Direct and Relative Effects of the Import Tariff: Estimation Using the Chinese Industrial Level Data

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Abstract

The importing country usually imposes heterogeneous import tariff rates based on the national origins of the products. Reducing the tariff rates on the products from one origin country not only increases the imports from this country, but also decreases the imports from the other trade partners of the importing country. (Direct and relative effects of the import tariff) This paper constructs a variation of the conventional gravity model to analyze the direct and relative effects of the import tariff on international trade flows at the industrial level. Based on our theoretical framework, we compute a new indicator to measure the relative effect and estimate both effects using the Chinese industrial level data. Our empirical findings are consistent with our theoretical predictions: (i) if the tariff rates are reduced towards one origin country, the importing country will import more from this country but reduce the imports from the other origins; (ii) the relative effect is more effective at the industry or country where the importing penetration ratio is relatively high; and (iii) omission of the import penetration ratio will lead to the underestimation of the effects of the multilateral resistance terms on trade performances. Our research contributes to the existing literature by introducing a manipulable method to compute the direct and relative effects of the trade cost at the industrial level, which takes the heterogeneity among industries and countries into account.

JEL classification: F14 F15

Keywords: International trade, Gravity equation, Industrial heterogeneity, China

1 Introduction

In the past decade, we see a rapid rise in the number of the regional trade agreements (RTAs) globally. In 1995, when the WTO was established, the cumulative number of the physical RTAs was only 44, but this number has increased to 289 in 2017 according to the record of WTO. With the rapid increase of the RTAs, the tariff policies become more and more complicated across countries. Generally, the tariffs imposed by the importing countries towards the original countries are mainly recognized as the following types: the ordinary tariff to the non-WTO members, the Most Favored Nation (MFN) tariff to the WTO members, the reciprocal tariff to the trade partners with the Free Trade Agreements, and the unilateral preferential tariff to the trade partners with the Preferential Trade Arrangements. An example of the last type of tariff policy is the Generalized System of Preferences (GSP), which is usually imposed by the developed countries on the products from the developing countries. The tariff rates are largely different among these tariff schemes. In this situation, we have to take the tariff rates imposed by the importing country towards the other countries into account, when estimating the effect of the bilateral tariff on the trade flows from one exporting country. Essentially, this consideration refers to the concept of the multilateral resistance which is firstly pointed out by Anderson and Wincoop (2003). The so called multilateral resistance terms (or multilateral prices) measure the effects of the interactions between an importing country and all other trade partners of this country on the bilateral trade flows between a specific exporting origin and this importing country. We may estimate a bias bilateral tariff elasticity between an importing and exporting countries if omitting the effect of tariff rate imposed by the importing country to the third country. For example, consider a world with only three countries, i.e. country A, B, and C. Country A and B make exports to country C and country C imposes tariff on the products from both countries. When country C reduces the tariff rate on the products from country A while keeping the tariff rate unchanged towards country B, then country C will import more from country A but less from country B. Here, the multilateral resistance terms measure the effects of the change of tariff rate to country A on the trading between country B and C. Furthermore, in the case of the tariff rate, we can reinterpret the effects captured by the multilateral resistance terms as the relative effect of the tariff, i.e. reduction of tariff rate towards country A will crow out the imports from country B. Similarly, the increase of imports from country A can be called the direct effect of the tariff. In this paper, we also emphasize the interactions of the consumption ratio of domestic products on the effectiveness of the relative effect of the tariff. Based on our analysis, the effectiveness of the relative effect of tariff will be relatively low if the importing country consumes a relatively high ratio of domestic products.

In a related study, Fugazza and Nicita (2013) estimate the direct and indirect effects of tariff using the national aggregate level of trading data. Following the method of Kee et al. (2008, 2009), Fugazza and Nicita (2013) aggregate the national-product level of tariff rates into the national level, and compute the overall tariff restrictiveness index and the relative preferential margin for controlling the effects of the multilateral tariffs. Based on the estimation results, they find that the bilateral tariff is negatively while the multilateral tariffs are positively correlated with the bilateral trading flows. In this paper, we will introduce and apply a new method to control the effects of the multilateral tariffs at the national-product level, which make it possible to study the relevant issues at the product or industrial level.

The paper expands the works of Anderson and Wincoop (2003), and Baier and Bergstrand (2009) by applying their theoretical frameworks and empirical methods, which are mostly used to analyze the effects of trade costs on trade flows at the national aggregate level, into the study of the relevant issues at the industrial level (product level). Anderson and Wincoop (2003) provide theoretical foundations to the traditional gravity-trade model, emphasizing the endogeneity of "multilateral prices" that affect the trade volume. The difficulty to apply the model of Anderson and Wincoop (2003) into empirical analysis is that the multilateral resistance terms are in complex non-linear forms and also as functions of each other. That means we cannot solve the multilateral resistance terms as formulas of a plenty of exogenous variables (multilateral trade costs). To solve this issue, Baier and Bergstrand (2009) use the first order Taylor-expansion skill to linearize the multilateral resistance terms, then estimate the border effects on trade using the US-Canada trade data. In this paper, we apply the estimation skill of Baier and Bergstrand (2009) to the study at industrial level: firstly, we redefine the utility function of consumers in order to feature the heterogeneity among industries; secondly, considering the production and consumption volume may be different at the country-industrial level (happening in most cases in reality), we prove that the linearization skill suggested by Baier and Bergstrand (2009) still works with this case; [1] lastly, as we cannot construct a similar indicator for the multilateral resistance terms as Baier and Bergstrand (2009) due to the data-missing issue at the country-industrial level, we approximate

[1] As Bair and Bergstrand (2009) study the issue at the national aggregate level, the production and consumption volume should be equal.

a new formula for this indicator with some conventional assumptions on consumers' preferences, reshaping the indicator as a complexity of two feasible indices, i.e. industry's horizontal penetration ratio and import-weighted average tariff rate. In summary, our research provides both theoretical foundations and empirical methods to estimate the direct and relative effects of the tariff at country-industrial level, emphasizing the heterogeneity across industries and countries. Using Chinese industrial data, we confirm the main predictions of our theoretical analysis: (i) reducing the tariff rate faced by some original country, the importing country will import more from this country but reduce the imports from the other countries; (ii) the relative effect is more effective at the industry or importing country where the importing penetration ratio is relatively high; and (iii) mis-specification of the multilateral resistance terms may lead to biased estimation of the relative effects of tariffs. [2]

The rest of this paper is organized as follows. In section 2, we review the relevant literature and discuss our contributions to the existing studies. Section 3 constructs a variation of the conventional gravity-trade model to fit the industrial level analysis. Section 4 empirically tests our theoretical predictions using the Chinese industrial data and section 5 checks the robustness of our empirical estimations. Section 6 concludes our research findings and contributions.

2 Literature Review

The literatures related with our study can be classified as two groups. The first group of studies estimate the effects of the tariff on trade performance. The traditional estimation method on this issue is based on a partial equilibrium model which only considers the change of the bilateral tariff rates imposed by the importing country on a specific exporting country, and ignores the interactions of the multilateral tariffs imposed on the other trade partners of the importing country. Under the WTO trading system, each member country imposes the MFN tariff rates on the imported products from other member countries. In this situation, we can ignore the effects of the multilateral tariffs. However, as the growing of the regional free trade agreements, more and more countries set heterogeneity tariff rates towards different trade partners, which makes the estimation be biased without taking the multilateral tariffs into consideration. The traditional studies treat

[2] The method can be applied to the other countries, not only the case of China.

the MFN tariff as the average tariff rate imposed by an importing country, and use the gap between the MFN and preferential tariff rates as the measurement of the preferential margin (World Bank, 2005 and Magee, 2015). However, as the fast growing of the number of preferential trade agreements, it becomes more and more biased to use the MFN tariff rate as the indicator for the average tariff rate. To solve this issue, many researches begin to use the actual tariff rates imposed by the importing country towards its trade partners and compute a weighted average tariff rate with the trade volume as the weight, for example Fugazza and Nicita (2013), Fugazza and McLaren (2014), and Carrère et al. (2010). In this paper, we add to the existing literature with emphasizing the competition between the foreign and domestic producers. In an importing market, the foreign firms face the competition not only from the other foreign producers, but also with the domestic products of this country. Due to the emerging of the home market effects, the imported products may be in disadvantage position when competing with the domestic products. For example, the consumers may prefer more on domestic products, and government sets invisible market barriers towards the foreign firms. To control the home market effects, we re-scale the multilateral resistance terms by the import penetration ratio, which measures the proportion of the foreign products in the market. As the tariff rate on domestic products is zero, we may over-estimate the multilateral resistance terms and preferential margin if the sales of domestic products are not taken into computation. In addition, some existing literature also suggest to take the intra-national trade into consideration when approximating the gravity model, i.e. Yotov (2012), Dai et al. (2014), and Anderson et al. (2016).

Another group of studies focus on the trade creation and trade diversion of the regional trade agreement (RTA). As pointed by Viner (1950), on one hand the RTA reduces the bilateral tariff rates and non-tariff barriers directly, and thus increases the trade flows among the member countries of the agreement, which is known as the trade creation effect of the RTA; on the other hand, the tariff reduction processes among the RTA member countries will increase the relative trade costs of the non-member countries, and cause the substitution of imported products from the non-member countries with those from the regional countries. The second effect is the so called trade diversion effect. Many literature study the trade creation and diversion effects of the RTA empirically. The key literature on this issue include Magee (2008), Baier and Bergstrand (2007, 2009), Baler et al. (2014), and Limão (2016). All these researches allow a dummy to indicate the effective of the RTA, instead of using the real values of the change of tariff rates. With this method, we can control the changes of the non-tariff and post border barriers after the effective of the RTA, but ignore the effectiveness-heterogeneity of the RTAs with different tariff-reduction scales. Based on the discussion by Limão (2016), we can perfectly estimate the trade creation effect of the RTA using the structural gravity model. However, Magee (2008) argues that the structural gravity model is not suitable for estimating the trade diversion effect, because the information regarding the number of RTAs signed by a country is fully absorbed by the dummies that control for the exporter-year and importer-year fixed effects. To solve this issue, Dai et al. (2014) suggest to allow a dummy to indicate whether the country signs RTAs with other countries, instead of computing the number of RTAs signed by this country. However, this method also fails to accurately identify the trade diversion effect because the number of RTAs are much different across countries. Comparing with the existing literature, this paper proposes a new method to accurately estimate the trade creation and diversion effects using the industrial level of tariff data. Based on our specification, the elasticity of the bilateral tariff rate measures the trade creation effect and the elasticity of the multilateral tariff rate measures the trade diversion effect.

3 Theoretical Model

$$X_{ijk} = \left(\frac{p_{ik}t_{ijk}}{P_{jk}}\right)^{1-\sigma} \alpha_{jk}Y_j \tag{1}$$

where X_{ijk} is the exporting value of product k from country i to j; p_{ik} is the price of product k produced by country i ; t_{ijk} measures the marginal trade cost between the countries i and j , i.e. $t_{ijk} \equiv \varsigma_{ijk} \left(1+\tau_{ijk}\right)^{\frac{\sigma}{\sigma-1}}$, where ς_{ijk} captures the ice-berg costs and τ_{ijk} is the tariff rate ; and α_{jk} is the consumption share of product k in country j (out of the country j's GDP).

After clearing up the market k in country i , we obtain the following condition:

$$\beta_{ik}Y_i = p_{ik}^{1-\sigma} \left[\sum_j \left(\frac{t_{ijk}}{P_{jk}}\right)^{1-\sigma} \alpha_{jk}Y_j\right] \tag{2}$$

where β_{ik} is the output share of product k in country i (out of the country i's GDP).

Following this result, we further get:

$$X_{ijk}=\left(\frac{\beta_{ik}\alpha_{jk}Y_iY_j}{\bar{\alpha}_kY^T}\right)\frac{t_{ijk}^{1-\sigma}}{P_{jk}^{1-\sigma}\Pi_{ik}^{1-\sigma}} \tag{3}$$

where $P_{jk}=\left[\sum\limits_i\frac{\beta_{ik}Y_i}{\bar{\alpha}_kY^T}\left(\frac{t_{ijk}}{\Pi_{ik}}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$, $\Pi_{ik}=\left[\sum\limits_j\frac{\alpha_{jk}Y_j}{\bar{\alpha}_kY^T}\left(\frac{t_{ijk}}{P_{jk}}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$, and $\bar{\alpha}_k$ is consumption (or equivalently the output) share of product k in the whole world.

Applying the method by Baier and Bergstrand (2009), we linearize the equation (3) as:

$$lnX_{ijk}=ln\beta_{ik}+ln\alpha_{jk}+lnY_i+lnY_j-(\sigma-1)lnt_{ijk}$$

$$+(\sigma-1)\left[\left(\sum_l\frac{\alpha_{lk}Y_l}{\bar{\alpha}_kY^T}lnt_{ilk}\right)+\left(\sum_m\frac{\beta_{mk}Y_m}{\bar{\alpha}_kY^T}lnt_{mjk}\right)-\left(\sum_l\sum_m\frac{\alpha_{lk}\beta_{mk}Y_lY_m}{(\bar{\alpha}_kY^T)^2}lnt_{mlk}\right)\right] \tag{4}$$

To fit our data structure, we make the following adjustments of equation (4):

$$lnX_{jkt}=\beta_0-\sigma ln\left(1+\tau_{mjkt}\right)+\sigma\Theta_{jkt}\left[\sum_m\rho_{mjkt}ln\left(1+\tau_{mjkt}\right)\right]+\delta_{jk}+\delta_{jt}+\delta_{kt}+\varepsilon_{jkt} \tag{5}$$

[3]

where $\Theta_{jkt}\equiv\frac{import_{jkt}}{import_{jkt}+value\_added_{jkt}-export_{jkt}}$ is the horizontal import penetration of the sector k in country j at the year t; ρ_{mkt} is the import share from country m ; and the term $\sum\limits_m\rho_{mjkt}ln\left(1+\tau_{mjkt}\right)$ computes the import-weighted average of import tariff imposed by country j at sector k. To manipulate the index Θ_{jkt} , we may use the following three methods:

(i) If the data are available for computing the horizontal penetration ratio in each country-sector level, we can compute the index Θ_{jkt} directly.

(ii) If we assume the import penetration ratio is constant over time, we may allow country-sector dummies on the term$\sigma\left[\sum\limits_m\rho_{mjkt}ln\left(1+\tau_{mjkt}\right)\right]$ or use the fixed (random) effects method.

(iii) We may make very strong assumption on the index Θ_{jkt}, i.e. $\Theta_{jkt}=\Theta$ is constant across countries, sectors, and years.

[3] We omit the denote i here because in our data set only one country make exporting.

4 Empirical Applications

4.1 Data

4.1.1 Export value

In this paper, the Chinese export value data are retrieved from the BACI database of the CEPII website. This database provides the data of China's export values in more than 5,000 products, which are categorized by HS6 code (1992), across 219 countries covering the years 1995 to 2013. To match the data of the other variables, we convert the export value data from the HS6 code to the ISIC rev3 4-digit sector category. [4] Using these data, we also compute the import and export values at the nation-industrial level. Using these data, we also compute the aggregate import and export values at the country-industrial level for each importing country.

4.1.2 Import penetration

Another key indicator in our study is the import penetration ratio. Computing this index requires the data for the domestic production value. We retrieve these data from the INDSTAT4 2018 ISIC Rev.3 database of the United Nations Industrial Development Organization (UNIDO). This database provides the data of the industrial output values from 127 sectors which are classified by the 4-digit ISIC code in 122 countries, which are originally collected from the National Bureau of Statistics in each country. Combing the domestic production data and the import data from the BACI database, we compute the import penetration ratio at the country-industrial level. Here, what we should emphasize is that the following factors may cause computation errors of the import penetration ratio: the measurement of the product price, heterogeneity of the industrial categorization methods, and the inconsistency of the statistics scopes between the output and trade data. Firstly, the output value is usually computed based on the producers' prices, while the transaction value is treated as the trade value. Secondly, in each country, the industrial categorization method is based on the industrial structure of this country, which means that different countries may use different methods to design the industrial category code. The errors may arise when converting these codes to the ISIC sector

[4] The industrial concordance codes are retrieved from the website of the world bank, https://wits.worldbank.org/product_concordance.html.

code. lastly, the statistics scopes of the output and trade data are different. For example, the Chinese manufacturing database only covers the samples of the state-owned industrial enterprises and non-state-owned industrial enterprises with annual revenue from principal business above 5 million yuan, while the Chinese customs database records all the trade transactions. In this case, we will relatively under-measure the domestic output value. Due to all the causes discussed above, we find nearly 2.4% of the computed import penetration ratios are in negative values, and around 17.3% of them are greater than 1. We drop the samples with negative values and substitute the values that are greater than 1 with 1.

Another concern we need to take notice is that the INDSTAT4 2016 ISIC Rev. 3 database reduced the statistics size on the ISIC Rev.3 manufacturing industries after 2008. We use the data from the INDSTAT4 2016 ISIC Rev.4 database to replace these missing data. As many data from ISIC Rev.4 and ISIC Rev.3 databases are not one-to-one uniquely matching, we only use the data that can be uniquely converted between the both databases. Our sample size increases by 8% after this manipulation.

4.1.3 Tariff

The sources of the tariff data in this paper are the World Integrated Trade Solution (WITS) and Trade Analysis and Information System (TRAINS). Each country usually decides the tariff rate based on the HS code in 8, 10 or 12 digits. As the designation of the industrial categories above the 6 digits is different across countries, the TRAINS computes a simple average of the tariff rates and generates an aggregate tariff rate at the 6 digits level. Generally, there are three types of tariff regimes: (i) general tariff rate, which is imposed on the products from the non-member countries; (ii) MFN tariff rate, which is imposed on the products from the WTO members; and (iii) preferential tariff rate (PTR), which is imposed on the products from the RTA members. Based on the collection methods, the tariffs are classified as the ad valorem tariff, the specific tariff, and the compound tariff. The most common is an ad valorem tariff. For the samples with the other types of the TRAINS converts other forms of tariffs into the ad valorem equivalents of non ad valorem tariffs.We make the following adjustments on the original data from the TRAINS database. We adopt the Effective applied tariff rates to measure the bilateral tariff. Specifically, if the preferential tariff data are available, we adopt these data, but when the data are missing, we substitute the missing values with the MFN tariff rates. Obviously, we may need to tolerate some estimation biases to approximate the Effective applied tariff rates with this method, however, to our best acknowledge, this is the optimal estimation method we can adopt. Secondly, we use the weighted Effective applied tariff rates across countries reported by the TRAINS to measure the multilateral tariff term. Thirdly, as the Chinese output data are classified with the ISIC code, we convert the data with the HS6 code into the ISIC classification code. Then we compute the weighted average tariff rates using the tariff data from the TRAINS and classified with the ISIC code, weighted by the import values. Fourthly, as the European countries impose the identical tariff rates to the countries out of the region, we use the European Union's tariff rates as the national import tariff rates for each European country. Lastly, we eliminate the samples whose tariff rates are greater than 100%. Merging the bilateral tariff and the exporting value data sets, we obtain 250,796 observations. As the Chinese output data only cover the manufacturing sectors and the data missing issue is serious in some years (e.g. 2009-2013), we lose much more observations with adding the multilateral tariff terms into our regression model. With the multilateral tariff rates, our sample size is largely reduced to 64,683, covering 114 nations and 119 industries.

Table 1 Data Description

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Sample Size	Mean	Standard Deviation	Minimum	Maximum
ln(Export Value)	64,666	8.098	2.958	0	17.65
Bilateral Tariff	64,666	0.0678	0.0912	0	0.999
Multilateral Tariff	64,666	0.0582	0.0839	0	0.999
Import Penetration	64,666	0.579	0.349	4.66e-06	1
Multilateral Tariff×Import Penetration	64,666	0.0302	0.0491	0	0.881

Source: Authors' calculations based on the data described in the text.

4.2 Estimation Results

Table 2 reports our baseline results. We control the country-industry, country-year, and industry-year fixed effects in all regressions. [5] In the first model (column 1), we estimate the correlation between the bilateral tariff and the trade flows without controlling the multilateral resistance terms. Consistent with our expectation, we observe a significantly negative coefficient on the variable bilateral tariff rate, which indicates that the importing volume from an exporting origin is negatively affected by the tariff rate imposed on the products from this country. In the second regression model (column 2), we add the MFN tariff rate to control

[5]Specifically, we use the Stata package REGHDFE developed by Correia, S. (2017) to do the regressions.

for the multilateral resistance terms. In this regression, we find that the scale of the coefficient on bilateral tariff does not change significantly, but the coefficient on the MFN tariff rate is insignificant. We suppose there are two reasons for this insignificance: firstly, the MFN tariff is strongly related with the bilateral tariff faced by China because Chinese firms enjoy the MFN tariff rates in some countries, which results in the multiple-linearity issue; Secondly, the variations of the MFN tariff rates are very small over our observation years, and because of this the effects of the MFN tariff rate are largely absorbed by the country-industry fixed effects.

In the third model (column 3), we construct the indicator for the multilateral resistance terms as the product of the import penetration ratio (industrial level) and the MFN tariff rate, i.e. $\Theta_{jkt} \times MFN\_tariff_{ijkt}$. [6] Different from the results of model 2, we observe a significantly positive coefficient on the variable that indicates for the multilateral resistance terms, which means that if the importing country increases the tariff rate towards the country other than China, the importing flows from China will increase. Comparing the results between the first and second models, we find that it is important for accurately measuring the effects of the multilateral resistance to take the import penetration ratio into account. In the forth model (column 4), we measure the multilateral resistance as the weighted average tariff rate with the origin-based import values as weights, i.e $\sum_{m} \rho_{mjkt} ln\left(1+\tau_{mjkt}\right)$. The value-weighted average of tariff rate is a traditional indicator for the multilateral resistance terms. In this regression, we find a significantly positive coefficient on the weighted average tariff rate. In the fifth model (column 5), we compute the indicator for multilateral resistance as the product of the import penetration ratio of the importer and the average tariff rate weighted by the import values, i.e. $\Theta_{jkt} \times \left[\sum_{m} \rho_{mjkt} ln\left(1+\tau_{mjkt}\right)\right]$. Comparing with the forth model, we find a larger scale of the coefficient on the multilateral resistance terms. It indicates that we may underestimate the effects of the multilateral resistance terms in the forth model. The intuitive explanations for the difference between results of model 4 and 5 is as follows. As pointed out by some existing literature, e.g. Hanson and Xiang (2004), consumers may prefer more on the domestic products and the government also conducts some preferential policies for the domestic producers. That means the foreign and domestic firms usually face unequal market competition. In this case, we need to take the import penetration ratios (or domestic consumption ratios) in each market into consideration and re-scale the weighted average tariff rate by the import penetration

[6] The size of observations largly decreases from 249577 to 58464 because some values for the import penetration ratio are missing.

ratio. A smaller import penetration ratio means that Chinese firms (exporter) will face higher competition intensity from the domestic firms in the importing market but less from the other trade partners of the importing country. In this case, without involving the import penetration ratio, the weighted average tariff rate will over measure the scale of the multilateral resistance terms and thus leads to the underestimation of the effects.

As the sample size reduces significantly from model 4 to 5, we may concern that the result difference between both models could be attributed to the sample losses. In this case, we replicate the regression of model 4 but using the samples which show up in model 5 and report the relevant results in the last column. In the last estimation, we find a significantly positive coefficient on the multilateral resistance terms, which result is similar as that of model 4, indicating that our results are robust to the change of sample size.

Table 2 The direct and relative effects of tariffs: basic estimation

	(1)	(2)	(3)	(4)	(5)	(6)
Bilateral Tariff	-1.005***	-0.956***	-0.922***	-1.237***	-1.025***	-0.919***
	(0.095)	(0.129)	(0.252)	(0.126)	(0.255)	(0.277)
Multilateral Tariff		-0.110		0.444***		0.493*
		(0.169)		(0.142)		(0.269)
Multilateral Tariff×Import Penetration			1.442***		1.749***	
			(0.360)		(0.306)	
Importer-Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes
Importer-Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.922	0.922	0.943	0.922	0.943	0.943
Number of observations	249457	249457	63536	249457	63536	63536
Number of importers	177	177	105	177	105	105
Number of industries	144	144	119	144	119	119

Standard errors clustered by importer-industry. Significant at *** 1%, **5%, and *10%

5 Robustness Checks

5.1 Alternative specifications of the key indicators

In this section, we will check the robustness of our baseline estimation results. The first concern is that the simultaneity bias may arise when constructing the weighted average tariff rate using the importing value as weights: the importing value is endogenously determined by the tariff rate. To eliminate the potential simultaneity issue, we try two alternative methods to estimate the weighted average tariff rate, i.e. using the initial year's values as weights and keep the weights over time, or computing a simple average tariff rate with the same weight. The column 1 of table 2 reports the results with the simple average tariff rate, and it shows that the results do not change significantly from our previous estimation results with the weighted average tariff rate. In the second column of the table, we follow the method of Fugazza and Nicita (2013) and construct the weighted average tariff rate using the time-fixed weights which are computed as the average of importing value from each trade partner over three initial years, 1995 to 1997. In column 3, we use the method suggested by Haveman et al. (2003) and compute the relevant weights using each trade partner's total exporting value in each year. The regressions in column 4 and 5 take the misusing of the preferential tariff rates (PTRs) into consideration. In order to prevent the non-member countries from taking free ride on the PTR policy, the RTA members usually decide the qualification of the PTRs on products based on their national origins, where the national origins are distinguished according to the rules of origins. Specifically, the rules of origins require the products which benefit from the PTRs to satisfy the rule that their major production process or vital transformation is made within the geographic region of the RTA member countries. As the growing of intra-industrial trade and international co-operations in production processes, it's more and more costly for the firms to meet the requirements of the rules of origins. Firstly, in order to meet the rules of origins, the firms may decide their sources of intermediate inputs based on the origins rather than the qualities and prices of the inputs. Secondly, the firms need to spend more management fees to certify that their products meet the rules, because their intermediate inputs are sourced from more and more origins. Due to the rising of the cost, the firms may not ask for the PTRs, and they may face tariff rates higher than the PTRs. However, it is difficult to get the actual tariff rate faced by each firm and fully solve this issue. Instead, we try the following method to solve this issue partially. According to the approximations of Francois et.al (2006), the firms will choose the PTRs only if the MFN tariff rate is higher than the PER by 4%. In another study, Estevadeordal et al. (2008) estimate the same critical value as 2.5%. Following these studies, we assume that the firms will choose the MFN tariff rate when the difference between the MFN tariff rate and the PER is small enough. In column 4, we report the regression results with the assumption that the firms choose the MFN tariff rate when the difference between both types of tariff rates is less than 2.5%. In column 5, we run a similar regression as column 4 but re-set the critical value for the difference as 4%. Unsurprisingly, all these robustness check results are consistent with our baseline regression models. In column 6, we replicate the estimation with taking the simultaneity bias issue arising when computing the import penetration ratio into consideration. For example, if the bilateral tariff rates decrease, both the importing volume from the origin country and the import penetration ratio of the importing country will increase simultaneously. Using the similar method as the one discussed in previous content, we replace the original import penetration ratio with the time-fixed import penetration ratio which is averaged over the years 1995 to 1997 to solve this issue. Because lots of data are missing after 2009, the sample size enlarges when we use the time-fixed import penetration ratio. The estimation of column 6 shows an identical results as previous models. Besides all the robustness checks discussed above, we also check the case when we use the fixed import penetration ratio, fixed importing weights, and consider the availability ratio of the PTRs simultaneously, and find the results are still consistent with our previous ones.

Table 3 The direct and relative effects of tariffs: robustness checks on variable measurement

	(1)	(2)	(3)	(4)	(5)	(6)
Bilateral Tariff	-0.792***	-0.673***	-0.816***	-0.871***	-0.870***	-0.826***
	(0.263)	(0.256)	(0.263)	(0.262)	(0.262)	(0.261)
Multilateral Tariff×Import Penetration	1.572***	1.059***	1.679***	1.900***	1.900 ***	0.905**
	(0.301)	(0.325)	(0.336)	(0.329)	(0.329)	(0.400)
R2	0.943	0.943	0.943	0.943	0.943	0.941
Number of observations	63629	63638	63671	63688	63688	76108

Standard errors clustered by importer-industry. Significant at *** 1%, **5%, and *10%

5.2 Robustness of the model specification

In the first column of table 4, we control the variable import penetration ratio. In the second column, we control the consumption of each product in each country. Following Baler et al. (2014), we also try the difference-in-difference method to estimate the effects of the tariff on the trade performance. (See the column 3 of table 4) The reasons for adopting the difference-in-difference method is as follows: firstly, the tariff may have long-run effects on trading, however the fixed effects dummies may be inefficiency in a long period; secondly, considering the export value and tariff rate may be unit-root processes, Wooldridge (2010, p. 324) points out that the fixed effects estimation method may create the spurious regressions. Finally, in the last column, we consider the incomplete pass-through of the tariff, and run the regression using the export quantity as the dependent variable.

Table 4. The direct and relative effects of tariffs: alternative model specifications

	(1)	(2)	(3)	(4)
Bilateral Tariff	-0.899***	-1.220***	-1.000***	-1.108***
	(0.257)	(0.256)	(0.261)	(0.313)
Multilateral Tariff×Import Penetration	1.160***	2.832***	1.763***	1.958***
	(0.326)	(0.324)	(0.314)	(0.407)
Import Penetration Ratio	0.299***			
	(0.059)			
Consumption		0.258***		
		(0.017)		
R2	0.943	0.944	0.943	0.914
Number of observations	63536	63536	62447	63203

Standard errors clustered by importer-industry. Significant at *** 1%, **5%, and *10%

5.3 Other potential issues

Table 5 reports the results for checking the robustness when taking the effective lags of the tariff policies and the interactions of some other trade barriers on our results into account. TRAINS only investigates two types of bilateral tariff, i.e. the MFN tariff and preferential tariff, ignoring the general tariff imposed by the member countries on the products from the non-member countries. Although China had already enjoyed the MFN tariff rates in most countries before her entry into the WTO in 2001, some countries may still impose the general tariff rates on Chinese products after 2002. Thus, in the regression reported in column 1, we drop the samples before 2002. For the same reason, instead of dropping the data before 2002, we eliminate the samples of the non-members of the WTO at the observation year and report the relevant results in column 2. Column 3 discusses the missing issue of the preferential tariff policy. When referring to the tariff-reduction schedule in the regional trade agreements signed between China and other countries and the signature years of the agreements, we find the data are missing for the following country-year pairs : Peru (2011-2013), Pakistan (2009-2010), Chile (2013), Vietnam (2008-2009), Brunei (2006, 2010, 2012, 2013), Cambodia (2007), Indonesia (2008), Malaysia (2005, 2006, 2010-2013), Myanmar (2005, 2006, 2008, 2009, 2012, 2013), Philipines (2005, 2006, 2008, 2009, 2010), Singapore (2005, 2006, 2011), Thailand (2006-2013), New Zealand (2011, 2012). TRAINS uses the MFN tariff rates to replace the missing values of the PTRs. To avoid any bias arising due to this manipulation, we drop all the missing values of the PTRs in the regression of column 3. The estimation of column 4 considers the interactions of the non-tariff trade barriers on our results. It is still unclear about the relationship between the tariff and non-tariff trade barriers: some times, countries potentially set high tariff and non-tariff barriers simultaneously to protect their domestic producers and we will observe a positive correlation between the two types of trade barriers; in some other cases, when a country promises to reduce the import tariff, it may set some invisible non-tariff barriers at the same time to substitute the function of tariff, in which case we will see a negative correlation between both barriers. In this case, we cannot confirm how our estimation results are affected without controlling the effects of the non-tariff barriers. This paper doesn't discuss the case with the non-tariff trade barriers due to two reasons. Firstly, as pointed by Egger and Nelson (2011), the non-tariff barriers are mostly concentrated in the agricultural sector, but our research focuses on the manufacturing sector. Secondly, the data regarding the non-tariff barriers are very little. In the manufacturing sector, a typical example of the non-tariff barrier is the quota restriction set by U.S., Canada, and European Union on the textile products from China. In 2005, all countries terminate this quota restriction policy. To reduce the interactions of the quota restriction on our estimation results, in the regression of column 4, we eliminate the samples from the textile sector. [7] Lastly, considering the potential interactions of the financial crisis on our results, we drop the samples of the years 2008 and 2009 in column 5. In column 6, the incomplete pass-through of tariff is taken into consideration, and the dependent variable is replaced with the exporting quantity (instead of exporting value). Again, all these robustness check results are consistent with our baseline estimation models.

The last concern is the zero-trade issue. Many researches argue that ignoring the effects of the zero-trade samples may lead to the covariance heterogeneity and sample selection issues, i.e. Silva and Tenreyro (2006), Helpman, Melitz and Rubinstein (2008). In this case, they suggest to adopt the PPML model or the two stages estimation method to control the selection issue. In this paper, we don't consider the zero-trade issue because the zero-trade samples take very small proportion in our sample.

Table 5 The direct and relative effects of tariffs: checking other robustness concerns

	(1)	(2)	(3)	(4)	(5)
Bilateral Tariff	-0.901***	-0.766***	-1.000***	-1.043***	-0.958***
	(0.299)	(0.267)	(0.261)	(0.263)	(0.267)
Multilateral Tariff×Import Penetration	1.534***	1.708***	1.763***	1.708***	1.877***
	(0.351)	(0.310)	(0.314)	(0.313)	(0.323)
R2	0.954	0.945	0.943	0.942	0.944
Number of observations	42752	59631	62447	62262	56453

Standard errors clustered by importer-industry. Significant at *** 1%, **5%, and *10%

[7] The eliminated samples are mostly distributed in two industries, i.e. Preparation and spinning of textile fibres; weaving of textiles (1711), and Manufacture of wearing apparel, except fur apparel (1810).

6 Conclusion

It is usually ignored to distinguish the heterogeneity across industries among the existing literature which study the direct and relative effects of trade cost on trade performances. To the best of our acknowledge, all the previous studies on this issue are focused on the national aggregate level. In this paper, we adjust the conventional gravity-trading model to fit the empirical analysis at the industrial level and also prove that we can still use the Taylor-expansion method suggested by Baier and Bergstrand (2009) to linearize this adjusted version of the conventional model. In addition, to solve the issue that the data are missing for the globally industrial aggregate output, we decompose the multilateral resistance terms as a product of the nation-industrial level of import penetration ratio and a weighted average import tariff rate at the nation-industrial level with some assumption on the consumers' tastes across countries. We use the Chinese costume data to test the predictions of our theoretical model and have the following main findings: (i) reducing the tariff rate faced by some original country, the importing country will import more from this country but reduce the imports from the other countries; (ii) the relative effect is more effective at the industry where the import penetration ratio is relatively high in the importing country; and (iii) the omission of the import penetration ratio will underestimate the effects of the multilateral terms and also affects the scale of the coefficient on the bilateral tariff rate. In summary, our research contributes to the existing literature by introducing a manipulable method to compute the direct and relative effects of the trade cost at the industrial level, and emphasizing the industrial heterogeneity and the importance of involving the import penetration ratio into consideration, which distinguishes the competition from the foreign or domestic producers.

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Appendix

Proof of equation (4):

Define $\widetilde{t_{ijk}} \equiv t_{ijk}/t$, $\widetilde{P_{jk}} \equiv P_{jk}/t^{\frac{1}{2}}$, $\widetilde{\Pi_{ik}} \equiv \Pi_{ik}/t^{\frac{1}{2}}$, $b_{ik} \equiv \frac{\beta_{ik}Y_i}{\bar{\alpha}_k Y^T}$, and $a_{jk} \equiv \frac{\alpha_{jk}Y_j}{\bar{\alpha}_k Y^T}$.

If all countries face symmetric trade cost, i.e. $t_{ijk} = t$ for $\forall i$, j, k, the centralized tariff rate is directly solved as $\widetilde{t_{ijk}} = 1$. Following this result, we have $\widetilde{\Pi_{ik}}^{1-\sigma} = \sum\limits_j a_{jk}\widetilde{P_{jk}}^{\sigma-1}$ or equivalently $1 = \sum\limits_j a_{jk}\left(\widetilde{\Pi_{ik}}\widetilde{P_{jk}}\right)^{\sigma-1}$. As noted in Feenstra (2004, p. 158, footnote 11), the solution to this equation is $\widetilde{P_{jk}} = \widetilde{\Pi_{ik}} = 1$.

Before the log-linearization process, it is convenient to rewrite the equations for P_{jk} and Π_{ik} as:

$$\begin{cases} (1-\sigma)\, e^{lnP_{jk}} & = \sum\limits_i e^{lnb_{ik}} e^{(1-\sigma)lnt_{ijk}} e^{(\sigma-1)ln\Pi_{ik}} \\ (1-\sigma)\, e^{ln\Pi_{ik}} & = \sum\limits_j e^{lna_{jk}} e^{(1-\sigma)lnt_{ijk}} e^{(\sigma-1)lnP_{jk}} \end{cases} \tag{6}$$

Making first order log linearization of the equations above at the point $\left(\widetilde{\Pi_{ik}}, \widetilde{P_{jk}}, \widetilde{t_{ijk}}\right) = (1, 1, 1)$, we obtain the following equations:

$$\begin{cases} lnP_{jk} & = -\sum\limits_i b_{ik} ln\Pi_{ik} + \sum\limits_i b_{ik} lnt_{ijk} \\ ln\Pi_{ik} & = -\sum\limits_j a_{jk} lnP_{jk} + \sum\limits_j a_{jk} lnt_{ijk} \end{cases} \tag{7}$$

To solve for lnP_{jk} and $ln\Pi_{ik}$, we can simplify the problem with considering the case with only three countries. To simplify our notation in math steps, we define the following variables: $X_{jk} \equiv lnP_{jk}$, $Y_{ik} \equiv ln\Pi_{ik}$, $ext_{ik} \equiv \sum\limits_j a_{jk} lnt_{ijk}$, and $imt_{jk} \equiv \sum\limits_i b_{ik} lnt_{ijk}$. Following equation set (7) with assuming the number of countries is three, we have the following equation set:

$$\begin{cases} Y_{1k} = & -\sum_j^3 a_{jk} X_{jk} + ext_{1k} \\ Y_{2k} = & -\sum_j^3 a_{jk} X_{jk} + ext_{2k} \\ Y_{2k} = & -\sum_j^3 a_{jk} X_{jk} + ext_{2k} \\ X_{1k} = & -\sum_i^3 b_{ik} Y_{ik} + imt_{1k} \\ X_{2k} = & -\sum_i^3 b_{ik} Y_{ik} + imt_{2k} \\ X_{3k} = & -\sum_i^3 b_{ik} Y_{ik} + imt_{3k} \end{cases} \tag{8}$$

Normalizing the price index for country 1 in sector ι as $X_{1l} = 1$, and we write the price index for country 1 in sector k as $\rho_{1k} \equiv X_{1k}/X_{1l}$. Following these settings, we solve the equation set (8) as:

$$\begin{cases} Y_{1k} = & -\rho_{1k} + imt_{1k} - \sum_j^3 a_{jk} imt_{jk} + ext_{1k} \\ Y_{2k} = & -\rho_{1k} + imt_{1k} - \sum_j^3 a_{jk} imt_{jk} + ext_{2k} \\ Y_{2k} = & -\rho_{1k} + imt_{1k} - \sum_j^3 a_{jk} imt_{jk} + ext_{3k} \\ X_{1k} = & \rho_{1k} \\ X_{2k} = & \rho_{1k} + imt_{2k} - imt_{1k} \\ X_{3k} = & \rho_{1k} + imt_{3k} - imt_{1k} \end{cases} \tag{9}$$

Following equation set (9), we obtain the equation (4) directly.

Q.E.D.

Proof of equation (5):

In this proof, we focus on the transformation of the term $\sum_m \frac{\beta_{mk} Y_m}{\bar{\alpha}_k Y^T} ln\left(1 + \tau_{mjk}\right)$ to $\Theta_{jkt} \left(\sum_m \rho_{mjkt} ln\left(1 + \tau_{mjk}\right) \right)$.

Assume the consumption ratio of country j on product k out of the total output of product k of the country i as $\gamma_{ijk} \equiv \frac{X_{ijk}}{\beta_{ik} Y_i}$. Also we have $\gamma_{ijk} \equiv \frac{X_{ijk}}{\beta_{ik} Y_i} = \frac{t_{ijk}^{1-\sigma} \alpha_{jk} Y_j}{P_{jk}^{1-\sigma} \Pi_{ik}^{1-\sigma}}$. If we assume that the term $\frac{t_{ijk}^{1-\sigma} \alpha_{jk} Y_j}{P_{jk}^{1-\sigma} \Pi_{ik}^{1-\sigma}} \approx \alpha_{jk} Y_j * constant_k$, then we have γ_{ijk} is identical across i, i.e. $\gamma_{ijk} \approx \gamma_{jk}$. That means the country j will consume the same ratio of product k across all countries. The reasonability of this assumption relays on two points: firstly, at the starting point where we make our linearization, the trade costs across countries are assumed as identical, and at this point the equation $\gamma_{ijk} = \gamma_{jk}$ naturally holds; secondly, as the Taylor-expansion formula is an approximation of the original function using the information at the point where all trade costs are identical, we believe that the term $\sum\limits_m \frac{\beta_{mk} Y_m}{\bar{\alpha}_k Y^T} ln\left(1+\tau_{mjk}\right)$ approximately measures the average tariff rate weighted by the consumption ratio from each country. In this case, our transformation of the the term $\sum\limits_m \frac{\beta_{mk} Y_m}{\bar{\alpha}_k Y^T} ln\left(1+\tau_{mjk}\right)$ is to restore the information it describes. Following this assumption, we have $\sum\limits_m \frac{\beta_{mk} Y_m ln(1+\tau_{mjk})}{\bar{\alpha}_k Y^T} = \sum\limits_m \frac{\gamma_{jk}\beta_{mk} Y_m ln(1+\tau_{mjk})}{\gamma_{jk}\bar{\alpha}_k Y^T} \approx \sum\limits_m \frac{\gamma_{mjk}\beta_{mk} Y_m ln(1+\tau_{mjk})}{\gamma_{jk}\bar{\alpha}_k Y^T}$.

Then we have

$$\sum\limits_m \frac{\gamma_{mjk}\beta_{mk} Y_m ln(1+\tau_{mjk})}{\gamma_{jk}\bar{\alpha}_k Y^T}$$
$$= \frac{\sum\limits_m import\_value_{mjk} * ln(1+\tau_{mjk})}{\sum\limits_m import\_value_{mjk} * ln(1+\tau_{mjk}) + domstic\_value_{jk} - export\_value_{jk}}$$
$$= \frac{\sum\limits_m import\_value_{mjk} * lnt_{mjk}}{\sum\limits_m import\_value_{mjk}} * \frac{\sum\limits_m import\_value_{mjk}}{\sum\limits_m import\_value_{mjk} * ln(1+\tau_{mjk}) + domstic\_value_{jk} - export\_value_{jk}}$$
$$= \Theta_{jkt}\left[\sum\limits_m \rho_{mjkt} ln\left(1+\tau_{mjk}\right)\right]$$ [8]

Q.E.D.

[8] $\sum\limits_m \gamma_{mjk}\beta_{mk} Y_m ln\left(1+\tau_{mjk}\right) = \sum\limits_{m \neq j} import\_value_{mjk} * ln\left(1+\tau_{mjk}\right) + domestic\_value_{jk} * ln\left(1+\tau_{mjk}\right)$.However, as $ln\left(1+\tau_{mjk}\right) = 0$ (no tariff within one country), $\sum\limits_m \gamma_{mjk}\beta_{mk} Y_m ln\left(1+\tau_{mjk}\right) = \sum\limits_{m \neq j} import\_value_{mjk} * ln\left(1+\tau_{mjk}\right)$.