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Country Economics Department
The World Bank
September 1988
WPS 83

Welfare Costs of U.S. Quotas on Textiles, Steel, and Autos

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and
David Tarr

Protectionism is popular but costly: the United States loses $21 billion a year in welfare costs through quotas on textiles, steel, and autos.

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Trade Policy

Nontariff barriers prevent a transition to the realities of international competition, and their welfare costs are huge.

The United States loses an estimated $14 billion a year in revenues through rents lost to exporting countries through export quotas. Add another $7 billion for distortionary costs.

Removing the remaining tariffs (an average 3.5% in 1984) would produce a welfare gain of about $0.9 billion — for a net benefit of $105 billion, measured in terms of the discounted value of displaced workers' lost earnings over a lifetime.

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Welfare Costs of U.S. Quotas in Textiles, Steel, and Autos

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Jaime de Melo
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David Tarr

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The paper draws on a larger study by Tarr (1988) while he was at the US Federal Trade Commission. We thank participants of the General Equilibrium Trade Policy Modelling Workshop at the University of Western Ontario for comments. The views are those of the authors, not those of the USFTC, nor those of the World Bank. We thank Julie Stanton for extremely valuable research assistance, Maria Ameal for logistic support, and Soren Nielsen for computer support.

I. Introduction

The United States, along with other developed countries, is progressively abandoning its commitment to the postwar multilateral trading system. The shift towards bilateralism is evident in the proliferation of discriminatory trade measures, which have increasingly canceled the benefits to the world economy since World War II of the successive rounds of multilateral tariff reductions on a most-favored-nation (MFN) basis. Discriminatory trade measures are not only administered bilaterally; they are often undertaken unilaterally (e.g. various forms of administered protection) or through multilateral arrangements (e.g. the Multi-Fibre Agreement). Moreover, the MFN clause does not prevent countries not participating in the multilateral negotiations from facing higher average tariffs on their exports: in spite of the Generalized System of Preferences (GSP), developing countries exports to developed countries face tariffs that are on average twice as high as those faced by developed countries (Balassa and Balassa, 1984).

Though accentuated by the recent macroeconomic imbalances and resulting exchange rate imbalances among developed countries, the move towards discriminatory trade policy practices has been on the rise for the past twenty years. The rising protectionism in developed countries in the form of non-tariff barriers (NTBs) retards the relocation of production of mature industries from developed to developing countries. 1/ NTB protectionism is congenial to those who seek protection because it is quick and lacks transparency and to exporters who negotiate it because they gain the rents. Thus, NTBs engender widespread opposition to trade liberalization. NTBs also impose huge costs on consumers and prevent a smooth transition to the realities of international competition.

Quite a few studies have been carried out to drive home the costs of these special protection arrangements. Individual sector studies for textiles: [Morkre (1985); Tarr and Morkre (1984); Cline (1987); Keesing and Wolf (1980)]; for automobiles [Winston and Associates (1987); Tarr and Morkre (1984); Feenstra (1984, 1985a, 1985b); Dinopoulos and Kreinin (1986)]; for steel [Tarr and Morkre (1984)] are among the most widely known studies that provide estimates of the welfare costs of NTBs in the US. Perhaps the most comprehensive recent estimates come from the 31 case studies of special protection by Hufbauer, Berliner and Schott (1986). All these studies, using a partial equilibrium (PE) framework, provide a very useful range of estimates of the costs of non-tariff pr[illegible]ion. These studies are especially valuable when taken individually because the assumptions of PE analysis provide an adequate approximation of reality even though the behavior giving rise to the demand and supply curves used in the estimation are not always properly spelled out. But, as we discuss below, when it comes to aggregating the costs of all restrictions taken together, the underlying assumptions are much less tenable.

This paper deals with the problems of PE analysis by presenting estimates from a static ten-sector computable general equilibrium (CGE) model of the US economy calibrated to the year 1984 when QRs in textiles, and autos were in effect, and those on steel were in negotiation. To our knowledge, the treatment of QR-associated effects here is more satisfactory than in previous CGE applications. While the US-negotiated VER on automobiles has expired, demand for NTB protectionism in the US remains strong and may be on the rise because of presidential campaign politics. A new round of estimates of the costs of protection is therefore all the more welcome.

The general equilibrium (GE) approach used here accounts for three effects omitted by PE estimates. First, the inclusion of a balance of trade constraint (expressed in foreign currency units) removes an upward bias present in PE analysis. Second, the effects of income transfers to and from the rest-of-the-world (ROW) are properly accounted for so that, unlike PE analysis, capturing quota rents affects resource allocation. Third, economy-wide resource constraints and interindustry linkages provide a more accurate estimation of sectoral employment effects.

The remainder of the paper is organized as follows. Section 2 outlines the model. Section 3 details the sources of estimates of premia on preexisting QRs in 1984 and the sources for the parameters describing demand and supply elasticities. Welfare and employment estimates of QR removal are presented by industry and in the aggregate in section 4. Conclusions follow in section 5.

2. Model Outline 2/

The simulation model is a static CGE model with assumptions that correspond closely to those followed by the partial equilibrium estimates cited above, namely a neoclassical perfect competition Walrasian model in which a representative consumer maximizes utility subject to a budget constraint, atomistic producers minimize costs, and the government redistributes, in a lump-sum manner, tax revenues from trade policy. The economy has a fixed endowment of labor and capital, and faces an exogenous balance of trade constraint expressed in foreign currency units. Because we are interested in the static welfare costs of protection, we abstract from investment, thereby simplifying the welfare analysis. The components of demand therefore only include consumer demand and intermediate demand.

Under these assumptions, it is clear that the welfare changes due to a change in trade policy are the usual production and consumption costs of protection referred to in the literature on the costs of protection. Our measure of the welfare cost to the US of departures from free trade is given by the equivalent variation (EV) measure associated with the utility function selected for the representative consumer, i.e.,

$$EV = C[IU(p^1,y^1), p^o] - C[IU(p^o, y^o), p^1]$$

where C is the cost function corresponding to the selected utility function, superscripts o and 1 refer to the equilibrium before and after the counterfactual trade policy experiment, p is the vector of final goods prices, and IU is indirect utility which depends on prices and income. 3/

The structure of the ten-sector model is described in table 1. 4/ To best capture the trading possibilities at a relatively aggregated level for an economy like the US, we have treated commodities supplied (or purchased) abroad and domestic commodities sold on the domestic market as imperfect substitutes. This assumption of product differentiation, which has found considerable support at the disaggregate level (e.g. Isard, 1977), is commonly used in applied general equilibrium analysis and is also adopted in most of the partial equilibrium estimates of the cost of protection in the US cited above. The assumption is particularly suitable for the relatively high level of aggregation in our study and allows for the observed cross-hauling in trade statistics. On the export side, the assumption of product differentiation is reflected in the constant elasticity of transformation (CET) function between domestic and foreign sales. 5/ A symmetric functional form is specified for intermediate demand by sector (see below).

Table 1 shows that production possibilities are parametrized by assuming CES functions for value-added and Leontief functions between intermediates (as a whole) and value-added, as well as within intermediates. However, within each sector, intermediate demand is a CES function between the domestically produced intermediate and the competing foreign intermediate. To give an example, no substitution is allowed between purchases of steel and other manufacturing intermediates, but substitution in purchases is allowed between domestically produced and foreign produced steel when their relative prices change as a result of a change in trade policy. Likewise, in consumption demand, we allow for non-unitary income elasticities of demand and non-zero cross-price elasticities of demand between domestically produced and foreign produced consumer goods.

Finally is the issue of whether or not the US would face fixed terms-of-trade for the trade policy changes envisaged here. In previous single-country partial equilibrium estimates, authors have invariably assumed that the US is a small supplier and demander in world markets. 6/ In our estimates, we retain this assumption except for autos where, in some cases, we argue that differences in standards and the size of the US market results in a non-infinite foreign elasticity of supply. When we consider a simultaneous removal of all discriminatory protection, at times, we also assume that the US would face a non-infinite elasticity of demand for her agricultural exports. 7/

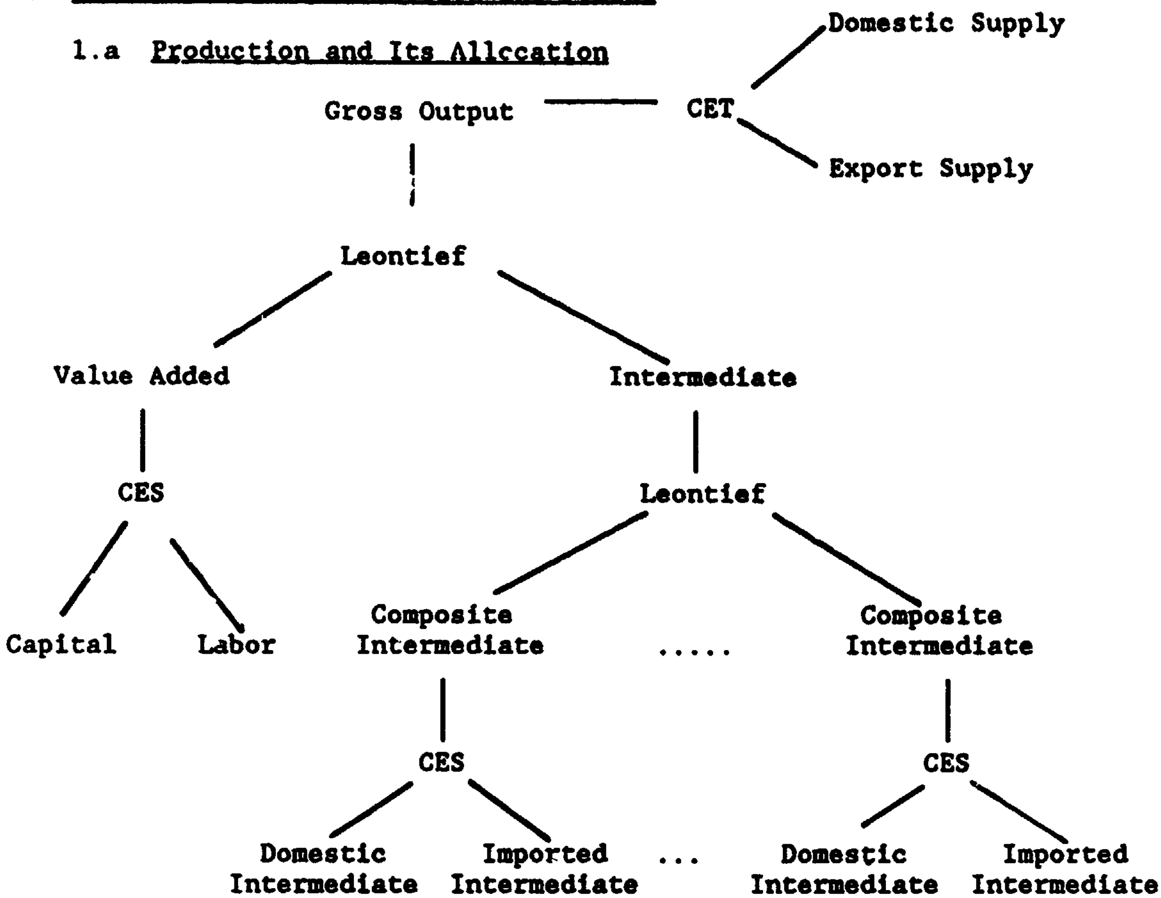
The description of the model is complete except for our treatment of QRs. In the US, for the sectors considered here, there are no government controls or direct quota allocations with resale prohibition. Hence,

Table 1

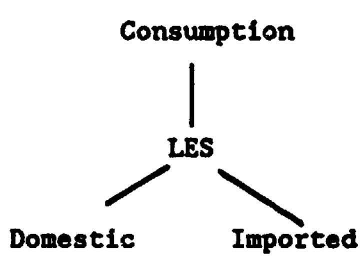
Model Structure

1. Substitution in Production and Demand

1.a Production and Its Allocation



1.b Consumer Demand



2. Import Supply and Foreign Export Demand

Import Supply: Infinitely elastic (except autos)

Foreign Export Demand: Infinitely elastic (except agriculture) unlike the case of many QR allocation schemes in developing countries, the US system of QRs allows for market-clearing prices. 8/ Since in 1984 quotas were already in place in autos and textiles, we assume that observed purchases were at the premia inclusive prices in that year. (The estimation of premia is discussed in section 3). Finally, it is worth noting that, following the calibration procedures in applied general equilibrium models, we are assuming that the prices and quantities observed in 1984 correspond to an equilibrium of the US economy with normal capacity utilization and in which the only distortions are the QRs and tariff on imports. This may be viewed as a strong assumption but it is implicit as well in all other estimates of the costs of protection.

Most previous GE studies of the costs of protection (e.g. Deardorff and Stern (1986) and Whalley (1985)) that have dealt with QRs have done so in the context of global models where QRs have been treated by their tariff equivalents without including the associated rent transfer that occurs with the US QRs. Moreover, the choice of functional forms has resulted in excessively large terms-of-trade effects for unilateral changes in trade policy (see footnote 6). 9/ Both problems are remedied in our approach.

3. Elasticity and Premia Estimates

The accuracy of our estimates of the welfare costs of protection depend on the assumptions embodied in the model, on the estimates of pre-existing premia due to QRs in existence and on the supply and demand elasticity estimates. With respect to the modelling assumptions, with the possible exception of noncompetitive behavior in autos (see Winston and Associates (1987) and Dixit (1987)), our assumptions are certainly plausible and representative. Hence considerable effort was devoted to a "parameter search" for elasticities of demand and supply and to constructing premia estimates for existing QRs in textiles and autos. We discuss these briefly below. (Tarr (1988, chaps. 6 and 7) is devoted to a detailed discussion of how these estimates were derived.)

Table 2 presents all the necessary elasticities and our constructed estimates of pre-existing premia. The elasticities reported in table 2 correspond to the "central" elasticities. When we report the likely range of welfare costs from removing all trade restrictions in table 4 below, we are reporting results from the "low" and "high" elasticities that are derived from the "central" elasticities in table 2 by subtracting (adding) a standard deviation. 10/ Because much econometric work has been done to estimate the capital/labor substitution elasticities, we are fairly confident about the relative accuracy of these elasticities. We are also fairly confident in the estimates of import demand elasticities for which a number of estimates are available. Less confidence can be placed on export supply elasticities. However, because these latter elasticities only enter indirectly into our estimations, we have found that our welfare estimates are quite insensitive to considerable changes in their values. 11/

Turning to the estimation of the premia rates estimates (expressed as a percent of landed US import price inclusive of tariffs), we have relied on Hamilton (1988) for apparel. In order to understand the problem of the premia rate estimation, it is crucial to recognize that the existing MFA arrangements allow a number of marginally inefficient foreign suppliers to sell in the U.S. If the MFA were abolished, many of them would be squeezed out of the US market by competition. The quota premium rate earned by these inefficient suppliers, is less than the quota premium rate

Table 2

Elasticity Specification (Central Case)

Sector	Column Notes (1)	(2)	(3)	(4)	(5)	Elasticity of Substitution Intermediates (+) (1)	Elasticity of Substitution Capital/Labor (2)	Elasticity of Transformation Domestic/Export Sales (3)	Price Elasticities of Final Demand: Domestic (4)	Price Elasticities of Final Demand: Imports (5)	Premia Rates (6)
Agriculture	a	c	e	k	f	1.4	0.6	4.0	0.75	0.8	
Food	a	c	e	f	f	0.3	0.8	3.0	0.90	1.1	
Mining	b	b	e	j	f	0.5	0.8	3.0	0.50	1.0	
Iron and Steel	a	d	e	i	f	3.0	1.0	3.0	1.0	1.4	
Motor Vehicles	a	c	e	h	h	2.0	0.8	3.0	1.2	1.1	22.6%
Textiles and Apparel	a	c	e	l	f	2.6	1.0	3.0	0.4	3.9	40.5%
Other Manufactures	a	c	e	f	f	3.6	0.8	3.0	1.5	1.8	
Other Consumer	a	c	e	f	f	3.2	0.8	3.0	1.9	2.4	
Traded Services	b	c	e	g	g	2.0	0.8	0.7	0.5	0.6	
Non-Traded Services		b		g			0.8		0.5		

(+) CES and CET functions imply that the corresponding elasticities of substitution (transformation) correspond to compensated import demand (export supply) elasticities.

All price elasticities of demand defined as positive numbers. For premia estimates, see text.
Column notes correspond to the sources from which estimates are interpolated. For interpolation details see Tarr (1988).

(a) Shiells, Deardorff and Stern (1986); (b) Dixon <u>et al</u>. (1982); (c) Caddy (1976); (d) Hekman; (e) own estimates; (f) Stern, Francis and Schumacher (1976); (g) Houthakker and Taylor (1970); (h) Levinsohn; (i) Crandall (1981); (j) Bohi and Russell (1978); (k) USDA (1984); (l) Hufbauer et al (1986).

paid by US consumers as a result of the MFA. Thus, we had to determine the marginal supplier to the US if the MFA were abolished. Data in Hamilton (1988), allow us to determine that Hong Kong, which had a quota premium rate of 47% for apparel sold to the US in 1984, or a supplier more efficient than Hong Kong, would be the marginal supplier if quotas were removed. 12/ The US is much more competitive in textiles than in apparel. Consequently, for textiles we take 5% for the premium rate, which is much more conservative than the one (15%) proposed by Cline (1987, p. 167). A positive rate, however, is indicated based on data in a study by the US International Trade Commission (1987). For autos we relied on the quality-adjusted premia estimates of Feenstra (1985a) for Japanese car imports by the US. For European car imports, we relied on the quality-adjusted price increase of European cars sold in the US estimated by Dinopoulos and Kreinin (1987). Our resulting premia estimates, which are weighted averages, are 40% for textiles and apparel and 23% for autos. 13/

4. Welfare Cost Estimates

Since the restrictions are administered by the exporting countries, the premia accrue to the exporting countries rather than to the US. One can therefore distinguish two components of the costs of the QRs: (1) the income or rent transfer to foreigners; (2) the distortionary cost due to the usual consumption and production costs of protection. Table 3 summarizes these costs for each of the three industries: textiles and apparel, autos and steel. Since the restrictions on steel -- which resulted in approximately a 15% reduction in the imports of steel starting in early 1985 -- were only implemented in 1985, we obtain the estimates for steel by reducing intermediate and final consumption of imported steel

Table 3

Welfare Costs and Employment Effects of QRs: Individual Sectors

	Welfare a/ Gain	Employment b/ Change in the Industry Losing Its QR	Economy-Wide c/ Employment Relocation
Textiles and Apparel			
Remove QRs	13.06	-158.3	158.3 d/ (.15)
Capture Rents from Foreigners	7.07	-3.3	35.2 (.03)
Autos			
Remove QRs	6.9	-1.14	1.27 (.001)
Capture Rents from Foreigners	6.2	+1.05	30.9 (.029)
Steel			
Remove QRs	0.91	-20.7	22.3 (.021)
Capture Rents from Foreigners	0.78	-0.1	3.9 (.004)

Notes: Estimates based on central elasticities.

a/ Welfare is EV measure expressed in 1984 US billion.
b/ Employment is expressed in thousand work-years.
c/ One-half of the sum of the absolute value of the employment changes expressed in thousand work-years.
d/ The numbers in parentheses in the third column are the percentage of employees in the economy who must relocate. For example, (.15) means that fifteen-hundredths of one percent of the economy's employees must relocate.

products by 15% from the observed levels in 1984. This restriction results in a 7% premium on imported intermediate steel products. The employment figures in column 2 are only for the industry subject to quota removal, and the total economy-wide relocation of workers is presented in column 3. This latter measure is a summary of interindustry effects (see. e.g. Deardorff and Stern (1986)).

The figures in Table 3 reveal that the largest welfare costs are due to the QRs in textiles and apparel. This may seem surprising since that sector is smaller than autos, and imports are 3/4 of auto imports in value (including premia). Furthermore the proportion of the total welfare costs due to distortionary costs are much higher in textiles and apparel. This is so because the price elasticity of demand for textiles and apparel is almost four times higher than the corresponding elasticity for autos. 14/ Furthermore, the relative homogeneity of domestic and imported steel reduce production costs of distortion.

Because elasticity estimates are not precise, we report in table 4 a range of welfare costs from removing all QRs simultaneously for low and high elasticities. Note that because the marginal benefits to the economy of an income transfer is a decreasing function of demand and supply elasticities, the welfare gains from capturing the rents from foreigners is higher in the low elasticity case than in the high elasticity case. Of course these welfare estimate gains due to the capturing of rents from foreigners are overestimates to the extent that rent-seeking activities dissipate them. For this reason, an auction quota mechanism is superior to a direct allocation of quota rights to imports. 15/ Thus our estimate of the annual cost of QRs in these three industries for the protection levels in 1985 is between US$21 billion and US$23 billion.

Table 4

Welfare Costs of QRs and Tariff Protection: Long-Run Estimates a/

	Low Elasticity Case	High Elasticity Case
Remove QRs	21.0	22.7
Capture Rents from Foreigners (retain QRs)	16.0	13.8
Eliminate Remaining Tariff Protection (after QR removal)	0.59	1.34

a/ Welfare is the EV measure expressed in US 1984 billion.

It is quite probable that the US has monopsony power in its purchase of imported autos and monopoly power in its sale of agriculture products because of its relative importance in the world market for these products. We have experimented with an export demand elasticity value of 4 for agricultural products and an import supply elasticity of 5 for autos. Insofar as removing QRs leads to an increase in agricultural exports and an increase in auto imports, the US terms of trade will decline and hence the welfare gain will be less. For the medium elasticity case, including terms-of-trade effects lowers the welfare gain from US$20.9 billion to $19.8 billion. This effect is small because of the relative importance of quota rents which account for two-thirds of the total welfare costs. Obtaining the quota rents is a pure income transfer from the ROW to the US whose effect is a real appreciation of the dollar (about 1%) which is accompanied by a small improvement in the terms-of-trade (the transfer gain with terms-of-trade effect is about $100 million more in the medium elasticity case than without terms-of-trade effects). Thus, the distortion gains from removing QRs with terms-of-trade effects is only $5.5 billion, about 22% less than in the small country case. 16/

It is conceivable that the US would have monopoly and monopsony power in all the sectors in which she trades. Although this seems unlikely because the US market share is usually small in her main import and export markets, we have experimented with generalized terms of trade across all sectors for the central elasticity case by assuming constant import supply for consumer goods imports and export demand elasticities of 5 for all sectors except autos (import supply elasticity of 3) and agriculture (export demand elasticity of 2). 17/ The gains from QR removal are smaller, but still substantial ($16.2 billion). However, because of the terms-of-trade effects, which result in expanded trade volume at higher foreign currency import prices and lower foreign currency export prices, the share of distortionary costs in total QR costs falls from 32 percent to 8 percent of total costs. Finally, adding unilateral tariff reduction now results in a welfare loss of $2.9 billion because of the dominating terms-of-trade effect, a result similar to those found in the global simulations mentioned in section 2.

Our welfare cost estimates are significantly higher than previous GE estimates and than most PE estimates. This is so for several reasons. First we properly account for the $14 billion transfer associated with the US system of QRs. Second, our results are not dominated by terms-of-trade effects. 18/ Third, in comparison with most previous PE estimates, we have benefitted from the detailed work on premia estimates by Feenstra (1985a), Hamilton (1986) and Dinopoulos and Kreinin (1988) which are higher than previous estimates. 19/

5. Employment

Table 5 presents estimates of the employment effects of simultaneous removal of QRs in textiles, autos and steel for the central elasticity case. The simultaneous removal of QRs also points out to conflicting worker interests across the three industries subject to QRs. While the steel and textiles and apparel sectors would lose almost as many jobs when all QRs are removed than when they are removed in their sector alone, the autos sector gains 1,900 jobs when the QRs on steel (and textiles and apparel) are removed concurrently with the VER on autos. This is so because steel, an input into auto production is cheaper and because the income elasticity of demand for autos is high. Both effects benefit the domestic auto industry which expands even when QR protection is removed.

Table 5

Employment Changes from Removing QRs in Autos, Steel and Textiles
(Central Elasticity Case)

(thousand jobs)

Agriculture	14.3
Food	1.6
Mining	4.0
Textiles and Apparel	-157.6
Autos	2.0
Steel	-16.2
Consumer Goods	17.5
Other Manufacturing	78.6
Traded Services	34.3
Non-Traded Services	21.6

Given that QR protection is obtained through the political process, one can argue that the US Congress has decided to value more highly a job in the protected sectors. Since the combined QRs preserve 174 thousand jobs in textiles, autos and steel, but comes at a cost of US$20.9 billion, the annual cost per job protected in these three sectors is about US$120 thousand. This is approximately 8(3) times the average annual total compensation of workers in the textile (steel) industries.

If QRs are removed, displaced workers will incur search, relocation, and retraining costs (see Mussa (1978)). Net benefits from QR removal are obtained by subtracting these costs. A proxy for these costs is the discounted value of the displaced worker's earnings losses over his lifetime. 20/ This measure allows us to estimate how much gainers will have left after compensating displaced workers for their earnings losses. Earnings losses for displaced workers last approximately six years. 21/ A conservative estimate of net benefits, NB, is obtained as

$$NB = \sum_{t=0}^{5} \frac{[20.9 - C_t]}{(1+r)^t}$$

where $r = 7\%$ is the discount rate and C_t are estimated earnings losses. 22/ NB is US$105 billion, with associated Benefit/Cost of 65. That is, for every dollar of earnings losses saved, the economy loses $65.

6. Conclusions

In the introduction, we said that PE estimates are upward biased because they fail to include the balance of trade constraint. An order of magnitude of the difference between PE and GE estimates due to this effect is obtained by solving the model with a fixed real exchange rate and hence an endogenous trade balance. This would correspond to what is typically done in PE estimates. For the central elasticity specification, removing all QRs would lead to a current account deterioration of US$11 billion and an EV estimate of US$33 billion. This estimate is about one and a half times the estimate obtained when the balance of trade constraint is properly taken into account. Economy-wide welfare costs estimates derived by adding up individual industry PE estimates are likely to be significantly upward-biased.

Perhaps the most striking result is the relative costs of protection from NTBs and from tariffs. While this is repeatedly mentioned in policy discussions, few relative estimates are available. The figures in table 4 suggest that the welfare cost of tariff protection is between 3% (low elasticity case) and 6% (high elasticity case) of the welfare cost of QRs in textiles, autos and steel. Since there are other QRs in the US beyond those examined here, this estimate is a lower bound.

An alternative way to evaluate the costs of QRs is to ask what tariff structure would give the same welfare loss as existing QRs in the three sectors. Returning to the central elasticity estimates, in that case the total welfare cost is estimated at US$20.9 billion of which 1984 US$6.7 billion is the distortionary component. For that set of elasticities, moving from the actual tariff structure to a uniform tariff structure yielding the same (import weighted) average protection would represent a welfare gain of US$0.60 billion. (Removing tariffs altogether would give a welfare gain of US$0.94 billion.) Starting from the existing tariff dispersion, to get the distortionary cost element of QRs would require multiplying each tariff by 3.8 times its 1984 value, which would amount to an average (import weighted) nominal protection of 15%. Adding the loss due to rent transfers would require multiplying tariffs by 6.9 times their 1984 value amounting to an average protection of 25%. 23/ It is no exaggeration to say that, in terms of protection costs, QRs are taking us back to the early days of multilateral tariff negotiations, especially if one includes the rent transfer element.

Footnotes

1/ See Baldwin (1984), Tumlir (1985) and Riedel (1986) on the political and economic causes for this shift in approach to trade policy. For the US, the shift towards discriminatory trade policy is associated with a combination of the decline in US hegemony politics and an increase in government intervention.

2/ Appendix A lists the equations describing the model, the endogenous and exogenous variables and details the functional forms.

3/ Consumption demand is represented by the linear expenditure system which is derived from the associated Stone-Geary utility function. The welfare measure used here is described in Varian (1984), who uses the term expenditure function rather than cost function, and Deaton and Muellbauer (1980).

4/ The ten sectors are: agriculture (1); food (2); mining (3); textiles and apparel (4); autos (5); steel (6); consumer goods (7); other manufacturing (8); traded services (9); non-traded services (10). All sectors are traded with the exception of sector (10). See Appendix B and Tarr (1988) for details on aggregation.

5/ The CET was first introduced by Powell and Gruen (1967) and has been adopted by Dixon et al. (1982) in the ORANI trade model.

6/ The large country assumption is always assumed in multi-country models (e.g. Deardorff and Stern, 1985; and Whalley, 1985). de Melo (1986) and Brown (1988) argue that the product differentiation assumption adopted in multicountry models overstates the extent of monopoly power countries are likely to have. Also see Deardorff and Stern (1986, p. 61) for a similar view.

7/ The (constant) elasticities are: import supply of autos (5.0); foreign elasticity of demand for US agriculture exports (4.0).

8/ If market clearing was not allowed one would need to use virtual prices in Hicksian demand curves along the lines suggested by Neary and Roberts (1980) as for example in Grais, de Melo, and Urata (1986).

9/ An important exception is the single country model of Harris (1984) in which unilateral free trade by Canada is shown to be welfare improving.

10/ As the sources for table 2 detail, the estimates were obtained from many studies. These studies generally provide standard errors of estimates. For those elasticities taken from Stern, Francis and Schumacher, the high and low estimates are generally the high and low estimates from their survey which are not standard-deviation-based. In a few cases the high and low estimates are obtained by doubling and halving the central estimate. See Tarr (1988, ch. 5) for details.

11/ For example, doubling (halving) the elasticity estimates in column (3) increases (decreases) our estimates of the welfare gains with the central elasticity estimates from US$20.9 billion to $21.0 ($20.8) billion, respectively, or ± 0.4%.

12/ We note that estimates of quota premia, in both textiles and automobiles, vary from year to year. We obtained estimates of quota premia for 1984, the year for which we benchmarked the model. Thus, our estimates apply to the conditions prevailing in that year. For other years, the premia rates and our cost estimates may differ.

13/ If the marginal supplier is more efficient than Hong Kong, our premium rate estimate is conservative and the associated welfare gain estimate is downward-biased.

14/ In his study of the similar arrangement for quota right distributions among cheese exporters to the US, Anderson (1985) comes to similar conclusions, i.e. that the distortionary costs coming from the bilateral quota arrangements is extremely high. Had we further disaggregated textiles and apparel as Anderson did in his study of cheese quotas, we would have found even higher welfare costs.

15/ See Elliott, Schott and Takacs (1987) for an appraisal of such a proposal for US trade policy.

16/ If one interprets the individual welfare estimates in table 3, as linear approximations to the nonlinear demand and supply curves in the model, then the sum of the individual estimates will underestimate the total welfare gain. This is indeed so, but the underestimate is small: for the small country case, the underestimate from table 3 is only $30 million. This non-linearity effect is even more important for the relatively large welfare equivalent (to QRs) of uniform tariffs reported below.

17/ It should be noted that, in the presence of a balance of trade constraint, the export demand and import supply elasticities are not independent (see Whalley and Yeung, 1984) and, along the offer curve will be less in absolute value than the figures cited in the text (see Jones and Berglas, 1977). The numerically calculated value for the aggregate export demand elasticity is -4.6; the numerical value for the aggregate import supply elasticity (including intermediates with the small country assumption maintained) is 6.3.

18/ For example, Whalley (1985, table 10.2) estimates welfare losses from US unilateral NTB removal and US unilateral tariff removal. Deardorff and Stern (1986, table 4.6) obtain small welfare gains.

19/ See Tarr (1988, chapter 2) for a comparison of our results with PE estimates.

20/ We call our estimate a proxy for these adjustment costs because we have not incorporated into our model an endogenous sector that moves resources, as suggested by the theoretical work by Mussa.

21/ See Jacobson (1978). To be conservative, we measure total compensation losses, which exceed earnings losses by the amount of fringe benefits. Morkre and Tarr (1980, Chapter 3) discuss the merits of this measure and the alternative unemployment cost measure.

22/ The estimate is conservative since earnings losses are zero after six years, while yearly benefits do not decay.

23/ In that experiment, we are increasing the variance of nominal protection by 3.8 and 6.9 times the variance prevailing in 1984. Since the distortionary costs of tariff protection is positively related to the average level of protection and to the variance of tariffs [see Johnson (1962)], another hypothetical calculation would consist of computing the average tariff under the assumption of no tariff dispersion across sectors. In that case, starting from a uniform tariff protection (3.5%) equivalent to the existing tariff protection in 1984, the distortionary cost element of QRs would require an average uniform protection of 24%. Adding the rent transfer loss would raise the average uniform protection to 48%. With linear, rather than constant elasticity demand and supply curves, welfare calculations would yield lower estimates as the corresponding elasticities would increase as one moves up the demand and supply curves.

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Appendix A

Model Equations

Notation

Variable subscripts indicate sectors. If double subscripts are employed, the first subscript denotes the sector of origin, the second the sector of destination. Upper case letters are reserved for endogenous variables, unless they have a bar, in which case they are exogenous variables or normalization constants. Parameters and policy variables are denoted by Greek or lower case Latin letters. There are $i,j=1,\ldots,n$ sectors, of which $k=1,\ldots,l$ are traded and the remainder $m=l+1,\ldots,n$ are non-traded. The index k(m) is reserved for traded (non-traded) sectors. NT refers to non-tradable sectors; T refers to tradable sectors.

Constant elasticity of substitution (CES) and constant elasticity of transformation (CET) functions are used throughout. To save on notation, we note first that CES and CET functions can be written analogously in the form $X=CES\ (X_1, X_2; \alpha_1, 1-\alpha_1, \rho, \bar{A})$ where $\sigma = \frac{1}{1-\rho}$; $1 < \rho < \infty$ in the CES case and $\sigma = \frac{1}{\rho-1}$; $1 < \rho < \infty$ in the CET case. To further save on notation, we write the unit dual cost functions associated with the CES (CET) functions as $PX = CES\ (CET)\ (PX_1, PX_2; \alpha, \sigma)$ where PX is the price of X and PX_1 and PX_2 the prices of X_1 and X_2.

Equations Listing

Equation (1) is unit average = marginal costs under the postulated technology (see table 1 in the text). Factor demands (equations 2-3) are obtained from Sheppard's lemma. The assumption of fixed factor endowments is reflected in equation (4). Equations (5-8) describe the choice between

Table A1

Equations Listing

1. Unit Cost

(1) $$CV_i = CES_i\ (W,\ R;\ \alpha_i,\ \sigma_i,\ \overline{AD}_i) + \sum_{j=1}^{n} a_{ji}\ X_i\ PC_{ji}$$

2. Factor Markets

(2) $$K_i^d = XD_i^{(1-\sigma_i)}\ CV_i^{\sigma_i}\ (R/(1-\alpha_i))^{-\sigma_i}$$

(3) $$L_i^d = XD_i^{(1-\sigma_i)}\ CV_i^{\sigma_i}\ (W/\alpha_i)^{-\sigma_i}$$

(4) $$\sum_i L_i^d = \overline{LS};\quad \sum_i K_i^d = \overline{KS}$$

3. Intermediate Products Demand

(5) $$V_{ji} = CES_i\ (VM_{ji},\ VD_{ji};\ \delta_j,\ \sigma c_j,\ \overline{AC}_{ji})$$

(6) $$VD_{ij}/VM_{ji} = ((1-\delta_j)/\delta_j)^{\sigma c_j}\ (PD_j/PMI_{ji}^{v})^{-\sigma c_j}$$

(7) $$VM_{ji} = 0 \qquad j \in NT$$

(8) $$V_{ij} = a_{ij}\ XD_i$$

4. Output Allocation for Tradables

(9) $$XD_k = CET_k\ (E_k,\ D_k;\ \gamma_k,\ \sigma t_k,\ \overline{AT}_k)$$

(10) $$D_k/E_k = ((1-\gamma_k)/\gamma_k)^{-\sigma t_k}\ (PD_k/PE_k)^{\sigma t_k}$$

Table A1 (continued)

5. Cost Prices

(11) $PS_k = CET_k\ (PE_k,\ PD_k;\ \gamma_k,\ \sigma t_k,\ \overline{AT}_k);\ PS_m = PD_m$

(12) $PC_{ij} = CES_j\ (PMI^v_{ij},\ PD_i;\ \delta_i,\ \sigma c_i,\ \overline{AC}_{ji});\ PC_{mj} = PD_m$

(13) $PN_i = PS_i - \sum_j a_{ji}\ PC_{ji}$

6. Definition of Internal Prices of Traded Goods

(14) $PE_k = PWE_k\ ER$

(15) $PMI^v_k = \overline{PWI}_k\ (1+tim_k)\ (1+pri_k)\ ER$

(16) $PM_k = PWM_k\ (1+tm_k)\ (1+prc_k)\ ER$

7. Import Supply; Export Demand

(17) $PWE_k = \overline{PWE}_k$ or $E_k = \bar{E}_k\ (PWE_k)^{-\Pi_k}\ ;\ \Pi_k > 0$

(18) $PWM_k = \overline{PWM}_k$ or $CM_k = \overline{CM}_k\ (PWM_k)^{\phi_k}\ ;\ \phi_k > 0$

$\Pi_k < \infty$ for agriculture; $\phi_k < \infty$ for autos

8. Consumer Demand and Market Equilibrium

(19) $CD_i = \lambda^d_i + (\beta^d_i\ /\ PD_i)\ (Y - COMIT)$

(20) $CM_k = \lambda^m_k + (\beta^m_k\ /\ PM^v_k)\ (Y - COMIT)$

where $COMIT = \sum_j \lambda^d_j\ PD_j + \sum_k \lambda^m_k\ PM^v_k;\ \ \sum_i \beta^d_i + \sum_k \beta^m_k = 1$

(21) $VTD_i = \sum_j VD_{ij}\ \ ;\ \ VTM_k = \sum_j VM_{kj}$

(22) $D_i = VTD_i + C^d_i$

Table A1 (continued)

9. Rationing

(23) $VTM_k = \overline{VTM}_k \ni PMI^V_{kj} \geq PMI_k \ (1 + PR_k)$

(24) $CM_k = \overline{CM}_k \ni PM^V_k \geq PM_k$ k = textiles, autos, steel

10. Rents on Rationed Sectors

(25) $RENTC_k = (FM^V_k - PM_k) \ CM_k + prc_k \ PWM_k \ CM_k \ (1+tm_k) \ ER$

(26) $RENTI_k = \sum_j \ (PMI^V_{kj} - PMI_k) \ VM_{kj} + \sum_j VM_{kj} \ (1+tim_k) \ pri_k \ ER$

11. Government Revenue (GR), Trade Balance Constraint ($\overline{B}$) and Income Definition (Y)

(27) $GR = \sum_k \ (\overline{PMV}_k \ VTM_k \ tim_k + PWM_k \ CM_k \ tm_k) \ ER$

(28) $\overline{B} = \sum_k \ (PWE_k E_k - PWM_k CM_k - PWI_k \ VTM_k)$

$- \sum_k \theta_k \ (RENTC_k + RENTI_k) \ / \ ER$

(29) $Y = W\overline{L}S + R\overline{K}S + GR + \sum_k \ (1-\theta_k) \ (RENTC_k + RENTI_k) - \overline{B} \ ER$

12. Numeraire

(30) $1 = \sum_j PD_j \ XD^o_j \ / \ \sum PD^o_j \ XD^o_j$

domestically and foreign produced intermediates. The allocation of domestic production between domestic and export sales is described in equations (9-10). Cost minimizing prices associated with the selected technology appear in equations (11-13). The relation between border and internal prices is given in equations (14-16). These equations allow for the existence of rationing in the base year in which case the premia rates pri_k, prc_k are positive. For sectors with no rationing, $pri_k = prc_k = 0$. The assumption of endogenous world prices for final import supply (for autos) and export demand (for agriculture) is reflected in equations 17 and 18. Consumer demand is described in equations 19 and 20 and sectoral supply-demand equilibrium is given in equation (22) after aggregating intermediate demands by sector of origin.

Because the textiles and apparel and auto sectors were rationed in 1984, we have allowed for the presence of rationing in the base year (see equations 15 and 16). When a sector is rationed the premium inclusive price (denoted with a superscript v) exceeds the corresponding internal price defined as the world price inclusive of border taxes and expressed in domestic currency units. Thus, for example, rationing of consumer demand for autos implies $PM^v_k > PM_k$, k = autos. Likewise, when total intermediate supply of imported intermediates originating in sector k is rationed, $PMI^v_{kj} > PMI_k$ by an endogenously determined amount PR_k which depends on the extent of rationing. When there is no rationing $PM^v_k = PM_k$ and $PMI^v_{kj} = PMI_k, V_j$. These assumptions are reflected in equations (23) and (24). Rents on rationed sectors are collected in equations (25) and (26). What portion of total rents goes abroad is determined by the parameter θ_k in equation (29).

Table A2

Endogeneous Variables			Number of Variables
CV_i	=	Unit costs	n
K_i^d	=	Sectoral capital stocks	n
L_i^d	=	Sectoral employment	n
V_{ji}	=	Composite intermediate purchases of sector i from sector j	n^2
VD_{ji}	=	Domestic intermediate purchases of sector i from sector j	n^2
VM_{ji}	=	Imported intermediate purchases of sector i from sector j	n(n-1)
XD_i	=	Gross output of sector i	n
D_i	=	Supply for domestic sales	n
E_k	=	Supply for export sales	m
PS_k	=	Unit price of composite domestically produced traded goods	m
PD_i	=	Unit price of domestically sold goods	n
PC_{ij}	=	Unit price of composite intermediate product of sector i sold to sector j	n^2
PN_i	=	value-added price of sector i	n
PE_k, PWE_k	=	Domestic and border price of exports from sector k (Note: PWE_k mostly exogenous)	m

Table A2 (continued)

$PM_k(PM_k^Y), PWM_k$	=	Domestic, (premium inclusive) and border price of consumer imports of sector k (Note: PWM_k mostly exogenous)	2m
$PMI_k, (PMI_k^Y)$	=	Domestic, (premium inclusive) price	2m
$RENTC_k, RENTI_k$	=	Rents on consumer and intermediate imports	2m
$VTD_i, VTM_k(PHI_k)$	=	Total domestic and import intermediate demands; (Premium on imported intermediate)	2m+n
CM_k, CD_i	=	Consumer demand for imports and domestically produced goods	m+n
GR,Y,ER	=	Government revenue from tariff collection, disposable income net of transfers and real exchange rate	3
W,R	=	Wage, rental rates	2
		TOTAL	$3n^2+n(n-1)+9n+12m+5$

Note: Number of endogenous variables varies according to model closure. (See text).

Finally the balance of trade constraint in foreign currency units (equation 28), the overall budget constraint (equation 29) and the numeraire (equation (30) close the model. Note that the choice of numeraire implies that the (endogenous) variable ER represents the real exchange rate. Thus when we fix the real exchange rate, we fix ER to its base year value and free the balance of trade B.

Table A2 lists the endogenous variables in the model. For our ten sector application with nine traded sectors and infinite trade elasticities, the model reduces to a system of $[3n^2+n(n-1)++9n+12m+15]-3m$ simultaneous equations since premia and virtual prices minus tariff inclusive prices are positive (zero) when quotas are binding (not binding).

Appendix B

Data Sources and Data Preparation

The model is calibrated from the 80x80 interindustry (I/O) flow matrix for 1982 commissioned by the US Forest Service. However, since 1982 was a recession year, after aggregating the I/O table to our ten-sector aggregation, we updated the table to 1984. The updating was done by applying the 1982 value added to gross output ratios to the 1984 value added figures published in the July 1986 Survey of Current Business. (Details of the mapping are provided in Tarr, 1988, Appendix). For imports and exports, we aggregated the seven digit level data published by the US Customs Service. For traded services, we used the data in the Survey of Current Business of June 1986, table 4.1. Next we corrected the data where they seemed inaccurate (e.g. we relied on US Census publication FT-990 for import and export data for Iron and Steel). Data on tariffs was obtained from the US Department of Commerce publication FT-990, of December 1984, p. A-17. Finally we scaled the trade data from the Census to make it consistent with the merchandise import and export data from the NIPA.

Next we made the necessary adjustments so that all flows are measured in US producer prices by using the data on the share of transportation and wholesale and retail trade embodied in the export data by using the estimates in the Survey of Current Business Table A of May 1984. Sectoral consumption is determined residually from sectoral material balance equations.

One final manipulation on the I/O data was required since the I/O flow matrix is a total matrix that does not separate domestic from foreign intermediate input use. Following the procedure suggested by Dervis, de

Melo and Robinson, General Equilibrium Models for Development Policy (1982, chapter 5) and adopted in previous studies of the US, we assume that the domestic use ratio in each sector is the same for all components of demand. Unfortunately, this is the closest approximation that can be achieved with existing information.

Data on employment was obtained from the US Department of Labor publication, Employment and Earnings, January 1985, pp. 186-9. Capital stock estimates were constructed from the first order conditions for sectoral labor and capital demand, an estimate of the wage rate from NIPA data, and an estimated rate of return on capital of 5.8% obtained from Survey of Current Business, August 1986 and July 1987. (Details are in Tarr 1988, chapter 4).

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