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RESEARCH ARTICLE

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Trade Restrictiveness and Deadweight Loss in China's Imports

Abstract China is believed to have gained immensely from its admission into the World Trade Organization (WTO) in 2001. One of the direct gains comes from the lessening of deadweight loss (DWL) due to tariff reduction. Conventional measures for DWL, however, are too aggregate to capture the trade policies, which are determined at a much higher disaggregated level, and ignore the interactions between tariff and corresponding import demand as suggested by theories. In this paper, we first systematically estimate the import demand elasticities at a highly disaggregated level and then match them with the most detailed lines of the applied tariff for the most favored nations as reported by the WTO. Using the detailed matching data, we construct Feenstra's (1995) simplified trade restrictiveness index (TRI), which captures the covariance of tariff and the corresponding demand elasticity. Finally, we use the TRI to compute the DWL from 1997 to 2008 and find that the DWL due to the tariff barrier was reduced to 0.73% of GNI in 2008, noticeably lower than the highest previous mark of 4.58% of GNI in 2001.

Keywords demand elasticities, non-processing imports, deadweight loss (DWL)

JEL Classification F12, F14, O47

1 Introduction

Over the past two decades, China has undergone salient growth and liberalization in its international trade sector. For example, China's level of trade openness, as

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measured by total value of trade (i.e., sum of import and export) divided by national GDP, amounts to about 60%—a drastic jump from nearly 25% in 1989. Although the whole world marvels at China's achievements as the so-called "world factory," relatively little attention has been given to its rapidly increasing import levels. Fig. 1 shows that the magnitude of China's import growth is similar to that of its export growth. To meet WTO's requirements, China has effectively removed many protection barriers against imports. For example, the simple average of China's import tariff has decreased from 17.51% in 1997 to 9.86% in 2008. As a result, China not only serves as one of the largest exporters in the world today, but is also one of the most attractive markets for international producers. Annual imports into China have increased from US$55 billion in 1988 to over US$1.1 trillion in just 20 years (see Fig. 1). This growth is especially drastic after China's accession into the WTO in 2001.

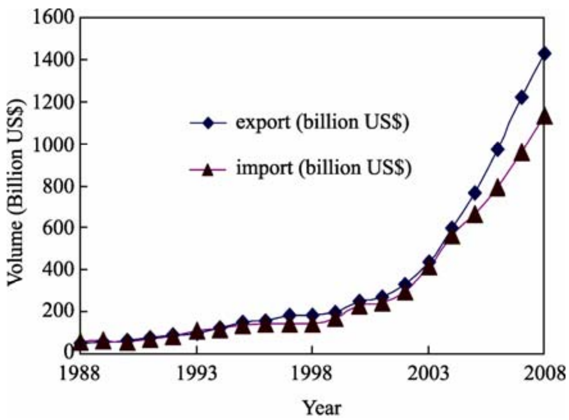

Fig. 1 China's Export and Import, 1988–2008

Source: General Administration of Customs of the People's Republic of China.

There are two related empirical questions following this trend: How much of the tariff barrier has China effectively removed, and consequently, how much welfare has China directly gained from reducing DWL due to lowered tariffs?[1] The first question needs to be answered by a scalar measure (referred to as "trade restrictiveness"), that is, a uniform tariff rate which can reasonably summarize the detailed changes across over 5,000 tariff lines. The ideal answer to the second question relies on information of detailed demand structures for thousands of imported products.

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[1] The gains from trade liberalization include not only reduction in tariff scheme, but also the removal of non-tariff barriers (NTBs) and other protective measures such as anti-dumping. Due to data limitation, we will focus on trade liberalization in the form of import tariff reduction.

To answer the first question, many studies often resort to using simple or weighted averages of all tariff lines.[2] Such measures, however, are neither theoretically solid nor empirically convincing. First of all, simple average neglects the huge difference of import values among imported goods, and therefore does not take into account the dispersed degrees of importance of different goods. Secondly, although the value-weighted average tariff rate does treat imported goods differently, it does so in a misleading way. Goods subject to higher tariffs will be imported less and thus receive lower weights. Therefore, value-weighted average tariff rates tend to underestimate the real restrictiveness. One extreme case is that a prohibitive tariff will not be counted in the weighted average tariff rate because the import volume is virtually zero. Furthermore, goods usually have different price elasticities of demand, that is, their responsiveness to price change (due to imposing tariff) varies vastly. Therefore, these types of measures, which lack solid theoretical support, are in general unsatisfactory gauges of real trade restrictiveness (Rodriguez and Rodrik, 2001).

Cipolina and Salvatici (2008) and Coughlin (2010) also survey and discuss literature on measuring trade restrictiveness and support the idea that an ideal restrictiveness (tariff) indicator should leave the country or a representative agent indifferent between facing the uniform tariff and facing otherwise various tariffs of different industries. For example, Kreikemeier and Moller (2008) and Falvey and Kreikemeier (2009) use this idea to discuss the welfare impact of tariff reform.

Anderson and Neary’s (1992, 1994, 1996, 2003, 2007) seminal work, in particular, provided trade restrictive indexes on a sound theoretical ground. Essentially, they define trade restrictiveness index (TRI) as a uniform tariff that generates the same aggregation results (i.e., welfare distortion, profit, volume, etc.) as the existing tariff structure.[3] Furthermore, their application shows the empirical applicability of the TRI in computable general equilibrium (CGE) models. The CGE-based indexes can take into account the income and substitution effects due to tariff changes and the interaction between tariff policy and domestic policies (i.e., taxation policy and monetary policy). However, these indexes suffer from a serious problem: Due to the constraints in CGE models, tariff changes have to be studied at an aggregated industry level, which cannot capture the heterogeneity of the protection levels within these industries.

Based on a partial equilibrium, which ignores the feedback effects in general equilibrium, Feenstra (1995) provides a simplified version of TRI that only

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[2] One common way is to use actual import volumes as weights. See, for example, Edwards (1998).

[3] See Anderson and Neary (2005) for a thorough discussion.

requires import demand elasticities, import shares, and tariff schedules. The greatly simplified TRI can be conveniently applied in econometric intensive approaches, which allows for tractability of highly disaggregated tariff lines. Kee et al. (2008, 2009) have applied Feenstra's (1995) TRI and estimate TRI indexes (as well as their trade barrier indexes) for a number of countries, including developed and developing ones. Furthermore, Kee et al. (2008) also show that TRI can be conveniently applied to calculate countries' DWL defined at a highly disaggregated tariff line level, which can be used to answer our second question.

This paper aims to measure the changes of China's trade restrictiveness and correspondingly China's DWL over the past decade due to revisions on tariff schedules required by WTO. More specifically, we first estimate the price elasticities, following the method proposed by Feenstra (1994) and Broda and Weinstein (2006). In particular, we utilize the most disaggregated product category available (Harmonized System at 8 digit, HS8) to do the estimation for as possible. We end up with several thousands elasticities. We then combine those estimates of elasticities with import shares and tariff data to construct a measure of TRI as suggested by Feenstra (1995) and Kee et al. (2008, 2009). Reduction in TRI from 1997 to 2008 is then used to compute the yearly DWL reduction in China's imports. Furthermore, since China regained its membership with the WTO at the end of 2001, which is covered by our data, we could also roughly gauge how much China gained directly from its WTO accession. We find thanks to WTO accession, China's DWL due to the import tariff barrier was reduced to 0.73% of GNI in 2008 from the highest level of 4.58% of GNI in 2001.

The most relevant paper to ours is Kee et al. (2008). However, these two papers differ substantially from the method of estimating import demand elasticities, which are the keys for computing DWL in both papers. Kee et al. (2008) develop a production-based semi-flexible GDP function from Kohli (1991) and Harrigan (1997), and use a panel estimation method to estimate the parameters needed in computing elasticities at 6-digit HS level. In contrast, we estimate our elasticities at 8-digit HS level based on the widely applied constant elasticity of substitution (CES) welfare function developed by Feenstra (1994) and Broda and Weinstein (2006). In comparison, their elasticities non-linearly depend on the estimates of the own price elasticities of GDP, which are estimated by a panel analysis. That is, they have to assume that their own price elasticities are the same across 88 countries in the panel. This is a fairly strong assumption because each respective country's price elasticities typically depend on the country's production technology, which is rather different across countries.[4]

[4] Note that import demand derived from GDP function is partly determined by the production technology.

Nevertheless, ours are estimated only from China's import data, and thus we do not rely on this assumption. Furthermore, the variances of their elasticities depend on those of their own price elasticities inflated by the square of the inverse HS6 level import shares. The import shares are typically fairly small at this disaggregated level; hence, the variance of the elasticities is significantly inflated, which makes the elasticities less accurate.

We make contributions on the following two fronts. First, we provide systematic import demand elasticity estimates for more than 4,000 import industries at the HS8 level (the most disaggregated import industry level available in China). Such highly disaggregated elasticities allow us to more accurately obtain the elasticities at higher aggregate levels (i.e., HS6 level in this paper).[5] We weight these highly disaggregated import demand elasticities to the HS6 levels to match the HS6 tariff lines recorded by WTO, which, to our knowledge, is the first detailed study in China. Following Feenstra (1995), we construct TRI for China, which takes into account not only the conventional weighted tariff but also the effects of tariff variance and their covariance with elasticities. The TRI allows us to compute closely the change on DWL in China over time and thus reveal the alleviation of tariff distortion, thanks to the WTO. Second, we correct the problem caused by processing imports in our calculation of China's DWL. The role of processing trade is often ignored in the existing literature, including in Kee et al. (2008). In fact, around one third of China's total imports in the most recent decade are imported intermediates for processing. As discussed in Chen and Ma (2011), unlike the ordinary imports, processing imports enjoy free duty and are mainly used for producing exports. Therefore, processing imports do not actually suffer from tariff distortion, and including them will seriously overstate the DWL. After correcting the disturbance of processing imports, our estimates of elasticities, TRI, and corresponding DWL are all concerned with "ordinary imports."

The rest of the paper is organized as follows. Section 2 presents an overview of China's imports and tariffs in the most recent decade. Section 3 discusses the empirical strategy for estimating import demand elasticities. Section 4 constructs a TRI and computes the DWL in China's imports from 1997 to 2008. Section 5 concludes.

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[5] Because of the fact that goods are highly differentiable, elasticities that are estimated at an aggregate level cannot capture the heterogeneity of the goods at a higher disaggregated level (see Broda and Weinstein (2006)).

2 Data Overview

Our import data consist of import values and quantities as reported by the General Administration of Customs of the People's Republic of China (GAC) at 8-digit HS level (HS-8), which is highly disaggregate. However, since HS-8 was introduced by the GAC after 1996, our dataset covers only the most recent 12 years, from 1997 to 2008. Another notable feature of China's import is that a significant share of imported products lies under the category of imported intermediate inputs, which will be processed in China's factories and then exported as finished goods. Considering that imports labeled as "for processing" are exempt from import tax or VAT,[6] including processing imports in our empirical investigation will bias our trade restrictiveness measure. Thus, we will only consider non-processing trade in this paper. Fig. 2 shows the basic trend of total imports and non-processing imports over the past two decades. Over time, the share of non-processing trade initially decreased from over 70% to nearly 50%, and then eventually increased to two-thirds of the total imports. On average, we have more than 6,000 imported products, and each product has been sourced from over 10 countries. With this dataset, we could compute import shares, and estimate the elasticities of imports as well.

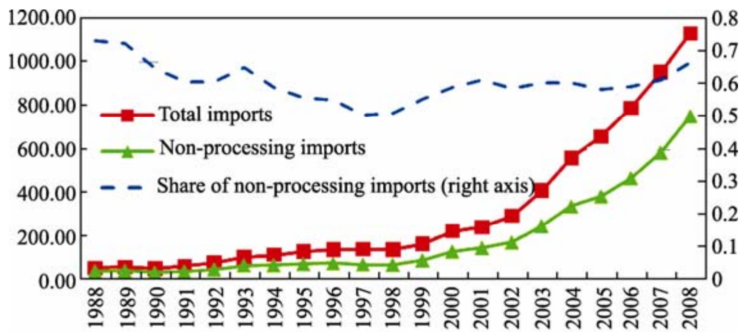

Fig. 2 Total Imports and Non-Processing Imports

Source: General Administration of Customs of the People's Republic of China.

Our tariff data come from the World Integrated Trade Solution (WITS), which is at 6-digit HS level. The tariff data for 2002, however, is missing in the WITS. So we supplement WITS using data from the WTO when necessary. An overview of the data indicates that the average tariff rates were eventually reduced during

[6] To be more precise, there are two subcategories within "processing" trade: processing and assembly, and processing with imported inputs. Under the first category, firms do not pay import tax or VAT, whereas for the second category, firms pay the taxes first and then claim the rebates when the finished goods are exported.

our sample period. This is shown in Fig. 3, where we depict the simple and weighted average tariff rate, as well as the TRI, which we will estimate in Section 5. Obviously, we could see a sharp drop of average tariff rates around 2001, when China formally regained its WTO membership. With tariff data at 6-digit HS level, we will merge HS-8 products into HS-6 and then match with the MFN tariff.

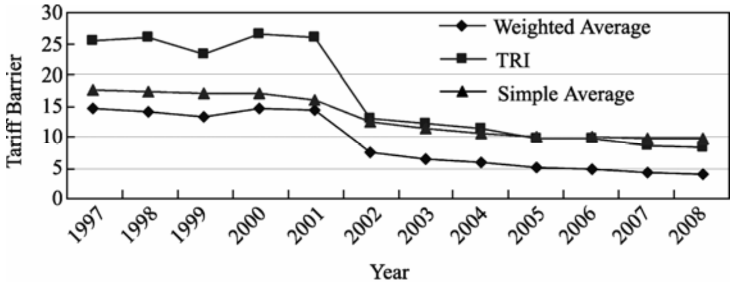

Fig. 3 Simple and Weighted Average Tariff Versus TRI

Source: General Administration of Customs, P. R. China and Authors' own calculation based on data from the WITS Tariff Database and the General Administration of Customs.

3 Empirical Strategy

As is widely applied in trade and many other fields of economics, we assume that a country's welfare on imports can be summarized by a constant elasticity of substitution (CES) function initially introduced by Dixit and Stiglitz (1977). That is, we assume that the elasticity of substitution between varieties, σ (sigma), within the same goods, g, is constant. A remarkable feature of such CES functional form is that the elasticity of substitution between varieties, the sigma, can also be interpreted as the price elasticity of demand for given imported goods.

As is standard in macro-level studies, a variety as defined by Armington (1969) is a country-goods pair. Particularly, a good in this paper is an HS-8 category, and varieties of it are its exporting countries. For instance, "safety headgear" is a typical HS-8 product ("HS 65061000"). Suppose China imports this product from six different countries, then we shall treat "safety headgear" as a good with six imported varieties. A typical import demand function derived from the CES welfare maximization problem is shown as,

$$\Delta \ln s_{gvt} = \varphi_{gt} - (\sigma_g - 1)\Delta \ln p_{gvt} + \varepsilon_{gvt} , \tag{1}$$

where s_{gvt} is the imports share of variety *v* of goods *g*;[7] φ_{gt} acts as a random effect to capture the special characters of demand on goods *g* overtime; p_{gvt} is the price of variety *v* of goods *g*; ε_{gvt} is the error term; σ_g is the time invariant elasticity[8] of substitution between varieties of goods *g*, and it is assumed to be bigger than unity to ensure a convex welfare. Finally, the difference operator " Δ " is applied between years to phase out goods-fixed effects.

However, Eq. (1) has two problems, which result in biased estimation for the sigmas. First, there is a simultaneity problem. That is, supply curves facing the importing countries may be upward-sloping, which result in import prices to increase with higher import demand. Second, there is a measurement error problem. The prices of imports are usually unavailable; hence, they are approximated by unit prices. Therefore, prices and demand may still be correlated.

To solve the simultaneity problem, we follow Broda and Weinstein (2006) and assume an upward sloping supply curve as Eq. (2).

$$\Delta \ln p_{gvt} = \psi_{gt} + \frac{\omega_g}{1+\omega_g} \Delta \ln s_{gvt} + \delta_{gvt} , \tag{2}$$

where ψ_{gt} is a random effect to capture the special characters of supply on goods *g* overtime; $\omega_g \geqslant 0$ is the inverse supply elasticity, and δ_{gvt} is the error term that captures any random changes in the production technology.

Considering that both φ_{gt} and ψ_{gt} are unobserved random effects, we further difference equations (1) and (2) with a base country "*b*".[9] The "difference in difference" of the demand and supply equations is respectively given by equations (3) and (4):

$$\Delta^b \ln s_{gvt} = -(\sigma_g - 1)\Delta^b \ln p_{gvt} + \varepsilon^b_{gvt} , \tag{3}$$

$$\Delta^b \ln p_{gvt} = \frac{\omega_g}{1+\omega_g} \Delta^b \ln s_{gvt} + \delta^b_{gvt} , \tag{4}$$

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[7] Demand is expressed in terms of expenditure shares rather than quantities to avoid the potential measurement error imparted from the use of unit values. See Kemp (1962).

[8] Intuitively, the elasticities, which reflect productivity or tastes, should not significantly change in a short period. For example, Broda, Greenfield, and Weinstein (2006) find that the elasticities of 77 countries do not significantly change during the two sub-periods: 1994–1998 and 1999–2003.

[9] The base country varies across goods. Basically, the based country of goods "*g*" just needs to be the country that exports "*g*" every year or most frequently from 1997 to 2008.

where $\Delta^b x_{gvt} = \Delta x_{gvt} - \Delta x_{gbt}$. For the sake of identification, we assume that $E(\varepsilon^b_{gvt}\delta^b_{gvt}) = 0$. That is, demand and supply errors are uncorrelated once goods and time specific effects are controlled for.

By multiplying (3) and (4), we obtain a "reduced form" as Eq. (5)

$$(\Delta^b \ln p_{gvt})^2 = \theta_1(\Delta^b \ln s_{gvt})^2 + \theta_2(\Delta^b \ln p_{gvt}\Delta^b \ln s_{gvt}) + u_{gvt}, \tag{5}$$

where $\theta_1 = \dfrac{\omega_g}{(1+\omega_g)(\sigma_g - 1)}$, $\theta_2 = \dfrac{1-\omega_g(\sigma_g - 2)}{(1+\omega_g)(\sigma_g - 1)}$, and $u_{gvt} = \varepsilon^b_{gvt}\delta^b_{gvt}$.

Note that Eq. (5) provides the relationship between equilibrium prices (measured by unit prices) and quantities (measured by share) without the simultaneity problem as we assume $E(u_{gvt}) = E(\varepsilon^b_{gvt}\delta^b_{gvt}) = 0$. However, Eq. (5) still suffers from measurement error problems, which result in the OLS estimates of $\beta_g = \begin{pmatrix}\sigma_g \\ \omega_g\end{pmatrix}$ becoming inconsistent. Feenstra (1994) proposes that consistent estimates can still be obtained if we exploit the panel nature of the data set and assume constant supply and demand elasticities for the same goods over time. Particularly, averaging Eq. (5) overtime, the error term $\overline{u_{gv}}$ is independent of the regression and given σ_g and ω_g are time invariant. The unbiased estimates can then be obtained from Eq. (6).

$$\overline{(\Delta^b \ln p_{gv})^2} = \theta_1\overline{(\Delta^b \ln s_{gv})^2} + \theta_2\overline{(\Delta^b \ln p_{gv}\Delta^b \ln s_{gv})} + \overline{u_{gv}}, \tag{6}$$

where $\overline{x}$ denotes the time average.

We use the generalized method of moments (GMM) to exploit the independence of the unobserved demand and supply disturbances for each country over time. According to Feenstra (1994), we can define a set of moment conditions such that

$$G(\beta_g) = E_t(u_{gvt}(\beta_g)) = 0 \ \forall \ v, \tag{7}$$

as long as all countries exporting goods *g* satisfy the following condition:

$$\chi^2_{\varepsilon^b_{gv}} / \chi^2_{\varepsilon^b_{gv}} \neq \chi^2_{\delta^b_{gv}} / \chi^2_{\delta^b_{gv}},$$

where χ^2_x is the variance of *x*. Eq. (7), therefore, gives us V_g independent moment conditions for each goods *g* to estimate the two parameters of interest. For each goods *g*, the following objective function can be used to obtain Hansen's (1982) estimator:

$$\hat{\beta}_g = \arg\min_{\beta \in B} G^*(\beta_g)' W G^*(\beta_g), \tag{8}$$

where $G^*(\beta_g)$ is the sample analog of $G(\beta)$; *W* is a positive definite weighting matrix; and *B* is the set of economically feasible β such that $\sigma_g > 1$ and $\omega_g \geqslant 0$. Specifically, the weighting matrix, *W*, is related to the time span and the inverse of lagged import quantities as in Broda and Weinstein (2006). We first estimate θ_1 and θ_2 and then solve for β_g. The standard errors for β_g are derived using the delta method. In case of ill-defined estimates, we use a grid search of β's over the space defined by *B*. In particular, we compute the minimized GMM objective function over $\sigma_g \in [1.05, 200.5]$ at intervals that are 5% apart. Standard errors of β_g in this case are obtained by bootstrapping the grid-searched parameters.

4 TRI and DWL

We use the following steps to calculate the DWL due to tariff cuts from 1997 to 2008. First, we estimate the elasticity of substitution (among the varieties), σ_g, for more than 4,000 of HS 8-digit goods and aggregate them to the HS-6 level to match with the tariff data. Next, we calculate the TRI using the formula suggested by Feenstra (1995). Then we follow Kee et al. (2008) to decompose the TRI into three components, namely, the import weighted tariff, the variance of the tariffs, and the covariance between tariffs and import demand elasticities. Finally, we apply the TRI to compute the DWL from 1997 to 2008.

4.1 Elasticities of Substitution

We successfully estimate the sigmas for 4,034 HS-8 imported goods.[10] It is impossible to report all the sigmas. Instead, we report in Table 1 the means of estimated sigmas for 16 HS-2 aggregation categories.

Column (3) in Table 1 shows that the most important imports are machinery/electrical products and mineral products, which account for 31.46% and 23.74% of the total imports, respectively. Column (4) reports the number of HS-8 goods in each industry. Relatively many more differentiated goods are in machinery/electrical, textiles industries and allied industries than others, which

[10] We abandon those estimates that do not make economic sense. That is, we drop the sigma estimates that are smaller than unity and larger than 250, which amounts for 20% of all the sigma estimates. As a comparison, Kee et al. drop 17% of theirs.

on average have 1,822, 1,330 and 1,311 HS-8 goods, respectively, during the sample period. Column (5) reports the median number of varieties, which ranges from the lowest of 2.68 in animal and animal products to the highest of 5.02 in plastics/rubbers, raw hides, skins, leather. The most important results, the sigmas, are reported in Column (6). The simple average of sigmas ranked from the smallest of 3.75 in machinery/electrical products to the largest of 12.83 in foodstuffs. Aside from the reports in Table 1, we also compute the overall median and simple average of sigmas, which are about 3.54 and 7.69, respectively.

Table 1 Sigma's for HS-2 Aggregation Level

HS-2 Code	Industry	Average import share* (%)	Number of HS-8 goods	Varieties per HS-8 goods	Sigma	
					Simple Average	Weighted Average
(1)	(2)	(3)	(4)	(5)	(6)	(7)
01–05	Animal & Animal Products	0.64	366	2.68	10.96	5.56
06–15	Vegetable Products	4.01	622	2.84	10.10	4.62
16–24	Foodstuffs	0.94	324	3.32	12.83	6.45
25–27	Mineral Products	23.74	245	3.30	11.24	5.20
28–38	Chemicals & Allied Industries	9.64	1330	4.03	9.23	4.08
39–40	Plastics / Rubbers	4.55	304	5.02	10.22	4.75
41–43	Raw Hides, Skins, Leather, Furs	0.27	158	2.92	9.53	4.10
44–49	Wood & Wood Products	3.40	462	3.54	12.09	4.68
50–63	Textiles	1.66	1311	3.45	6.55	3.55
64–67	Footwear / Headgear	0.05	70	3.75	6.25	3.10
68–71	Stone / Glass	0.72	307	3.87	6.21	3.37
72–83	Metals	8.30	878	4.08	8.36	3.63
84–85	Machinery / Electrical	31.46	1822	4.19	3.75	2.62
86–89	Transportation	5.95	360	3.19	6.85	3.39
90–97	Miscellaneous	4.69	616	4.33	4.51	2.59

Note: * denotes the average import share throughout 1997 to 2008.

Source: Authors' calculation.

As a comparison, Broda, Greenfield, and Weinstein (2006, hereafter, BGW) estimate the import demand elasticities for 73 countries in the world including China. They employ the HS-6 digit data from the COMTRADE database in

1994–2003 and aggregate the elasticities at the HS-3 digit level. Based on a similar estimation method, they report that the median import elasticity of China is about 3.4 and the simple average is about 6.2, which seems slightly smaller than our estimates. Except for the time coverage difference (we contain more post-WTO data), the small discrepancy between our findings and BGW's (2006) is mainly due to the generally lower substitutability of goods at the HS-6 level in their study than those at the HS-8 level in ours. As stated in the empirical strategy, sigma is the elasticity of substitution between varieties. A lower sigma implies less substitutable variety. Goods in the more aggregated level are intuitively less substitutable; hence, we are expected to find larger sigmas than those in BGW (2006). Another comparison is with Kee et al. (2008). They employ HS-6 data from 1988 to 2001 and use a rather different estimating strategy. They report that the simple average of China's import elasticities (HS-6 level) is 7.26, which is very close to ours. Although it is hard to argue which estimation is more precise, ours is at least fairly in line with the relevant works in general.

Next, we aggregate the sigmas at the HS-8 level to the HS-6 level to match the tariff data. That is, the HS-6 sigmas are the weighted ones at the HS-8 level in the same HS-6 category where the weights are the corresponding HS-8 imports values. Although we eventually also have sigmas at the HS-6 level as in Kee et al. (2008), ours have one advantage over theirs. That is, the HS-6 level sigmas are obtained from the HS-8 level, which are based on finer/more disaggregated data and thus have better quality. Of course, due to data availability, it is not possible to match all the tariff lines at the HS-6 level.[11] However, given that consumers usually have similar tastes for similar goods, we assume that a missing sigma can be extrapolated based on sigmas of similar goods (i.e., the HS-6 goods under the same HS-4 category). Thus, we approximate a missing HS-6 sigma by the weighted average of the sigmas in the rest of the HS-6 industries that are under the same HS-4 category.

4.2 Constructing TRI and Calculating DWL

We directly apply our elasticities estimates to the Feenstra's (1995) TRI, as specified below:

$$TRI_t = \left[\frac{\sum_n s_{nt} \sigma_n t_{nt}^2}{\sum_n s_{nt} \sigma_n} \right]^{1/2}, \tag{9}$$

[11] For example, to estimate Eq. (6), we need at least four supplying countries in each HS-8 goods that survives at least two years.

where s_n is the import share of goods *n* (defined at the HS-6 level); σ_n is the corresponding elasticity of substitution that is time invariant; t_n is the corresponding tariff; and the subscript *t* denotes year.

Kee et al. (2008) show that the Feenstra's (1995) TRI in Eq. (9) can be simply expressed as a function of weighted tariffs ($\bar{t}$), variance of the tariffs (δ^2), and the covariance between tariffs and the corresponding import demand elasticities (ρ). The relevant variables are defined as follows:

(1) Import weighted tariff: $\bar{t}_t = \sum_n s_{nt} t_{nt}$; variance of tariffs: $\delta_t^2 = \sum_n s_{nt} (t_{nt} - \bar{t}_t)^2$;

(2) Import weighted elasticity of substitution: $\bar{\sigma}_t = \sum_n s_{nt} \sigma_n$;

(3) Adjusted elasticities: $\tilde{\sigma}_{nt} \equiv \dfrac{\sigma_n}{\bar{\sigma}_t}$; and the covariance: $\rho_t = Cov(\tilde{\sigma}_{nt}, t_{nt}^2)$.

Note that although individual elasticity is time invariant, their average and the adjusted ones are time variant because the weights change overtime. TRI can be rewritten as Equation (10):

$$TRI_t = \left[\sum_n s_{nt} \tilde{\sigma}_{nt} t_{nt}^2\right]^{1/2} = [E(\tilde{\sigma}_{nt} t_{nt}^2)]^{1/2} = [\bar{t}_t^2 + \delta_t^2 + \rho_t]^{1/2} . \qquad (10)$$

Eq. (10) clearly reveals that TRI is theoretically consistent: as suggested by TRI, trade restriction should be higher than otherwise suggested by the weighted average tariff if the tariffs have a big variance and the tariffs are positively related to the import demand elasticities. Intuitively, the higher variance of tariffs implies a higher probability of highly distortionary or even prohibitive tariffs on some specific industries. Furthermore, the restriction would be more severe if higher tariffs were imposed on goods with higher demand elasticities (i.e., more sensitive to price changes).

Table 2 reports the TRI in China from 1997 to 2008. Columns (2) and (4) report simple average tariff and TRI. Both measures reveal that China effectively reduces its tariff barrier after 2001, the year it accessed to the WTO. However, such WTO effect seems to fade away gradually in 2007 and 2008. The trade restrictiveness indicated by TRI is higher than otherwise suggested by the simple average tariff except in 2007 and 2008. The reason can be uncovered from the decomposition of TRI as reported in Columns (5)–(7). Compared to the simple average tariff, TRI is higher in the early years mainly due to the high variation of tariffs. Faster decrease in TRI can be attributed to the great reduction of the variation. This reduction indicates that China not only reduces overall tariff but also reduces more on the relatively higher tariff. As a result, tariff rates are more harmonized, and the variance is significantly smaller. Interestingly, column (3) (the same as column (5)) is the value-weighted average tariff, which is persistently smaller than the simple average tariff and TRI. The reason can be revealed in column (7): the positive covariance between import elasticities and tariffs implies that China's government still tends to set relatively higher (more restrictive) tariffs on imports with higher demand elasticities since the reduction on those tariffs means faster growth on those imports.

Table 2 Trade Restrictiveness Indexes in China: 1997–2008

Year	Simple average tariff	Weighted average tariff	Trade restrictiveness index (TRI)	Decomposition of TRI		
				Average	Variance	Covariance
1997	17.51	14.71	25.48	14.71	322.55	110.12
1998	17.43	14.17	25.85	14.17	315.88	151.47
1999	17.04	13.27	23.24	13.27	265.18	98.71
2000	16.98	14.68	26.51	14.68	345.24	141.83
2001	15.88	14.42	25.85	14.42	344.63	115.69
2002	12.37	7.53	12.96	7.53	89.82	21.42
2003	11.30	6.59	12.08	6.59	72.72	29.80
2004	10.41	6.06	11.23	6.06	75.72	13.80
2005	9.99	5.15	9.62	5.15	54.32	11.70
2006	9.95	4.88	9.60	4.88	49.02	19.37
2007	9.86	4.43	8.62	4.43	38.39	16.33
2008	9.86	4.13	8.29	4.13	35.40	16.26

Source: Authors' own calculation based on data from the WITS Tariff Database and China Customs General.

Finally, following Kee et al. (2008), the DWL given TRI and its decomposition can be calculated from Eq. (11):

$$\begin{aligned} DWL_t &= \frac{1}{2} IMP_t \sum\nolimits_n s_{nt}\sigma_n t_{nt}^2 = \frac{1}{2}(TRI_t)^2 \sum\nolimits_n s_{nt}\sigma_n \\ &= \frac{1}{2} \underbrace{\bar{t}_t^{\,2} IMP_t \bar{\sigma}_t}_{\text{weighted average tariff}} + \frac{1}{2} \underbrace{\sigma_t^2 IMP_t \bar{\sigma}_t}_{\text{tariff variance}} + \frac{1}{2} \underbrace{\rho_t IMP_t \bar{\sigma}_t}_{\text{tariff-elasticity covariance}}, \end{aligned} \tag{11}$$

where *IMP* denotes the total import value.

Eq. (11) shows that the total DWL can be further decomposed into the losses from weighted average tariff, tariff variance, and tariff-elasticity covariance, respectively.

Table 3 reports the DWL in China's imports from 1997 to 2008. The DWL peaks in 2001 with the largest loss of US$ 59,737 million, followed by a sharp drop in 2002 with a loss of US$ 15,164 million, then the loss modestly grows with some variations until 2008.[12] Considering the decreasing TRI after 2001, the growing loss is mainly attributed to the rapid increase in China's imports after 2001. That is, the base for calculating DWL has significantly expanded. Similar dynamic patterns are reported in the decomposed DWL due to average tariff, tariff variance, and their covariance with corresponding tariffs. The alleviation of DWL due to tariff reduction, however, can be better measured by the DWL-GNI ratio as reported in Column (3). Compared to 2001, China's income/welfare loss due to the existence of tariff barrier is significantly reduced from the highest 4.58% of GNI in 2001 to only 0.73% of GNI in 2008.

Table 3 Deadweight Loss Due to Import Tariff in China: 1997–2008

Year	Total deadweight loss [a] (DWL)	DWL as percentage of GNI	Decomposition of DWL		
			Average	Variance	Covariance
1997	21909.01	2.33	7305.54	10886.77	3716.70
1998	22905.74	2.28	6885.32	10828.14	5192.28
1999	24361.08	2.28	7944.09	11963.75	4453.24
2000	52654.28	4.45	16152.66	25873.01	10628.61
2001	59737.66	4.58	18594.30	30803.15	10340.21
2002	15164.04	1.05	5121.71	8108.42	1933.91
2003	20403.5	1.25	6076.68	10162.28	4164.54
2004	25083.66	1.30	7294.02	15047.91	2741.73
2005	21105.37	0.94	6055.29	12382.22	2667.87
2006	25355.81	0.95	6549.78	13479.16	5326.87
2007	26341.29	0.77	6953.03	13601.87	5786.39
2008	31746.34	0.73	7892.75	16345.48	7508.11

Note: [a] Losses are measured in current million US dollars.

Source: Authors' own calculation.

5 Conclusion

The past decade has seen an enormous liberalization in China's foreign trade. Although the literature discusses intensively the surge in China's exports, relatively few studies focus on its imports, which has shown growth of similar magnitude in recent years. The current paper aims to measure the restrictiveness of China with regard to imports. The reduction in trade restrictiveness helps in

[12] The currency unit is current dollar. However, the dynamic pattern will not change even if we use real dollar.

understanding the welfare gain from reducing DWL due to less distortionary tariff schedules.

To achieve this goal, we use extremely disaggregated import data from 1997 to 2008 to estimate the demand elasticities for more than 4,000 imported goods. Such detailed elasticities then allow us to construct a good measure of TRI, following the methodology proposed in Feenstra (1994) and Kee et al. (2008). We find the movement of TRI over our sample period1997–2008 to be much more dramatic compared to the conventional measure of protection, such as the simple or weighted average of tariff schedules. Moreover, given our estimates of TRIs, we predict that thanks to WTO accession the DWL due to tariff barrier was reduced to 0.73% of GNI in 2008 from the highest of 4.58% of GNI in 2001.

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