) except that city fixed effect is controlled instead of northern dummy. Column (3) uses log of tariff in polluting industries as instrument for log of export values, and Column (4) uses log of tariff in polluting industries directly.
Table 8: Mortality rates in three cases: without WTO and without pollution, with WTO and without pollution, and with WTO and with pollution.

<table>
<thead>
<tr>
<th>Case</th>
<th>WTO membership</th>
<th>Pollution growth</th>
<th>Log of GDP</th>
<th>Log of tariff in plln. ind.</th>
<th>Log(MR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No</td>
<td>No</td>
<td>9.36</td>
<td>1.4</td>
<td>1.49</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>No</td>
<td>9.40</td>
<td>1.4</td>
<td>1.48</td>
</tr>
<tr>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
<td>9.40</td>
<td>1.2</td>
<td>1.58</td>
</tr>
</tbody>
</table>

Note: In Case 1, the log of per capita GDP is predicted value in 2005 where I have log of tariff as 1.4 (2000 level) instead of 1.2 (2005 level). In Case 2 and 3, the log of per capita GDP is the mean value in 2005. Log of mortality rates are predicted values in Case 1 and Case 2. In Case 3, log of mortality is the mean value in 2005.
Table 9: Welfare analysis in three cases: without WTO and without pollution, with WTO and without pollution, and with WTO and with pollution.

<table>
<thead>
<tr>
<th>Case</th>
<th>WTO membership</th>
<th>Pollution growth</th>
<th>GDP p.c. (Yuan)</th>
<th>Mortality (1/1000)</th>
<th>Welfare</th>
<th>Welfare gains from WTO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No</td>
<td>No</td>
<td>11614</td>
<td>4.4</td>
<td>1078.8</td>
<td>N.A.</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>No</td>
<td>12088</td>
<td>4.4</td>
<td>1087.4</td>
<td>8.6</td>
</tr>
<tr>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
<td>12088</td>
<td>4.9</td>
<td>1086.9</td>
<td>8.1</td>
</tr>
</tbody>
</table>
Figure 1: Average import tariff of Chinese goods, 2000-2010, all goods, polluting goods and non-polluting goods

Note: Data for tariff is from World Integrated Trade Solution (WITS). Each data point here is overall tariff faced by Chinese exporters in a year. For a year, the tariff is simple mean across 96 product categories. And product level import tariffs are the tariffs imposed on 96 Chinese goods by partner countries, with product category by 2-digit Harmonized System (HS) codes. For a product in a specific year, the tariff is weighted average across partner countries, with weights as the import value share. Polluting and non-polluting goods are defined according to their corresponding industry characteristics. For division of polluting and non-polluting industries, refer to Section 3.2.3.
Figure 2: Density of log of import tariff of Chinese goods, 2000 and 2005, polluting and non-polluting goods

Polluting goods

Non-polluting goods

Note: Data for tariff is from World Integrated Trade Solution (WITS). The figure on the left is the density of log of tariff for polluting goods, and the figure on the right is the density of non-polluting goods. There are 96 product categories in total, and 24 are defined as polluting goods. Kernel density is estimated with bandwidth 0.11.
Figure 3: Density of log of tariff faced by cities, 2000 and 2005, polluting and non-polluting industries

Note: Data for tariff is from World Integrated Trade Solution (WITS). Data for exports by industry and city is from Chinese Industrial Enterprise Survey (IES). The figure on the left is the density of log of tariff faced by cities in polluting industries, and the right figure is the density of non-polluting industries. City level tariff is the weighted average of tariff by industry, with weights as the value share. Polluting and non-polluting industries are defined according to their corresponding industry characteristics. For details about the aggregation method, refer to Section 3. Kernal density is estimated with bandwith 0.11.
Figure 4: Average per capita GDP and exports (from polluting and non-polluting industries) across Chinese cities, 2000-2008

Note: Data for export is from Chinese Industrial Enterprise Survey (IES). Data for GDP and population by city is from City Statistics Yearbook. For division of pollution v.s. non-polluting industries, see Section 3.2.3.
Figure 5: Export values in leather and metal industry, City of Guangzhou and Langfang, 2000-2008

Guangzhou

Langfang

Note: Data for export is from Chinese Industrial Enterprise Survey (IES).
A  Matching U.S. Industry with Chinese Industry

[Table 10 about here.]
[Table 11 about here.]
[Table 12 about here.]

B  Summary of statistics

In this section I will present summary of statistics for the variable that will be used later in regressions.

B.1  Tariff and export value/changes, product level

First I will show the export value and actual applied tariff by product from 2000 to 2010 in 96 product categories. Out of 96 categories, 24 products are defined as polluting ones, and 72 as non-polluting ones.

We can see on average, the tariff is higher in non-polluting industries than that in polluting ones (4.7 v.s. 2.2). This is consistent with our intuition that importing countries encourages imports of polluting goods more to protect their own environment. Total export growth rate is about 20%, and on average, polluting industries have larger sizes of exports than non-polluting ones.

[Table 13 about here.]

B.2  City-level statistics


We can see that overall there is large decrease in mortality: 5.8 per thousand to 4.9 in 2005. Export values, per capita GDP and total population increase during the period. In terms of distribution, we can see that there is large variation in terms of export in polluting and non-polluting industries, tariff level and mortality across cities.

[Table 14 about here.]
<table>
<thead>
<tr>
<th>Industry Code</th>
<th>Industry Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agricultural Production - Crops</td>
</tr>
<tr>
<td>2</td>
<td>Agricultural Production - Livestock and Animal Specialties</td>
</tr>
<tr>
<td>7</td>
<td>Agricultural Services</td>
</tr>
<tr>
<td>8</td>
<td>Forestry</td>
</tr>
<tr>
<td>9</td>
<td>Fishing, Hunting and Trapping</td>
</tr>
<tr>
<td>10</td>
<td>Metal Mining</td>
</tr>
<tr>
<td>12</td>
<td>Coal Mining</td>
</tr>
<tr>
<td>13</td>
<td>Oil and Gas Extraction</td>
</tr>
<tr>
<td>14</td>
<td>Mining and Quarrying of Nonmetallic Minerals, Except Fuels</td>
</tr>
<tr>
<td>15</td>
<td>Building Constrctn - General Contractors &amp; Operative Builders</td>
</tr>
<tr>
<td>16</td>
<td>Heavy Constrctn, Except Building Construction - Contractors</td>
</tr>
<tr>
<td>17</td>
<td>Construction - Special Trade Contractors</td>
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<td>20</td>
<td>Food and Kindred Products</td>
</tr>
<tr>
<td>21</td>
<td>Tobacco Products</td>
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<td>22</td>
<td>Textile Mill Products</td>
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<tr>
<td>23</td>
<td>Apparel, Finished Prdcts from Fabrics &amp; Similar Materials</td>
</tr>
<tr>
<td>24</td>
<td>Lumber and Wood Products, Except Furniture</td>
</tr>
<tr>
<td>25</td>
<td>Furniture and Fixtures</td>
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<tr>
<td>26</td>
<td>Paper and Allied Products</td>
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<tr>
<td>27</td>
<td>Printing, Publishing and Allied Industries</td>
</tr>
<tr>
<td>28</td>
<td>Chemicals and Allied Products</td>
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<td>29</td>
<td>Petroleum Refining and Related Industries</td>
</tr>
<tr>
<td>30</td>
<td>Rubber and Miscellaneous Plastic Products</td>
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<tr>
<td>31</td>
<td>Leather and Leather Products</td>
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<td>32</td>
<td>Stone, Clay, Glass, and Concrete Products</td>
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<tr>
<td>33</td>
<td>Primary Metal Industries</td>
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<tr>
<td>34</td>
<td>Fabricated Metal Prdcts, Except Machinery &amp; Transport Eqpmnt</td>
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<tr>
<td>35</td>
<td>Industrial and Commercial Machinery and Computer Equipment</td>
</tr>
<tr>
<td>36</td>
<td>Electronic, Electrl Eqpmnt &amp; Cmpnts, Except Computer Eqpmnt</td>
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<tr>
<td>37</td>
<td>Transportation Equipment</td>
</tr>
<tr>
<td>38</td>
<td>Mesr/Anlyz/Cntrl Instrmnts; Photo/Med/Opt Gds; Watches/Clocks</td>
</tr>
<tr>
<td>39</td>
<td>Miscellaneous Manufacturing Industries</td>
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### Table A.2: List of Relevant Chinese Industries by 2-digit GB code

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<thead>
<tr>
<th>Industry Code</th>
<th>Industry Name</th>
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<tbody>
<tr>
<td>6</td>
<td>Agriculture</td>
</tr>
<tr>
<td>7</td>
<td>Mining and Washing of Coal</td>
</tr>
<tr>
<td>8</td>
<td>Extraction of Petroleum and Natural Gas</td>
</tr>
<tr>
<td>9</td>
<td>Mining and Processing of Ferrous Metal Ores</td>
</tr>
<tr>
<td>10</td>
<td>Mining and Processing of Non-ferrous Metal Ores</td>
</tr>
<tr>
<td>11</td>
<td>Mining and Processing of Nonmetal Ores</td>
</tr>
<tr>
<td>13</td>
<td>Mining of Other Ores</td>
</tr>
<tr>
<td>14</td>
<td>Processing of Food from Agricultural Products</td>
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<tr>
<td>15</td>
<td>Manufacture of Foods</td>
</tr>
<tr>
<td>16</td>
<td>Manufacture of Beverages</td>
</tr>
<tr>
<td>17</td>
<td>Manufacture of Tobacco</td>
</tr>
<tr>
<td>18</td>
<td>Manufacture of Textile</td>
</tr>
<tr>
<td>19</td>
<td>Manufacture of Textile Wearing Apparel, Footware, and Caps</td>
</tr>
<tr>
<td>20</td>
<td>Manufacture of Leather, Fur, Feather and Related Products Feather and Related Products</td>
</tr>
<tr>
<td>21</td>
<td>Processing of Timber, Manufacture of Wood, Bamboo, Rattan, Palm, and Straw Products</td>
</tr>
<tr>
<td>22</td>
<td>Manufacture of Furniture</td>
</tr>
<tr>
<td>23</td>
<td>Manufacture of Paper and Paper Products</td>
</tr>
<tr>
<td>24</td>
<td>Printing, Reproduction of Recording Media</td>
</tr>
<tr>
<td>25</td>
<td>Manufacture of Articles for Culture, Education and Sport Activity</td>
</tr>
<tr>
<td>26</td>
<td>Processing of Petroleum, Coking, Processing of Nuclear Fuel</td>
</tr>
<tr>
<td>27</td>
<td>Manufacture of Raw Chemical Materials and Chemical Products</td>
</tr>
<tr>
<td>28</td>
<td>Manufacture of Medicines</td>
</tr>
<tr>
<td>29</td>
<td>Manufacture of Chemical Fibers</td>
</tr>
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<td>30</td>
<td>Manufacture of Rubber</td>
</tr>
<tr>
<td>31</td>
<td>Manufacture of Plastics</td>
</tr>
<tr>
<td>32</td>
<td>Manufacture of Non-metallic Mineral Products</td>
</tr>
<tr>
<td>33</td>
<td>Smelting and Pressing of Ferrous Metals</td>
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<td>34</td>
<td>Smelting and Pressing of Non-ferrous Metals</td>
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<td>Manufacture of Metal Products</td>
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<td>Manufacture of General Purpose Machinery</td>
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<td>37</td>
<td>Manufacture of Special Purpose Machinery</td>
</tr>
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<td>Manufacture of Transport Equipment</td>
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<td>39</td>
<td>Manufacture of Electrical Machinery and Equipment</td>
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<td>40</td>
<td>Manufacture of Communication Equipment, Computers and Other Electronic Equipment</td>
</tr>
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<td>41</td>
<td>Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office Work</td>
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<td>42</td>
<td>Manufacture of Artwork and Other Manufacturing</td>
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### Table A.3: Matching U.S. and Chinese industries

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<td>43</td>
<td>39</td>
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<tr>
<td>Variable</td>
<td>Obs</td>
<td>Mean</td>
<td>Std. Dev.</td>
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<td>-----</td>
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<td>-----------</td>
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<td><strong>Polluting industries:</strong></td>
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<tr>
<td>Export value</td>
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<td>12695.3</td>
<td>37338.2</td>
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<tr>
<td>Actual applied tariff</td>
<td>264</td>
<td>2.2</td>
<td>1.8</td>
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<tr>
<td>(Unit: %)</td>
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<td></td>
<td></td>
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<td>Change in export</td>
<td>240</td>
<td>2124.3</td>
<td>9004.1</td>
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<tr>
<td>(Unit: 1million $)</td>
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<tr>
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<td>-.05</td>
<td>0.7</td>
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<tr>
<td>(Unit: %)</td>
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<td>Export growth rate</td>
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<td>.4</td>
</tr>
<tr>
<td>Tariff growth rate</td>
<td>240</td>
<td>.04</td>
<td>0.6</td>
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<td><strong>Non-polluting industries:</strong></td>
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<tr>
<td>Export value</td>
<td>792</td>
<td>7155.6</td>
<td>27095.6</td>
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<td>(Unit: 1million $)</td>
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</tr>
<tr>
<td>Actual applied tariff</td>
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<td>4.7</td>
<td>3.9</td>
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<td>(Unit: %)</td>
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<td>Change in export</td>
<td>720</td>
<td>1135.8</td>
<td>5780.7</td>
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<tr>
<td>(Unit: 1million $)</td>
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<tr>
<td>Change in tariff</td>
<td>720</td>
<td>-.1</td>
<td>1.3</td>
</tr>
<tr>
<td>(Unit: %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export growth rate</td>
<td>720</td>
<td>.2</td>
<td>.3</td>
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<tr>
<td>Tariff growth rate</td>
<td>720</td>
<td>.1</td>
<td>1.6</td>
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Note: Tariff and export information are from WITS.
Table A.5: City level statistics: export value, tariff, mortality rate and ect., 2000 & 2005

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<thead>
<tr>
<th>Variable</th>
<th>2000</th>
<th>2005</th>
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<tr>
<td></td>
<td>Obs</td>
<td>Mean</td>
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<tr>
<td>Export, total</td>
<td>259</td>
<td>4719.9</td>
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<td>(Unit: 1000 RMB)</td>
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<tr>
<td>Export, pollut.</td>
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<td>1828.1</td>
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<td>(Unit: 1000 RMB)</td>
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<tr>
<td>Export, non-pollut.</td>
<td>259</td>
<td>2891.8</td>
</tr>
<tr>
<td>(Unit: 1000 RMB)</td>
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<td></td>
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<tr>
<td>Tariff, total</td>
<td>259</td>
<td>4.3</td>
</tr>
<tr>
<td>(Unit: %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tariff, pollut.</td>
<td>259</td>
<td>4.4</td>
</tr>
<tr>
<td>(Unit: %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tariff, non-pollut.</td>
<td>259</td>
<td>4.0</td>
</tr>
<tr>
<td>(Unit: %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total standardized mortality</td>
<td>259</td>
<td>5.8</td>
</tr>
<tr>
<td>(Unit: 1/1000)</td>
<td></td>
<td></td>
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<tr>
<td>Total population</td>
<td>259</td>
<td>4.2</td>
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<tr>
<td>(Unit: 1 million)</td>
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<td>Per capita GDP</td>
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<td>9.1</td>
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<td>(Unit: 1000 RMB)</td>
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<td>Sulfur dioxide emission</td>
<td>259</td>
<td>424.0</td>
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<td>(Unit: 1000 ton)</td>
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<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2005</th>
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<tbody>
<tr>
<td></td>
<td>Obs</td>
<td>Mean</td>
</tr>
<tr>
<td>Export, total</td>
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<td>Export, pollut.</td>
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<td>10532.3</td>
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<td>Tariff, total</td>
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<td>3.5</td>
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<tr>
<td>(Unit: %)</td>
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<td>Tariff, pollut.</td>
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<td>3.6</td>
</tr>
<tr>
<td>(Unit: %)</td>
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<td>Tariff, non-pollut.</td>
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<td>3.3</td>
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<td>(Unit: %)</td>
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<tr>
<td>Total standardized mortality</td>
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<td>(Unit: 1/1000)</td>
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<td>Total population</td>
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<td>4.8</td>
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<td>Per capita GDP</td>
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<td>Sulfur dioxide emission</td>
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Note: Tariff information from WITS. Export values are from IES. Mortality rate in 2000 is from Population Census. Mortality rate in 2005 is from 1% Population Survey. Population, GDP and sulfur dioxide emission are from City Statistics Yearbook.