Review of Development Economics, *18(2)*, *231–253*, *2014*
DOI:10.1111/rode.12081

Measuring the Impact of Trade Protection on Industrial Production Size

*Wei Tian and Miaojie Yu**

Abstract

Trade theory has no clear prediction on how import protection affects an importing sector's relative size. In this paper, we estimate the impact of US trade protection on industrial production relative size based on a translog GDP functional system. Using an industrial panel data set and controlling for factor endowments and technology improvement, we find empirical evidence that trade protection does not help much increase a sector's relative size. Such findings are also robust to both the inclusion of the role of political economy and the coverage of various non-tariff measures as proxies of industrial protection.

1. Introduction

When a government imposes an instrument of trade policy on its imports, it has a direct impact on both producers and consumers. An import tariff on a small country pushes up its domestic import price which in turn leads to higher domestic production and less consumption on the import. Without a doubt, a very small country bears a deadweight loss owing to both production and consumption distortions. In contrast, a large country might improve its national welfare owing to extra gains from terms of trade. This is because the terms of trade, its world relative price of exports relative to imports, would increase as a result of the change of the relative demand and supply of the import. Regardless of a country's size, an import tariff clearly raises both the import price and the quantity produced; yet the industrial relative size for the import sector does not necessarily increase since the tariff could indirectly change the sizes of other sectors as well.

Therefore, whether strong protection in an industry leads to high output share remains an empirical question. In fact, one can easily find opposing evidence for different industries. For example, in the 1960s, the USA abandoned high trade protection on its footwear industry. As a result, the output in the footwear industry decreased dramatically (Cassing and Hillman, 1986). Conversely, the story of the garment industry shows another side of the coin. Traditionally, the garment industry is one of the most highly protected sectors by the US government, yet its output share relative to the gross domestic product (GDP) shows a decreasing trend over the years.

In this paper we therefore estimate the effect of trade protection for an industry on its output share. Our paper contributes to the literature from two important perspectives. First, we extend the seminal work of Harrigan (1997) by considering the role of trade protection in a neoclassical trade specification model which believes that the

* Yu: China Center for Economic Research, National School of Development, Peking University, Beijing 100871, China. Tel: +86-10-6275-3109; Fax: +86-10-6275-1474; E-mail: mjyu@ccer.pku.edu.cn. Tian: School of International Trade and Economics, University of International Business and Economics (UIBE), Beijing 100871, China. The authors thank Robert Feenstra and Xiaopeng Yin for their very full comments for this project. However, all errors remains those of the authors.

pattern of international specification and trade is jointly determined by technology difference *a là* the Ricardian model and factor endowment difference *a là* the Heckscher–Ohlin–Vanik model. In contrast to an ideal free-trade setup, our empirical specification is closer to reality by allowing various trade protections such as import tariffs and non-barrier barriers such as import quota or export subsidy. We find strong evidence that trade protection plays a role in determining industrial size for some manufacturing industries.

Second, our empirical findings themselves also enrich the understanding of the effect of trade protection. It is a conventional wisdom that an industry could grow faster under import protection. For more than a century policy makers and even some economists believe the idea of "infant industry protection" as a favorable argument for trade protection. Our empirical findings instead cast doubt on such a theoretical conjecture. After controlling for factor endowments and technology improvement, we find empirical evidence that trade protection does not greatly help increase a sector's relative size, measured by its industrial output share over GDP.

The objective of this paper is to see how an import tariff imposed on an industry can change production sizes of itself and other related industries particularly in the USA. It is important to emphasize that a change in industrial production size could occur for reasons other than the change of an import tariff. First, the change of industrial output share could be due to factor endowment changes caused by a movement of international factors or other reasons. For example, consider a standard Heckscher–Ohlin model, in which labor is migrated from the foreign country to the home country. The home country's labor-intensive sector will expand according to the Rybczynski theorem.

Second, it might be because of the export-biased technology improvement. The advanced technology used in export-biased industries causes the expansion of exportable. Accordingly, resources will shift toward the exporting sectors from the importing sectors, which in turn causes the shrink of the importing sectors. As known as the "Immiserizing growth" initiated by Bhagwati (1958), for a large country, if the exportable-biased growth reduces the output of the importable good, and if the foreign demand for such an importable good is inelastic, then its national welfare would be reduced, in large part, because of the deterioration of its terms of trade.

Third, nontradable sectors grow very fast today. For example, according to the reports from the Bureau of Economic Analysis (BEA), the weight of professional services related to the GDP in the USA reached 20% in 2006. Such a quick move would make tradable sectors shrink relatively, which in turn also leads to a relative decline of import-competing tradable sectors. In addition, other domestic industrial policies such as a production subsidy on import-competing commodities could also make sizes of importing sectors shrink.

Finally, factors from the demand side could affect the industrial output share as well. For instance, an increase in the price of substitutable commodities for an industry could push the industrial demand curve shift right, since consumers will substitute commodities in the industry for their substitutable goods. Accordingly, both the equilibrium price and output increase, given others constant. In other words, an increase in the price of substitutables for an industry could affect its industrial output share.

Therefore, to estimate the effect of trade policy on production size for each industry, we need to control for other factors affecting industrial production size such as factor endowments, technology and price changes from other industries. We adopt a functional form of translog GDP system to handle this task for two reasons.

First, the translog GDP functional form can *systematically* measure effects of tariffs on industrial output shares for many industries. Since a change of one sector's price could affect, though indirectly, other sectors' outputs, it is inappropriate to *separately* estimate each industry. Instead, it is more desirable to jointly estimate a group of equations by allowing error terms for each industry in each equation correlated. The seemingly unrelated regressions (SUR) econometric approach associated with the translog GDP system also make the joint estimations feasible.

Second, the translog GDP functional form is motivated by a theoretical setup. It enjoys a striking advantage to cover neatly tariffs, factor endowments and technological changes into the model. As demonstrated in the next section, the translog GDP function is an ideal way to consider the maximized GDP function with many goods under a perfect competitive market. It hence sheds light on the way in which variables in the system interact with each other.

Possibly owing to such advantages, the translog GDP function is widely adopted by trade economists. Related empirical contributions of estimating a translog GDP function include Burgess (1976), Kohli (1990), Learmer (1984), Harrigan (1997), and Feenstra and Kee (2008), among others. The duality theory suggests that estimating an aggregate cost function is equivalent to estimating a GDP function. Burgess (1976) therefore estimates an aggregate cost function to show that traded goods are capital intensive whereas nontraded goods are labor intensive in the USA.

In contrast, some other works estimate a translog GDP function directly using data on primary inputs—capital and labor. Using this approach, Kohli (1990) suggests that consumption goods are capital intensive, while exports and investments are labor intensive. Harrigan (1997) instead explores how technology differences affect international specification using the translog GDP functional system. Last but not least, Feenstra and Kee (2008) use it to examine the effects of industrial export variety on country productivity.

To summarize, the translog GDP function is a widely accepted approach to explore the relationship among goods' prices, factor endowments, technological changes and industrial output shares. Therefore, we rely on this system to investigate impact of tariffs on production for each industry. Particularly, our data set coverage is the USA and its 14 OECD importing partners for several main industries (i.e. food, garments, paper, chemicals, glass, metals and machinery) over the years 1974–1990. We find empirical support that trade protection does not help much to increase a sector's relative size.

Since the variation in industrial size would reversely affect its protection level, the decline in an industrial output share could force the domestic special interest groups to lobby the government. Accordingly, such special interest groups would push the government to choose high commercial protection in capital-abundant countries such as the USA (Grossman and Helpman, 1994). To precisely investigate the impact of tariffs, we also control in the present paper for such endogeneity issues using the instrumental variable (IV) approach.

Our paper joins a growing literature in examining the effects of import tariffs on industry-level and firm-level performance. Previous works such as Trefler (2004) and Bernard et al. (2006) also explore the impact of import tariffs on firm productivity. In particular, Bernard et al. (2006) find that trade liberalization could lead to an intra-industry reallocation toward high-productivity firms. They also find that a decline in trade costs variable would lead to a decrease in domestic market share and domestic revenue for surviving firms. In contrast with their study to explore firm decision on domestic and foreign sales, in this paper we are more interested in the response of trade costs on industrial size. Trefler (2004) examine the effect of the North-American Free Trade Agreement on the performance of Canadian firms. He finds that industries with the deepest tariff cuts in Canadian would have an increase in industrial productivity, mainly by sweeping the less-productive firms out from the market. As opposed to focusing on productivity improvement as in Trefler (2004), this paper focus more on the impact of trade liberalization on industrial size.

2. The Empirical Model

Consider an economy with many goods. It has a GDP function as follows:

$$G(P, V, t) = \max \sum_{i=1}^{N} p_i f_{it}(v_i).$$

The country also faces a resource budget constraint:

$$\sum_{i=1}^{M} v_i \leq V,$$

where $P = (p_1, \ldots, p_N)$ is the price vector for N commodities, $V = (v_1, \ldots, v_N)$ is the endowment vector for M factors, and t is the time index which is used to measure the technological improvement. Previous studies like Harrigan (1997) use total factor productivity to measure technological improvement. This is an acceptable approach provided that the technology is Hicks neutral. However, in the present paper we do *not* restrict our scope to a Hicks-neutral technological change since it is mainly a theoretical simplification but earns little empirical support in reality (Basu and Fernald, 2002). We instead consider technological change by adopting a more general approach introduced by Mckay et al. (1983). We simply use the time index to control for technology improvement. The idea is that technology shifts over time as a result of technological change so that the representation of technology becomes a function of the time index. However, a caveat also exists. The time trend variable included here may capture various factors other than productivity improvement (e.g. a demand shift for nontraded goods).[1]

We use a conventional translog functional form introduced by Christensen et al. (1973), Diewert (1974), Kohli (1990), Feenstra (1994) and Harrigan (1997), among others. This functional form is flexible in the sense that it provides a second-order approximation of the GDP function. Specifically, it has the following form:

$$\begin{aligned} \ln G(P, V, t) = {} & \gamma_{00} + \beta t + \sum_{i=1}^{N} \gamma_{0i} \ln p_i + \sum_{k=1}^{M} \delta_{0k} \ln v_k + \frac{1}{2}\phi t^2 \\ & + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \gamma_{ij} \ln p_i \ln p_j + \frac{1}{2}\sum_{k=1}^{M}\sum_{l=1}^{M} \delta_{ij} \ln v_k \ln v_l \\ & + \sum_{i=1}^{N} \phi_{it} (\ln p_i) t + \sum_{k=1}^{M} \delta_{kt} (\ln v_k) t + \sum_{i=1}^{N}\sum_{k=1}^{M} \phi_{ik} \ln p_i \ln v_k . \end{aligned}$$

It is understood that there are three restrictions for the parameters of this translog GDP function. First, technology is assumed to be constant returns to scale following Kohli (1990) and others, which in turn implies the homogeneity of degree one in price. Therefore, we have the following restrictions for related parameters:

$$\sum_{i=1}^{N}\gamma_{0i}=1,\quad \sum_{i=1}^{N}\gamma_{ij}=0,\quad \sum_{i=1}^{N}\phi_{ik}=0,\quad \sum_{i=1}^{N}\phi_{it}=0.$$

Second, the following restrictions also guarantee that the GDP function is homogeneity of degree one in endowments:

$$\sum_{k=1}^{M}\delta_{0k}=1,\quad \sum_{k=1}^{M}\delta_{kl}=0,\quad \sum_{k=1}^{M}\phi_{ik}=0,\quad \sum_{k=1}^{M}\phi_{it}=0.$$

Third, without loss of generality, we also impose the symmetry constraints on the translog GDP function owing to Young's theorem: $\gamma_{ij}=\gamma_{ji}$, $\forall i, j$ and $\delta_{kl}=\delta_{lk}$, $\forall k, l$.

Our main aim is to explore the effect of an import tariff on the industrial output share. Note that we can obtain the output share s_i for industry i from (2).[2] Thus, differentiating the right-hand side of the translog GDP function (2), we obtain the following:

$$s_i=\gamma_{0i}+\sum_{j=1}^{N}\gamma_{ij}\ln p_j+\sum_{k=1}^{M}\phi_{ik}\ln v_k+\phi_{it}t,\quad \forall\, i=1,\ldots,N.$$

Clearly, the output share of sector i, which measures sector i's production size, depends on technology, domestic price of importable and factor endowments. With data on these variables, one can estimate the corresponding parameters γ_{0i}, γ_{ij}, ϕ_{ik} and ϕ_{it}.

As we mentioned above, nontradable sectors nowadays account for a significant weight in the USA. To fully explore the effect of tariffs on production size, we control for the effect of nontradable sectors by splitting all commodities into two categories: tradable and nontradable goods. Let tradable prices be represented by p^* and nontradable prices by p^{n*}, then we can write (3) as follows:

$$s_i^*=\gamma_{0i}^*+\sum_{j=1}^{N_T}\gamma_{ij}^*p_j^*+\sum_{k=1}^{M}\phi_{ik}^*\ln v_k^*+\phi_{it}^*t+\sum_{j=N_T+1}^{N}\gamma_{ij}^*\ln p_j^{n*},\quad \forall\, i=1,\ldots,N.$$

where a asterisk-notation (*), N_T and $N-N_T$ denote the USA, and its numbers of tradable sectors and nontradable sectors, respectively.

Similarly, exporting country c's output share function for industry i is:

$$s_{ic}=\gamma_{0ic}+\sum_{j=1}^{N_T}\gamma_{ijc}\ln p_{jc}+\sum_{k=1}^{M}\phi_{ikc}\ln v_{kc}+\phi_{itc}t+\sum_{j=N_T+1}^{N}\gamma_{ijc}\ln p_{jc}^{n},\quad \forall\, i=1,\ldots,N, \forall\, c.$$

For estimation purposes, we aggregate all commodities into an identical harmonized level (e.g. SIC 2-digit level). Accordingly, we obtain the relative output share for each industry across countries by subtracting (5) from (4):

$$\begin{aligned}s_i^*-s_{ic}&=(\gamma_{0i}^*-\gamma_{0ic})+(\phi_{it}^*-\phi_{it})t+\sum_{j=1}^{N_T}\left(\gamma_{ij}^*\ln p_j^*-\gamma_{ijc}\ln p_{jc}\right)\\&\quad+\sum_{k=1}^{M}\left(\phi_{ik}^*\ln v_j^*-\phi_{ikc}\ln v_{kc}\right)+\left(\sum_{j=N_T+1}^{N}\gamma_{ij}^*\ln p_j^{n*}-\sum_{j=N_T+1}^{N}\gamma_{ijc}\ln p_{jc}^{n}\right).\end{aligned}$$

Note that the cross price semielasticity of output share γ_{ij}^* measures the impact of sector j's price on sector i's output share since $\gamma_{ij}^*=\partial s_i^*/\partial\ln p_j^*$. Since an import tariff provides a wedge between the domestic price and the exporter's price for each industry, the cross price semi-elasticity of output share γ_{ij}^{*} is correlated with its exporter c's counterpart γ_{ijc}. To keep our estimations neat, we simply presume that such parameters are identical across trading countries: $\gamma_{ij}^{*}=\gamma_{ijc}$. Accordingly, their difference, if any, is absorbed into the error term. Similarly, we have the identical Rybczynski semi-elasticity ϕ_{ijc} across each country c: $\phi_{ij}^{*}=\phi_{ijc}$.

We measure sector j's import tariff for the USA as an *ad-valorem* one (τ) with $1+\tau_{jc}=p_j^{*}/p_{jc}$. That is, we ignore other trade-cost factors that affect international price difference (Anderson and Van Wincoop, 2004). By choosing a year as a base point, we re-express (6) as follows:

$$s_i^{*}-s_{ic}=(\phi_{it}^{*}-\phi_{it})t+\sum_{j=1}^{N_T}\gamma_{ijc}\ln(1+\tau_{jct})+\sum_{k=1}^{M}\phi_{ikc}\ln(v_k^{*}/v_{kc})$$
$$+\left[\gamma_{0i}^{*}-\gamma_{0ic}+\sum_{j=N_T+1}^{N}\gamma_{ij}^{*}\ln p_j^{n*}-\sum_{j=N_T+1}^{N}\gamma_{ijc}\ln p_{jc}^{n}\right].$$

The last four terms in (7) capture the impacts on the relative own price elasticity of GDP ($\gamma_{0i}^{*}-\gamma_{0ic}$) and the relative industrial output share of nontradable sectors' price in both exporter and importer ($\sum_{j=N_T+1}^{N}\gamma_{ij}^{*}\ln p_j^{n*}-\sum_{j=N_T+1}^{N}\gamma_{ijc}\ln p_{jc}^{n}$). Since price data on nontradable goods are generally unavailable (Harrigan, 1997), all of these terms are absorbed into and treated as a random variable ε_{ict}:

$$\varepsilon_{ict}=(\gamma_{0i}^{*}-\gamma_{0ic})+\left(\sum_{j=N_T+1}^{N}\gamma_{ij}^{*}\ln p_j^{n*}-\sum_{j=N_T+1}^{N}\gamma_{ijc}\ln p_{jc}^{n}\right).$$

We then decompose such a random variable, ε_{ict}, into three components: (1) country fixed-effect, η_{ic}, which captures the unobserved country-specific time-invariant fixed-effects; (2) time-specific fixed effect, μ_{it}; and (3) an idiosyncratic effect e_{ict} with zero expectation and heteroskedastic variance σ_i^2, which captures all other factors unspecified in this specification such as consumer confidence. Namely, the stochastic process can be characterized using a flexible and simple model:

$$\varepsilon_{ict}=\eta_{ic}+\mu_{it}+e_{ict}.$$

Note that here the role of nontradable sectors is captured by the time-specific fixed effect and country-specific fixed-effect. Thus far, we can write (7) as an empirical specification:

$$s_{it}^{*}-s_{ict}=\beta_t t+\sum_{j=1}^{N_T}\gamma_{ijc}\ln\tau_{jct}+\sum_{k=1}^{M}\phi_{ikc}\ln(v_{kt}^{*}/v_{kct})+\eta_{ic}+\mu_{it}+e_{ict}.$$

Clearly, in specification (8) sector i's output share in the USA depends on its own *ad-valorem* import tariff, import tariffs for other importing sectors, various relative factor endowments and technology level. Our main interest is the impact of each industrial import tariff on its own output share. To fully explore this effect, we also control for the exporting country's corresponding output share, the industrial fixed effect and the year-specific fixed effect.[3]

3. Data and Estimate Results

To estimate specification (8), we distinguish seven main manufacturing industries (i.e. food, garments, chemicals, papers, glass, metals and machinery) which are aggregates from the standard industrial classification (SIC) four-digit level. It is also necessary to drop one equation before the translog GDP functional system is estimated, provided that the sum of industrial output shares is one (Feenstra, 2003). However, since the sum of such seven industrial output shares is less than one, we can instead estimate the system directly.

Data

Table 1 summarizes the descriptive statistics of our data set. The sources of each variable are listed in Table 2. We use two different methods to measure trade protection: (1) *ad-valorem* import tariffs in which we have data for the years from 1974 to 1990; (2) nontariff barriers (NTBs) in which we have 4-year data after 1990 (particularly, 1993, 1994, 1996 and 1999). For each type of trade protection measurement, we include 14 major trading partners of the USA. Our coverage is close to Harrigan (1997): although we do not include West Germany as a result of data unavailability, we instead add several smaller OECD economies such as Australia, Austria, Finland, Ireland, Norway and Portugal. We also include Mexico since it is the third trading partner of the USA today.[4]

Table 1 includes the basic statistics on the differences of output shares between the USA and its trading partners for each of the seven industries. It is interesting to find that of all the seven industries the USA industrial output shares are, on average, relatively lower than their OECD trading partners. This serves as a side evidence to reflect the fact that non-manufacturing sectors in the USA (particularly, services sectors) play a more and more important role in its economy today. According to reports from the BEA, the weight of the service sectors increased rapidly from 6% in 1987 to around 10% in 1999. In contrast, the weight of manufacturing sectors decreased from 28% in 1987 to 23% in 1999.[5]

The SIC two-digit tariffs are aggregated from the SIC four-digit tariffs across industries, which, in turn, are calculated using values of industrial duties divided by their customs value. Overall, as shown in Table 3, industries such as food, garments and glass have relatively high import tariffs compared with others like paper, chemicals and metals for each country. These partially demonstrate the fact that the USA historically imposed a relatively high protection for those labor-intensive commodities and senescent industries (Brainard and Verdier, 1997). Comparing data from 1974 to 1990, we find that import tariffs decrease over time. This is consistent with the traditional wisdom: trade liberalization over time is an irreversible trend, in a large part owing to the efforts of various rounds of General Agreement on Tariffs and Trade/World Trade Organization (GATT/WTO) negotiations.

To have a rough idea on how a change in import tariff affects an industrial output share relative to GDP, in Figure 1 we plot the industrial output share against tariffs for the seven main industries. Interestingly enough, all of these seven industries demonstrate a trend that high tariffs are associated with low industrial output shares. Though a simple uni-variable ordinary least squares (OLS) estimate is insufficient to fully capture the complicated impact of trade protection, it still conveys a message that a high import tariff is not necessarily associated with high output share though it indeed increases both the industrial price and quantities produced at home.

Aside from tariffs, various NTBs nowadays play a more important role on trade policy. The Uruguay round of GATT/WTO completed in 1994, in which advanced countries are required to cut down on their tariffs by almost 40%, led to a switch of

Table 1. Descriptive Statistics of Variables

Variables	*Mean*	*Std Dev.*	*Min.*	*Max.*
Log Industrial Tariffs (1974–1990)				
Food	–2.596	0.739	–4.493	2.869
Garments	–1.919	0.240	–2.576	–1.383
Paper	–3.463	0.566	–5.127	–2.620
Chemicals	–3.075	0.319	–4.794	–2.200
Glass	–2.695	0.739	–4.605	1.445
Metals	–3.519	0.835	–8.148	–2.325
Machinery	–3.057	0.377	–4.543	–2.185
Difference on production relative size (*1974–1990*)				
Food	–0.176	0.369	–1.461	0.082
Garments	–0.024	0.050	–0.221	0.030
Paper	–0.123	0.284	–1.394	0.065
Chemicals	–0.063	0.204	–0.673	0.129
Glass	–0.028	0.049	–0.181	0.013
Metals	–0.269	0.770	–3.638	0.303
Machinery	–0.095	0.268	–1.264	0.103
Difference on production relative size (*after 1990*)				
Food	–0.158	0.314	–1.669	0.059
Garments	–0.032	0.099	–0.584	0.020
Chemicals	–0.072	0.193	–0.890	0.079
Metals	–0.326	0.879	–3.787	0.234
Machinery	–0.116	0.341	–1.402	0.082
Log factors difference (*1974–1990*)				
Durables	2.939	1.174	0.817	4.998
Nonresident construction	2.855	1.150	0.534	5.125
Low educated	–1.492	0.664	–2.598	0.305
Middle educated	0.446	0.400	–0.316	1.661
High educated	1.123	0.588	–0.239	2.379
Agricultural land	3.558	1.280	1.355	5.461
Log factors difference (*after 1990*)				
Capital	2.831	1.260	–0.272	4.915
Labor	2.653	1.155	0.686	4.545
Land	3.549	1.397	1.182	5.428

Notes: The source for each variable is described in Table 2. Difference on production relative size for each industry is measured by the US output share minus its counterpart in 14 OECD importers at the average level. The number of observations is 238 given data for 14 countries across 17 years included when the tariff is adopted for estimations. In contrast, the number of observations is 39 for each equation when the NTBs are adapted for estimations since some NTBs data are missing.

protection instruments from tariffs to NTBs. We therefore include NTBs as an alternative measure of US trade policy to measure its effect on production relative size.

Data on NTBs are based on ISIC (1968 revision II) classification from various years of the Trade Analysis and Information System (TRAINS) of UNCTAD (United Nations Conference on Trade and Development). According to their classification, the NTBs include many types of measurements such as price control measures, quantity control measures, customs charges and taxes, financial measures, technical measures, monopolistic measures and miscellaneous measures. Here, we use two ways to

Table 2. Data Source

Variables	*Definition, Measurement, and Data Sources*
	Data before 1990
Tariffs	Data from Feenstra et al. (2001)
Agricultural land	It is the product of arable land and land share. Such data can be accessed from the World Development Indicators (2002)
Non-residential construction capital	Data can be accessed from the Penn World Table 5.6.
Production durables capital	Data can be accessed from the Penn World Table 5.6
Highly educated workers	Such education data can be accessed from Barro and Lee (1993) while labor force data is from World Development Indicators (2003)
Medium-educated workers	The same as above
Low-educated workers	The same as above
	Data after 1990
Non-tariff barriers	Data from TRAINS of UNCTAD various years
Capital endowment	It is measured as the product of the fixed capital expenditure and GDP. Data is from the World Development Indicators (2002)
Labor force	It is directly used to measure labor endowments after year 1990. Education measurement is not considered here due to the lack of data for such countries. Data is from the World Development Indicators (2002)

measure the NTBs following Laird and Yeats (1990): coverage ratio and frequency ratio. Specifically, the coverage ratio for industry is defined as $\sum_i w_i^l I_i^l$, where w_i^l is the import share of product i relative to total imports in industry l, and I_i^l is the indicator variable that equals one when the product is covered by some measures of NTBs. In contrast, the frequency ratio for industry l is defined as $\sum_i I_i^l / N^l$, where N^l is the total number of commodities in industry l, and I_i^l is the indicator variable that equals one when the product is covered by some measures of NTBs.

Table 4 provides the basic statistics about NTB measurements for 14 countries after year 1990 (specifically, the years are 1993, 1994, 1996 and 1999). Of all the seven manufacturing industries, the non-tariff protection in the glass industry is minimal. By contrast, the food industry has the highest level of non-tariff protection regardless of measurement methods. This suggests that US food industry producers have sought protection from tariffs by using NTBs recently. Such an observation fits with reality quite well. For example, an import quota imposed on the US sugar industry was approximately 1.4 million tons in 2002. Accordingly, the domestic price of sugar was more than twice the price in the world sugar market.[6]

Data on factor endowment after year 1990 are the same as Harrigan (1997). We consider three primary factor endowments: capital, labor and agricultural land. Specifically, capital is split into two types of sub-categories: non-residential construction and production durables. We also separate three different labor endowments: (1) highly educated workers (i.e. those who have attained at least a college education); (2) medium-educated workers (i.e. those who have completed or at least attained secondary education), and (3) low-educated workers (those who have not attained any

Table 3. US Import Tariffs of Seven Main Industries for 14 countries

Exporter	*Year*	*Food*	*Garments*	*Paper*	*Chemicals*	*Glass*	*Metals*	*Machinery*
Australia	1974	0.22	0.16	0.06	0.03	0.12	0.02	0.06
	1990	0.02	0.10	0.02	0.03	0.07	0.02	0.03
Austria	1974	0.08	0.20	0.06	0.05	0.10	0.08	0.07
	1990	0.03	0.14	0.03	0.04	0.05	0.05	0.04
Canada	1974	0.27	0.13	0.01	0.04	0.02	0.02	0.04
	1990	0.07	0.08	0.01	0.03	0.01	0.01	0.02
Denmark	1974	0.08	0.12	0.03	0.06	0.14	0.03	0.07
	1990	0.05	0.11	0.03	0.04	0.05	0.06	0.04
Finland	1974	0.11	0.15	0.04	0.07	0.15	0.03	0.07
	1990	0.06	0.09	0.02	0.04	0.04	0.05	0.04
France	1974	0.09	0.21	0.05	0.05	0.13	0.05	0.08
	1990	0.04	0.13	0.02	0.06	0.07	0.04	0.03
Ireland	1974	0.08	0.21	0.07	0.07	0.06	0.04	0.07
	1990	0.01	0.12	0.04	0.05	0.04	0.05	0.03
Italy	1974	0.17	0.22	0.06	0.05	0.11	0.06	0.08
	1990	0.04	0.14	0.03	0.05	0.10	0.04	0.04
Japan	1974	0.17	0.24	0.06	0.06	0.18	0.05	0.08
	1990	0.09	0.11	0.03	0.06	0.07	0.05	0.04
Mexico	1974	0.12	0.18	0.05	0.06	0.13	0.02	0.08
	1990	0.04	0.10	0.01	0.04	0.04	0.03	0.03
Norway	1974	0.06	0.18	0.05	0.05	0.01	0.02	0.07
	1990	0.04	0.14	0.02	0.03	0.02	0.01	0.03
Portugal	1974	0.11	0.13	0.05	0.06	0.13	0.04	0.12
	1990	0.16	0.12	0.01	0.05	0.07	0.05	0.04
Sweden	1974	0.08	0.18	0.05	0.06	0.13	0.08	0.06
	1990	0.03	0.12	0.02	0.03	0.06	0.05	0.04
U.K.	1974	0.10	0.18	0.04	0.05	0.10	0.03	0.07
	1990	0.18	0.12	0.02	0.04	0.06	0.03	0.03

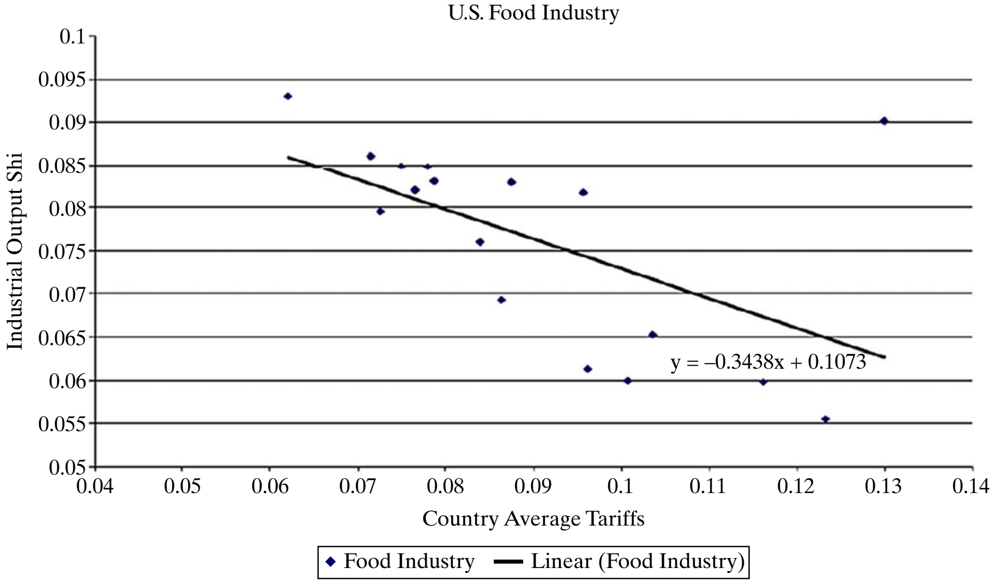
Source: Data are from Feenstra et al. (2001).

secondary schooling). Finally, agricultural land is measured by the product of arable land and land share.

Estimates

We have seven equations in the system for estimating. In each equation, the dependent variable is US industrial output share, whereas the independent variables include exporting partner's corresponding industrial output share, seven industrial *ad-valorem* tariffs, six types of factor endowments and a time trend that captures the technological improvement. All variables except for time trend are in logarithms, which in turn implies that those estimated coefficients can be interpreted as semi-elasticities.

We perform the iterated seemingly unrelated regression (SUR) of Zellner (1962) with two restrictions. First, the cross-price effect on the output share should be the same between two sectors i and j, $\gamma_{ij} = \gamma_{ji}$, owing to the symmetry setup. Second, all coefficients on the factor endowments should equal zero, $\sum_{k=1}^{M} \phi_{ik} = 0$. Table 5 reports the main estimation results using tariff data before 1990. We also include country



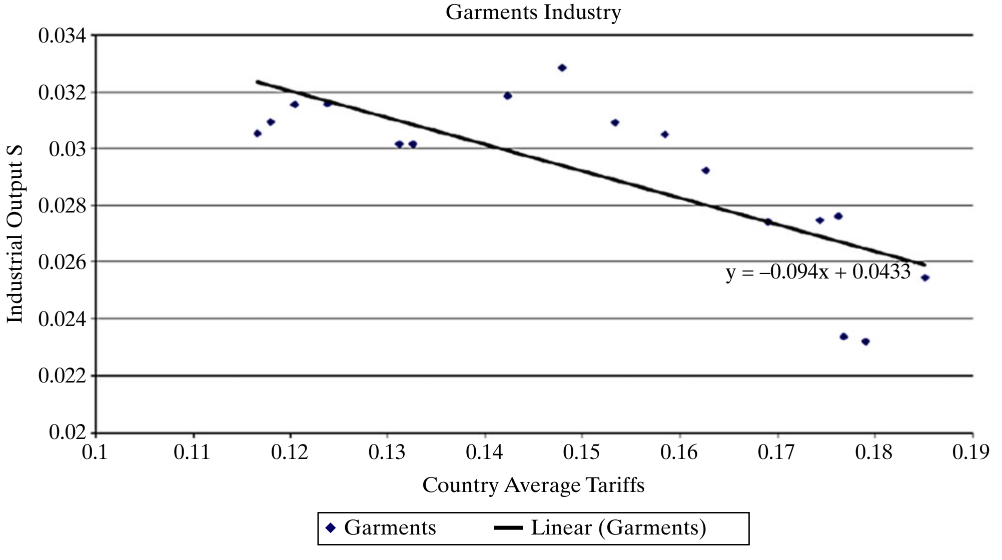
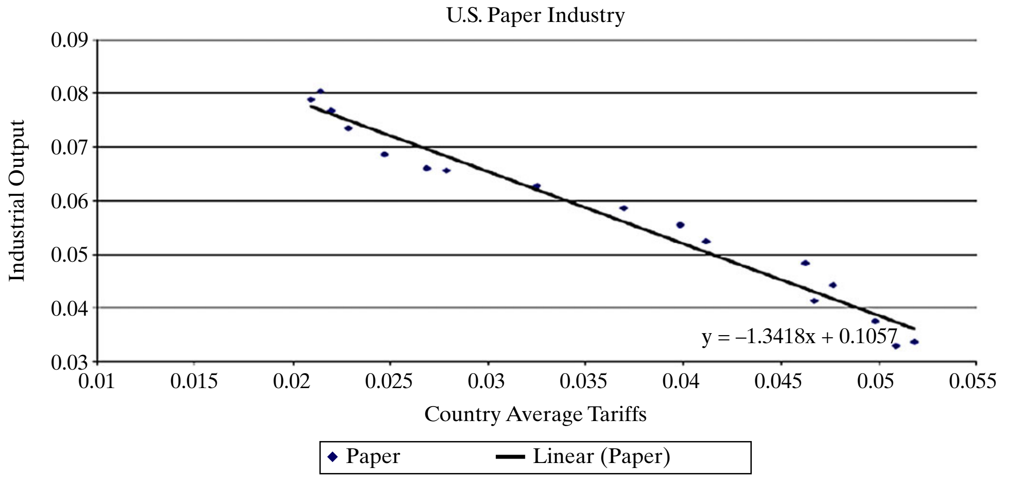
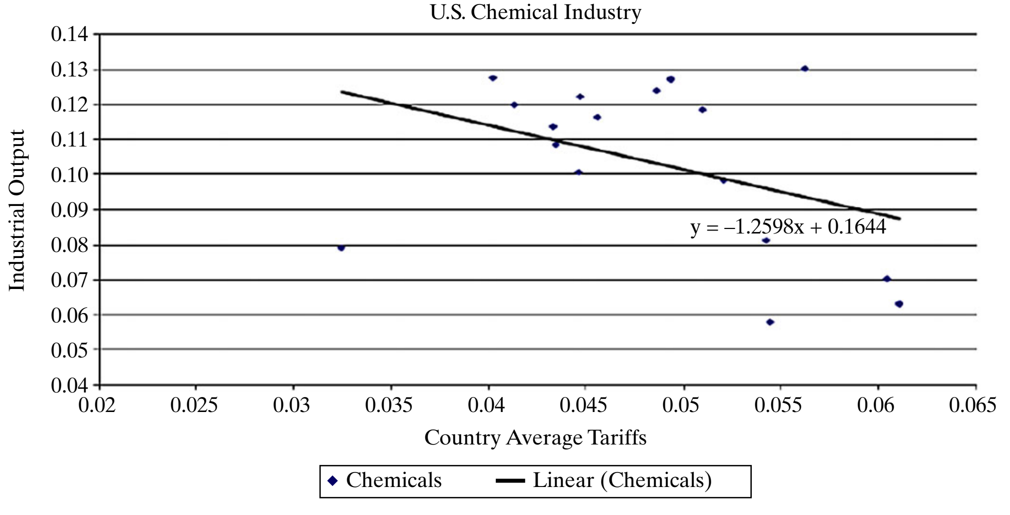


Figure 1. Import Tariffs and Industrial Output Shares for the Seven Industries

Notes: Graphs for the seven industries are plotted using data mentioned in the text. All of them demonstrate a negative relationship between tariffs and industrial output share.





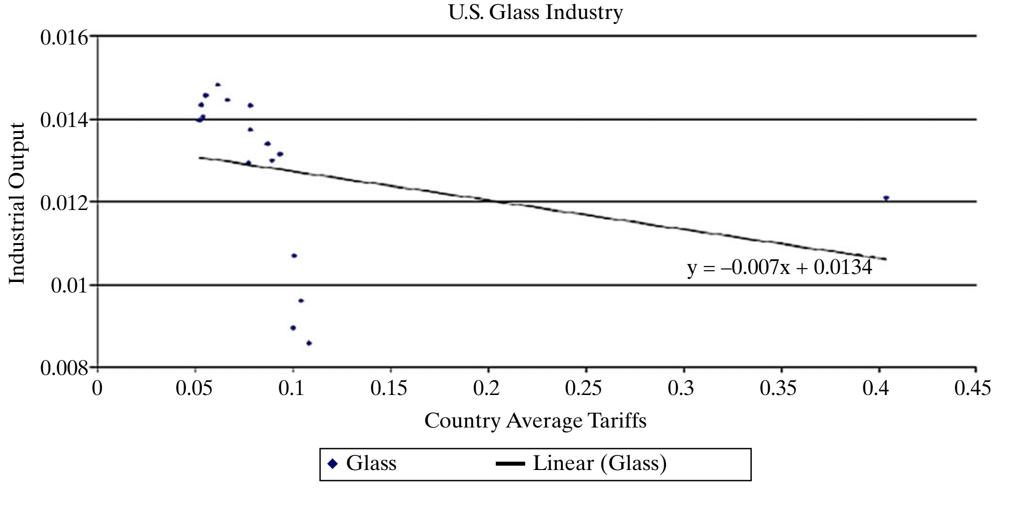
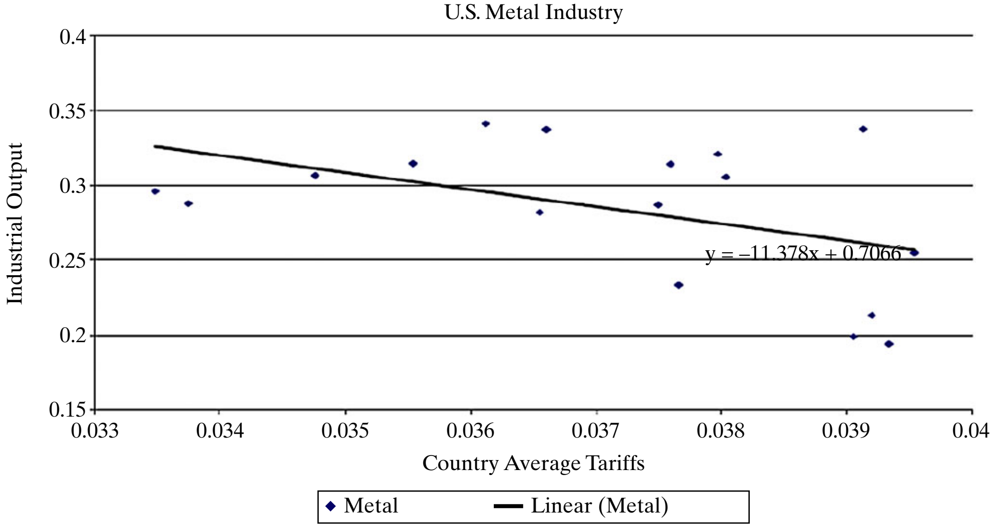


Figure 1. Continued



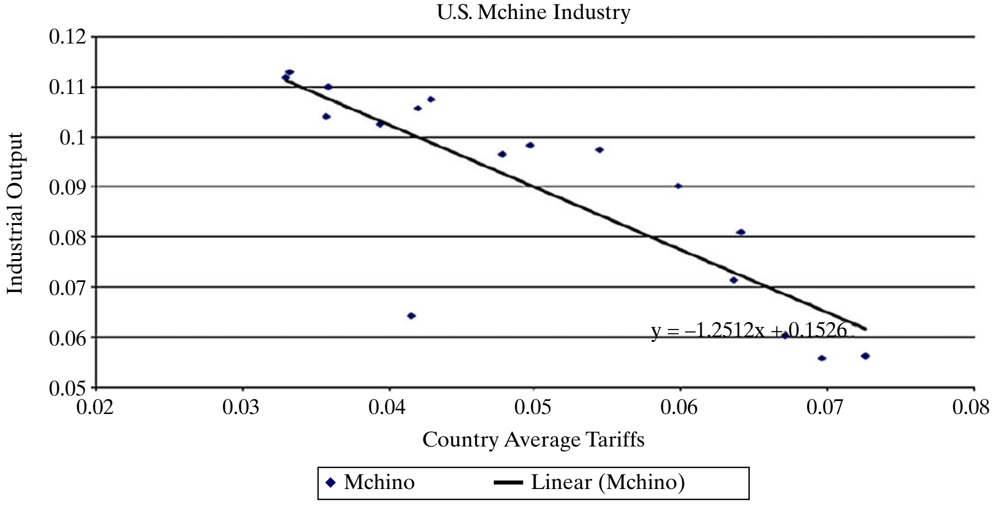


Figure 1. Continued

fixed effects and year-specific fixed effects which are not reported in order to save space, though these are available from the authors upon request.

The tariff semi-elasticities of each industry differ greatly. Of all the seven coefficients, the own tariff semi-elasticities for garments, chemicals and machinery are positive, whereas those for food, paper, glass and metals are negative. The machinery sector has the largest positive effect, followed by the chemicals', garments', paper, glass, food and metals' sectors.

The most interesting findings come from the chemicals, glass and machinery sectors. In particular, the own tariff coefficients of semi-elasticity are significantly positive for the chemical and machinery industries. A positive coefficient means that an increase in US import tariff causes its industry to expand relatively compared with its trading partners. An increase in the import tariff benefits the producers in that industry which, in turn, increases production and thus causes the industry to expand.

Table 4. US Non-tariff-barriers of Seven Main Industries for 17 countries

Exporter	*Type*	*Food*	*Garments*	*Chemicals*	*Metals*	*Machinery*
Australia	NTM_F	0.52	0.10	0.04	0.11	0.08
	NTM_C	0.65	0.12	0.07	0.04	0.07
Austria	NTM_F	0.52	0.10	0.05	0.10	0.08
	NTM_C	0.45	0.12	0.11	0.10	0.07
Belgium	NTM_F	0.41	0.14	0.04	0.14	0.11
	NTM_C	0.37	0.16	0.09	0.12	0.16
Canada	NTM_F	0.44	0.10	0.05	0.13	0.09
	NTM_C	0.44	0.13	0.07	0.12	0.11
Denmark	NTM_F	0.44	0.11	0.04	0.10	0.08
	NTM_C	0.39	0.13	0.08	0.06	0.07
Finland	NTM_F	0.53	0.10	0.04	0.08	0.08
	NTM_C	0.63	0.08	0.09	0.08	0.10
France	NTM_F	0.44	0.10	0.05	0.13	0.09
	NTM_C	0.46	0.09	0.12	0.12	0.07
Ireland	NTM_F	0.44	0.10	0.04	0.10	0.08
	NTM_C	0.42	0.12	0.09	0.04	0.05
Italy	NTM_F	0.44	0.10	0.06	0.12	0.09
	NTM_C	0.31	0.12	0.13	0.14	0.12
Japan	NTM_F	0.44	0.15	0.08	0.14	0.10
	NTM_C	0.48	0.11	0.07	0.14	0.17
Mexico	NTM_F	0.44	0.11	0.05	0.13	0.08
	NTM_C	0.48	0.12	0.07	0.13	0.11
Netherlands	NTM_F	0.44	0.11	0.04	0.14	0.08
	NTM_C	0.42	0.09	0.08	0.18	0.08
New Zealand	NTM_F	0.45	0.10	0.04	0.08	0.08
	NTM_C	0.58	0.13	0.06	0.10	0.10
Norway	NTM_F	0.44	0.10	0.04	0.08	0.08
	NTM_C	0.32	0.11	0.06	0.00	0.07
Portugal	NTM_F	0.44	0.10	0.04	0.12	0.08
	NTM_C	0.38	0.14	0.06	0.15	0.05
Sweden	NTM_F	0.44	0.10	0.05	0.10	0.09
	NTM_C	0.35	0.08	0.18	0.13	0.10
U.K.	NTM_F	0.44	0.10	0.05	0.14	0.09
	NTM_C	0.55	0.10	0.13	0.15	0.08

Source: Original Data of NTBs can be accessed from UNCTAD. The data used here cover the years 1993, 1994, 1996 and 1999. NTM_F means non-tariffs frequency ratio measurement (all). NTM_C means non-tariff coverage ratio measurement (all). The difference between these two approaches is introduced in the text in detail. Data on the paper and glass industries are unavailable.

An opposite situation happens for the glass industry in which the tariff has a significant negative effect on its output share.

Turning to the cross effects of a tariff on industrial output shares, their signs are a mix of positive and negative. When a cross effect of a tariff has an identical sign with its own effect, the two industries are broadly complemented. By contrast, a different sign between own effect and cross effect of a tariff suggests that the two industries are broadly substitutable. For example, as shown in Table 5, a tariff on the glass industry significantly leads to a decline in the glass industry itself, a contraction in the garment

Table 5. Estimate of the GDP Share Function Using Tariffs Data before 1990

	Food	*Garments*	*Paper*	*Chemicals*	*Glass*	*Metals*	*Machinery*
Tariffs_Food	*–0.02*	–0.01*	–0.02*	–0.00	–0.00	–0.01	–0.04**
	(–1.01)	(–1.83)	(–1.87)	(–0.6)	(–0.5)	–0.4)	(–4.08)
Tariffs_Garment	–0.01*	*0.00*	0.02**	–0.00	–0.01**	–0.01**	0.01
	(–1.83)	*(0.36)*	(3.01)	(–0.45)	(–3.52)	(–4.14)	(0.71)
Tariffs_Paper	–0.02*	0.02**	*–0.00*	–0.00	0.00	–0.00	–0.04**
	(–1.87)	(3.01)	*(–0.45)*	(–0.16)	(1.45)	(–0.18)	(–4.26)
Tariffs_Chemical	–0.00	–0.00	–0.00	*0.02**	0.01**	–0.01	–0.03*
	(–0.6)	(–0.45)	(–0.16)	*(1.77)*	(3.67)	(–0.42)	(–3.13)
Tariffs_Glass	–0.00	–0.01**	0.00	0.01**	*–0.00***	–0.00	–0.01**
	(–0.5)	(–3.52)	(1.45)	(3.67)	*(–2.98)*	(–1.00)	(–3.55)
Tariffs_Metal	–0.01	–0.01**	–0.00	–0.01	–0.00	*–0.03*	–0.05*
	(–0.4)	(–4.14)	(–0.18)	(–0.42)	(–1.00)	*(–0.72)*	(–2.83)
Tariffs_Machinery	–0.04**	0.01	–0.04**	–0.03**	–0.01**	–0.05**	*0.06***
	(–4.08)	(0.71)	(–4.26)	(–3.13)	(–3.55)	(–2.83)	*(3.20)*
Nonresident_Construction	–0.08	–0.01	–0.06	–0.05	–0.02**	–0.09	–0.02
	(–1.35)	(–1.22)	(–1.18)	(–1.5)	(–1.96)	(–0.65)	(–0.36)
Production_Durables	0.02	–0.00	0.05	0.04	0.01	0.09	–0.02
	(0.25)	(–0.24)	(1.01)	(1.26)	(1.15)	(0.62)	(–0.38)
Low_Edu_Workers	0.02	0.01**	–0.01	0.01	0.00	–0.06	–0.01
	(0.62)	(2.10)	(–0.27)	(0.41)	(0.57)	(–0.94)	(–0.44)
Mid_Edu_Workers	–0.20**	–0.02*	–0.15**	–0.12**	–0.02**	–0.34**	–0.13**
	(–3.63)	(–1.84)	(–3.22)	(–3.77)	(–2.98)	(–2.75)	(–3.08)
High_Edu_Workers	0.37**	0.03**	0.27**	0.20**	0.05**	0.70**	0.26**
	(8.03)	(4.50)	(7.27)	(7.70)	(7.15)	(6.78)	(7.29)
Arable land	–0.13**	–0.01**	–0.12**	–0.08**	–0.02**	–0.31**	–0.09**
	(–5.98)	(–3.58)	(–6.80)	(–7.07)	(–6.61)	(–6.43)	(–5.23)
Time trend	–0.02	0.00	–0.01	–0.00	–0.00	–0.04	–0.03**
	(–1.42)	(0.22)	(–1.51)	(–0.55)	(–1.23)	(–1.44)	(–2.66)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.43	0.28	0.37	0.42	0.42	0.35	0.35

Notes: Estimation results for seven industries are reported in columns. The dependent variable is the percentage output share of the industry. Independent variables are in logarithms except for the term of time trend. Numbers in italic form denote own semi-elasticity. Numbers in parenthesis are *t*-values. *,** Denote significance at 5% and 1% levels, respectively. Year and country fixed effects are not reported here to save space. There are 238 observations for these restricted seemingly unrelated estimations (SUR).

industry and an expansion of the chemical industry. This means that the glass sector is broadly a complement of the garment sector but is broadly a substitute for the chemical industry.

Capital endowments are broken into two categories in Table 5: production durables and non-residential construction. The production durable is positively related to output share for all manufacturing sectors except the garment and machinery industries. By contrast, non-residential construction is negatively related to output share for all industries. However, the coefficients for production durables are insignificant in all industries and its signs vary across industries. Similarly, the coefficients of non-resident construction are negatively significant only in the glass industry. Both of these suggest that factor endowment does not play an important role on industrial output share for the US economy during the sample period once we control for trade protection.

In addition, highly educated workers are positively associated with the size of the manufacturing sectors, while the medium-educated workers have a reverse connection. This is possible because manufacturing sectors relatively require highly skilled level workers compared with the agricultural sector. The coefficients for low-education workers are mixed. Only the garment industry has a positive significant number (0.09). This is consistent with the fact that the textile industry is relatively a downstream industry and requires less skill. For land endowment, arable land is negatively related to the output share for all manufacturing industries. This also makes good economic sense. An increase in land endowment will shrink the manufacturing sectors unambiguously, according to the prediction of the Rybczynski theorem. Finally, the coefficients of the time trend for all manufacturing industries are all negative, though some are insignificant.

Non-tariff Barriers

To completely explore effects of trade policy on industrial output shares, we also use a data set with non-tariff measurement to serve as robustness checks. The estimation results using this data set are reported in Tables 6 and 7.

Table 6 presents the estimation results for five industries (i.e. food, garments, chemicals, metals and machinery) using the data of non-tariff barriers. The data on the paper industry are completely unavailable, while much of the data on the glass industry are missing. Hence, these two industries are dropped for our estimation. We

Table 6. Estimate of the GDP Share Function Using NTBs (coverage) Data

	Food	*Garments*	*Chemicals*	*Metals*	*Machinery*
NTB_Food	*0.02*	–0.02	0.06	0.07*	0.02
	(0.25)	(–1.36)	(3.05)	(1.95)	(0.92)
NTB_Garment	–0.024	*0.01*	–0.01	0.01	–0.00
	(–1.36)	*(0.69)*	(–1.13)	(0.8)	(–0.1)
NTB_Chemical	0.06**	–0.01	*0.02***	0.03	0.01
	(3.05)	(–1.13)	*(2.08)*	(1.28)	(0.71)
NTB_Metal	0.07*	0.01	0.03	*0.06*	0.01
	(1.95)	(0.8)	(1.28)	*(0.53)*	(0.26)
NTB_Machinery	0.02	–0.00	0.01	0.01	*0.01*
	(0.92)	(–0.1)	(0.71)	(0.26)	*(0.34)*
Fixed capital	–0.37**	–0.14**	–0.20**	–0.72**	–0.25**
	(–5.4)	(–6.25)	(–4.39)	(–3.17)	(–2.78)
Labor force	0.42**	0.16**	0.22**	0.77**	0.27**
	(4.55)	(5.41)	(3.65)	(2.59)	(2.31)
Arable land	–0.05	–0.02**	–0.02	–0.06	–0.03
	(–1.16)	(–1.71)	(–0.82)	(–0.47)	(–0.52)
Time trend	0.03	0.02	–0.01	–0.16	–0.05
	(0.25)	(0.64)	(–0.2)	(–0.49)	(–0.37)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
R^2	0.58	0.53	0.48	0.30	0.25

Notes: Non-tariff barriers (NTBs) are measured by its coverage ratios. The glass and paper industries are dropped owing to the lack of data. Estimation results for five industries are reported in columns, with *t*-statistics in italics. The dependent variable is the percentage output share of the industry. Independent variables are in logarithms. Numbers in italic form denote own semi-elasticity. Numbers in parenthesis are *t*-values. *,** Denote significance at 5% and 1% levels, respectively. Year and country fixed effects are not reported here to save space. There are 39 observations in each equation.

Table 7. Estimate of the GDP Share Function Using NTBs (frequency) Data

	Food	*Garments*	*Chemicals*	*Metals*	*Machinery*
NTB_Food	*–0.04*	–0.05	0.01	0.07	0.01
	(–0.18)	(–1.01)	(0.23)	(1.00)	(0.09)
NTB_Garment	–0.05	*–0.04***	–0.00	0.01	0.01
	(–1.01)	(–2.27)	(–0.27)	(0.30)	(0.85)
NTB_Chemical	0.01	–0.00	*0.05***	0.03	0.01
	(0.23)	(–0.27)	*(1.91)*	(0.78)	(0.22)
NTB_Metal	0.07	0.01	0.03	*0.17*	0.08
	(1.00)	(0.30)	(0.78)	*(0.84)*	(1.02)
NTB_Machinery	0.01	0.01	0.01	0.08	*0.03*
	(0.09)	(0.85)	(0.22)	(1.02)	*(0.75)*
Fixed capital	–0.36**	–0.14**	–0.18**	–0.66**	–0.23**
	(–4.96)	(–7.03)	(–3.79)	(–2.89)	(–2.56)
Labor force	0.38**	0.15**	0.20**	0.70**	0.26**
	(4.23)	(6.17)	(3.30)	(2.45)	(2.29)
Arable land	–0.02	–0.01	–0.02	–0.04	–0.03
	(–0.50)	(–0.87)	(–0.64)	(–0.35)	(–0.60)
Time trend	0.05	0.03	0.00	–0.14	–0.05
	(0.50)	(1.22)	(0.02)	(–0.44)	(–0.42)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
R^2	0.44	0.59	0.34	0.26	0.23

Notes: Non-tariff-barriers (NTBs) are measured by frequency ratios. The glass and paper industries are dropped owing to the lack of data. Estimation results for five industries are reported in columns, with *t*-statistics in italics. The dependent variable is the percentage output share of the industry. Independent variables are in logarithms. Numbers in italic form denote own semi-elasticity. Numbers in parenthesis are *t*-values. *,** Denote significance at 5% and 1% levels, respectively. Year and country fixed effects are not reported here to save space. There are 39 observations in each equation.

first use the coverage ratio to measure NTBs, since it has an advantage of considering the weights of each commodity covered by non-tariff protection (Trefler, 1993). The own effects of NTBs on their output share vary, as shown by: metals (0.06), food (0.02), chemicals (0.02), machinery (0.01) and garments (0.01). It turns out that the effects of NTBs on output share are all positive. However, only the chemical industry has a significant sign.

We then measure the impact of NTBs using the frequency ratio in Table 7. Trade protection in the chemical industry again has a positive impact on its output share. In contrast, a significantly negative effect occurs in the garment industry when NTBs are measured by the frequency ratio.

To summarize, estimation results from Tables 5–7 demonstrate that trade protection in the chemical industry is significantly positively associated with output share regardless of the protection measurement. Tariffs in the machinery industry have a significant positive effect on output share. By contrast, tariffs in the glass industry are shown to have a negative impact on their output share.

Note that we have already examined the impact on industrial output share of tariffs and non-tariff barriers respectively. For the sake of completeness, it is better to include the two types of trade protection simultaneously in the regressions. As a result of data restrictions, we are not able to conduct such an exercise. In this sense, it is worthwhile to be aware that each separate regression above may suffer from some estimation bias owing to omitted variables.

Political Economy Issues

Previous analysis clearly established a channel that the industrial output share is affected by its trade protection by using a translog GDP system. However, it is reasonable to believe that each industry could inversely seek protection by lobbying the government. Therefore, trade policy is influenced by demands from special interest groups such as unions. Previous studies like Brainard and Verdier (1997) had *theoretically* shown that high protection industries can have declining output shares over time, by considering the cost of lobbying. Similarly, Broda et al. (2006) are also aware that commercial policy could be influenced by domestic political interest groups. In short, to fully explore the impact of trade protection on industrial production size, we need to control the endogeneity problem in our estimations raised by the possibility of reverse causality.

Another potential source of the endogeneity problem is caused by omitted variables. For instance, we ignore the international institutional organization constraint in our previous estimations, in large part, owing to the own limitation of the translog GDP approach. However, it may matter in the US NTB-setting process whether trading partners are members of GATT/WTO or in a preferential trade agreement (PTA) with the USA (see, e.g. Furusawa and Jinji, 2007; Zhao and Kondoh, 2007). Moreover, the exclusiveness of international organization is partly because of the data unavailability. For example, although it is ideal to consider a trading partner's bargaining power (such as retaliatory and bilateral aid) that makes the country more likely suffer from the NTBs imposed by the USA, a scientific index to measure a country's bargaining power, to the best of our knowledge, is unfortunately unavailable.

It is well recognized that the IV approach is a powerful approach to control the endogeneity problem (Wooldridge, 2002). However, the challenge of using such an approach is to choose good instruments which, ideally, are exogenous to the instrumented variable and affect the regressand through and only through the instrumented variable. Here, we adopt the percentage of industrial union members and the percentage of unions represented in each industry as instruments for the setting of NTBs for the following reasons.[7]

First, much empirical literature on political economy has recognized that greater industrial labor unions are associated with higher commercial protection. For example, Trefler (1993) provided evidence that various labor characteristics such as labor unions and employment size are positively associated with the NTBs for the USA. However, few works, if any, recognize a *direct* link between the strength of labor union for an industry and its output share, without considering the channel of trade protection. The pre-estimation partial correlations on our data sample also strengthen this idea. For example, for the garment industry, its percentage of industrial union members, one of indexes of labor union strength, is strongly correlated with its NTBs ($|\text{corr.}| = 0.73$) but relatively weakly associated with its output share ($|\text{corr.}| = 0.08$).

Second, we concentrate on the endogenous setting of NTB, but not the tariff-setting caused by data unavailability. As shown in Table 4, our data samples for estimation of industrial tariffs are the years 1974–1990. The corresponding industrial labor union data are, unfortunately, currently unavailable at the SIC two-digit level.[8] However, we instead consider the role of political economy for the setting of NTBs

Table 8. IV Estimates for the Garment Industry

	Food	*Garments*	*Chemicals*	*Metals*	*Machinery*
NTB_Food	*0.05*	0.06	0.40*	1.29**	0.40*
	(0.14)	(1.22)	(1.83)	(2.45)	(1.83)
NTB_Garment	–0.03	*–0.02**	–0.02	–0.08	–0.02
	(–1.55)	*(–1.89)*	(–0.59)	(–1.16)	(–0.59)
NTB_Chemical	0.14**	0.06**	*–0.01*	–0.01	–0.01
	(1.97)	(2.58)	*(–0.12)*	(–0.06)	(–0.12)
NTB_Metal	0.00	–0.00	0.01	*–0.09*	–0.05
	(0.14)	(–0.22)	(0.65)	*(–0.78)*	(–0.87)
NTB_Machinery	–0.01	–0.00	–0.01	–0.00	*0.01*
	(–0.49)	(–0.24)	(–0.45)	(–0.00)	*(0.19)*
Fixed capital	–0.35**	–0.12**	–0.19**	–0.63**	–0.26**
	(–5.01)	(–6.00)	(–4.01)	(–2.95)	(–2.88)
Labor force	0.36**	0.14**	0.18**	0.54*	0.24**
	(3.87)	(5.33)	(3.00)	(1.92)	(2.00)
Arable land	–0.03	–0.01	0.00	0.07	–0.01
	(–0.67)	(–0.94)	(0.06)	(0.55)	(–0.23)
Time trend	0.09	0.03**	–0.01	–0.06	0.01
	(1.50)	(1.96)	(–0.19)	(–0.35)	(0.16)
First stage F-statistics	4.44†	11.59†	2.89†	16.58†	4.49†
Anderson (1984) likelihood-ratio statistic	10.57†	22.95†	7.24†	29.60†	10.75†
Cragg and Donald (1993) test statistic	4.44†	32.10†	8.02†	45.91†	12.58†
Anderson–Rubin χ^2 statistic	1.41	5.38†	0.93	1.22	2.25
Sargan over-identification P-value	0.24	0.28	0.64	0.46	0.26
Shea partial R^2	0.25	0.47	0.18	0.56	0.26
R^2	0.60	0.60	0.47	0.43	0.37

Notes: Numbers in parenthesis are t-values. *,** Denote significance at 5% and 1% levels, respectively. † Indicates p-value of the statistic is less than 0.01. Year and country fixed effects are not reported here to save space. We use percentage of labor union members and percentage of labor union-represented as instruments here. Various statistical tests are used to check their validity.

since union affiliation data for the intermediate industries are available after year 1994. It is reasonable to believe that such a consideration can still capture the US economy well since NTBs played a significant role after the Uruguay round of GATT/WTO in year 1994.

Table 8 reports the estimates for the impact of NTBs on output share for each industry by using the two instruments mentioned above. After controlling for the endogeneity, trade protection in garment industry has a significant negative effect on its output share, which is consistent with the findings in Table 7. Turning to the chemical industry, the impact of NTBs on output share is insignificant. This implies that the positive coefficients for the chemical industry shown in Tables 5–7 are merely correlations but not necessarily causality. In addition, effects of the NTBs for the rest of the industries (i.e. food, metals and machinery) are all insignificant.

We now turn to check the validity of the two instruments used for controlling endogeneity. Technically, various statistical tests suggest that both indexes of the labor union strengths are valid instruments. First, the first-stage F-test for the two instruments are highly significant at the 1% level. Second, to check whether or not instruments are correlated with the endogenous trade platform, Anderson's (1984)

Table 9. Further Checks for the Validity of Instruments

	Food	*Garments*	*Chemicals*	*Metals*	*Machinery*
NTB_Food	0.36*	0.05	0.34**	1.70**	0.55**
	(1.76)	(1.09)	(2.40)	(2.27)	(2.26)
NTB_Garment	–0.02	–0.00	–0.00	0.01	–0.02
	(–0.54)	(–0.35)	(–0.18)	(0.14)	(–0.37)
Labor union members ratio	–0.47	0.23	0.01	0.85	–0.81
	(–0.77)	(1.07)	(0.03)	(0.74)	(–0.38)
Labor union represented ratio	0.47	–0.20	0.01	–0.75	0.80
	(0.81)	(–1.00)	(0.09)	(–0.70)	(0.41)
NTB_Chemical	0.17	0.06	0.02	0.02	0.05
	(1.28)	(1.28)	(0.29)	(0.04)	(0.24)
NTB_Metal	0.03	0.01	0.01	–0.02	0.03
	(0.90)	(1.14)	(0.58)	(–0.18)	(0.66)
NTB_Machinery	0.01	0.00	0.00	–0.07	0.01
	(0.44)	(0.57)	(0.00)	(–0.98)	(0.26)
Fixed capital	–0.36**	–0.13**	–0.19**	–0.69*	–0.27*
	(–2.77)	(–2.78)	(–2.36)	(–1.82)	(–1.86)
Labor force	0.38**	0.16**	0.19*	0.61	0.25
	(2.12)	(2.51)	(1.71)	(1.13)	(1.38)
Arable land	–0.03	–0.01	–0.00	0.00	–0.02
	(–0.59)	(–1.09)	(–0.11)	(0.01)	(–0.42)
Time trend	0.07	0.03	0.01	–0.32	–0.10
	(0.60)	(1.52)	(0.07)	(–0.80)	(–1.01)
R^2	0.65	0.68	0.54	0.47	0.45

Notes: Numbers in parenthesis are *t*-values. *,** Denote significance at 5% and 1% levels, respectively.

canonical correlation likelihood-ratio test is used to verify whether or not our specification is under-identified. The rejections at the 1% level for each specification again show that our specifications are well identified. Third, we take a step forward to see whether or not such instruments are merely weakly correlated with the endogenous trade platform. If so, then the estimates will perform poorly in such estimations. However, the Cragg and Donald's (1993) F-statistic provides strong evidence for rejecting the null hypothesis that the first stage is weakly identified at a highly significant level. Fourth, we include Sargen's over-identification statistic. A rejection at the conventional statistical level would cast doubt on the validity of instruments. As shown in Table 8, this test is not rejected at the 10% level for each industry.

Finally, we also provide extra easy-to-interpret evidence for the validity of our instruments. We add the two instruments as exogenous regressors. If the industrial labor union strength has a *direct* effect on its output share, then we would expect the estimated coefficient to be statistically significant. However, as seen in Table 9, the coefficients of labor union strength, regardless of its measurements, are statistically insignificant in all specifications. These again confirm that these two indexes affect output share through and only through the channel of commercial protection.

4. Concluding Remarks

Trade theory has an ambiguous prediction on how import protection affects industrial production relative size. Based on a model of translog GDP system, in the present paper we are able to fully explore the effects of import protection on the output share for the main manufacturing industries in the USA. After controlling for the endogeneity and various relevant factors, our estimates suggest that trade protection does not seem to help increase the relative size of production for most industries. The impact of trade protection for some industries such as garments may lead to a declining industrial output share once trade protection is particularly measured by non-tariffs barriers.

This paper enriches the literature by introducing trade protection into the traditional neoclassical trade model *à la* a GDP translog system. Previous work assumes a basic free-trade framework to examine the effect of various factor endowments and technology on industrial output share. We instead extend the model by considering a non-free-trade world. Aside from trade policy, effects of other factors such as factor endowments and technology improvement broadly fit well with many previous works such as those of Kohli (1991) and Harrigan (1997).

Several extensions and possible generalizations merit special consideration. One of them is to update data coverage across countries and over time. Owing to data restrictions, this paper only covers the USA and its main OECD trading partners before 2000. Given that international trade has increased dramatically since 2000 and developing countries like China and India are playing a more and more important role in US foreign trade, it would be a great plus to include developing countries by using data after 2000. Another possible extension is to include a full set of intermediate industries within the manufacturing industries. Such enrichment could enjoy more advantages attached to the translog GDP approach (Feenstra, 2003). Finally, it would be a plus to integrate the nontradable sectors explicitly into the model. These are the topics which we will pursue in future work once the related data are accessible.

References

Anderson, James E. and Eric van Wincoop, “Trade Costs,” *Journal of Economic Literature* 42 (2004):691–751.

Anderson, T. W., *Introduction to Multivariate Statistical Analysis*, 2nd edn, New York: John Wiley (1984).

Barro, Robert J. and Jong-Wha Lee, “International Comparisons of Educational Attainment,” *Journal of Monetary Economics* 32 (1993):363–394.

Basu, Susanto and John Fernald, “Aggregate Productivity and Aggregate Technology,” *European Economic Review* 46 (2002):963–91.

Bernard, Andrew B., J. Bradford Jensen, and Peter K. Schott, “Trade Costs, Firms and Productivity,” *Journal of Monetary Economy* 53 (2006):917–37.

Bhagwati, Jagdish N., “Immiserizing Growth: A Geometrical Note,” *Review of Economic Studies* 25 (1958):201–205.

Brainard S. Lael and Thierry Verdier, “The Political Economy of Declining Industries: Senescent Industry Collapse Revisited,” *Journal of International Economics* 42 (1997):221–37.

Broda, Christan, Nuno Limão and David E. Weinstein, “Optimal Tariffs: The Evidence,” NBER working paper 12033 (2006).

Burgess, David F., “Tariffs and Income Distribution: Some Empirical Evidence for the United States,” *Journal of Political Economy* 84, no. 1 (1976):17–45.

Cassing, James H. and Arye L. Hillman, “Shifting Comparative Advantage and Senescent Industry Collapse,” *American Economic Review* 76 (1986):516–23.

Christensen, L. R., D. W. Jorgenson, and L. J. Lawrence, “Transcendental Logarithmic Production Frontiers,” *Review of Economics and Statistics* 55 (1973):28–45.

Cragg, J. G. and S. G. Donald, "Testing Identfiability and Specification in Instrumental Variables Models," *Econometric Theory* 9 (1993):222–40.
Diewert, W. Erwin, "Functional Forms for Revenue and Factor Requirements Functions," *International Economic Review* 15 (1974):119–30.
Feenstra, Robert C., "New Product Varieties and the Measurement of International Prices," *American Economic Review* 84 (1994):157–77.
———, "Integration and Disintegration in the Global Economy," *Journal of Economic Perspective* 12 (1998):31–50.
———, *Advanced International Trade: Theory and Evidence*, Princeton, NJ: Princeton University Press (2003).
Feenstra, Robert C. and Hiau Looi Kee, "Export Variety and Country Productivity: Estimating the Monopolistic Competition Model, with Endogenous Productivity," *Journal of International Economics* 74 (2008):500–18.
Feenstra, Robert C., John Romalis, and Peter K. Schott, "U.S. Imports, Exports, and Tariff Data, 1989–2001," NBER working paper 9387 (2001).
Furusawa, Taiji and Naoto Jinji, "Tariff Revenue Competition in a Free Trade Area: The Case of Asymmetric Countries," *Review of Development Economics* 11 (2007):300–12.
Grossman, Gene M. and Elhanan Helpman, "Protection for Sale," *American Economic Review* 84 (1994):833–50.
Harrigan, James, "Technology, Factor Supplies, and International Specialization: Estimating the Neoclassical Model," *American Economic Review* 87 (1997):475–94.
Kohli, Ulrich, "Price and Quantities Elasticities in Foreign Trade," *Economics Letters* 33 (1990):277–81.
Kohli, Ulrich, *Technology, Duality, and Foreign Trade: The GNP Function Approach to Modeling Imports and Exports*, Ann Arbor: University of Michigan Press/London: Harvester Wheatsheaf (1991).
Laird, Sam and Alexander Yeats, *Quantitative Methods for Trade-Barrier Analysis*, Basingstoke, Hants: Macmillan Press (1990).
Learmer, E. Edward, *Sources of International Comparative Advantage: Theory and Evidence*. Cambridge, MA: MIT Press (1984).
McKay L., D. Lawrence, and C. Valstuin, "Profit, Output Supply and Input Demand Functions for Multiproduct Firms: The Case of Australian Agriculture," *International Economic Review* 24 (1983):323–39.
Trefler, Daniel, "Trade Liberalization and the Theory of Endogenous Protection: An Econometric Study of U.S. Import Policy," *Journal of Political Economy* 101 (1993):138–60.
———, "The Long and Short of the Canada–U.S. Free Trade Agreement," *American Economic Review* 94 (2004):870–95.
Wooldridge, Jeffery, *Econometric Analysis of Cross Section and Panel Data*, Cambridge, MA: MIT Press (2002).
Zellner, Arnold, "An Efficient Method of Estimating Seemingly Unrelated Regression Equations and Tests for Aggregation Bias," *Journal of the American Statistical Association* 57 (1962):348–68.
Zhao, Lex and Kenji Kondoh, "Temporary and Permanent Immigration under Unionization," *Review of Development Economics* 11 (2007):346–58.

Notes

1. We thank a referee for pointing this out.
2. This is due to $\partial \ln {}_G/\partial \ln p_i = \partial G/G \cdot p_i/\partial p_i = p_i y_i/G \equiv s_i$ in which the second equality comes from the application of the envelope theorem.
3. The SUR system also enjoys an advantage of allowing the error term in an industry correlated with its counterpart in another industry. In other words, the SUR allows for a possible case that different industry-level observations for different exporting countries are relatively

dependent observations, owing to the fact that the USA is a member of the GATT/WTO and hence applies the same most favored nation (MFN) tariff rate to all other GATT/WTO members.

4. According to US Department of Commerce, in 2008 the American top trading partner was Canada whereas the second was China.

5. One possible reason for this phenomenon is the increasing outsourcing over years. Feenstra (1998) is an excellent survey for the production disintegration. For the data source, see the web pages of the Bureau of Economic Analysis at http://www.bea.gov.

6. Source: U.S. International Trade Commission, *The Economic Effects of Significant U.S. Import Restraints*, Washington, DC (2004).

7. In addition to the percentage of industrial union members, an alternative index is the percentage of unions represented, which refers to members of a labor union who report no union affiliation but whose jobs are covered by a union or an employee association contract.

8. The Bureau of Labor Statistics does have union affiliation data for years 1983–2006 by industry at highly aggregated level. However, data by intermediate industry at SIC 2-digit level are available only for years 1994–2006.