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Revenue-Raising Taxes: General Equilibrium Evaluation of Alternative Taxation in U.S. Petroleum Industries

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Should the United States increase energy tariffs and taxes to help reduce the federal deficit? And if so, what combination of tariffs and taxes makes the most sense?

Should the United States increase taxes and tariffs in the energy sector to reduce its federal deficit?

The authors used a twelve-sector general equilibrium model to estimate the fiscal effects, and the effects on welfare and employment, of

- A 25 percent import tax on imported crude oil.

- A 15 percent excise tax on petroleum products.

- A combination of the two.

The excise tax would be the most efficient instrument for raising revenues.

The 25 percent import tariff would raise $7.3 billion in government revenues, while the 15 percent excise tax on petroleum products would raise $35 billion in government revenues.

Moreover, each dollar raised through a tariff on imports would come at a loss of 25 cents in welfare. Each dollar raised through the excise tax on petroleum products would come at a loss of only one cent in welfare.

Not only would an import tariff on crude oil cause much dislocation (an estimated 153,000 workers would have to relocate), but it would pose trade policy problems.

A combination of excise taxes, subsidies, and import tariffs would be the least costly way (in terms of welfare) to raise $20 billion in government revenues. Taxing both sectors minimizes distortion-induced resource movements. The welfare cost of raising $20 billion is least when domestic petroleum production is subsidized by the combination of an import tariff and a small subsidy to counteract the distortion resulting from the tax on oil and gas, an input of the petroleum sector.

The optimal tax structure would involve a tariff and a small subsidy on petroleum products to counteract the distortion induced by a tax on oil — the most important input for petroleum products.

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by
Jaime de Melo, Julie Stanton and David Tarr

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This paper draws on a larger study by Tarr (1988) while he was at the U.S. Federal Trade Commission. We thank Bela Balassa for comments and Maria D. Ameal for excellent logistic support. The views are those of the authors, not those of the USFTC nor those of the World Bank.

I. Introduction

Several proposals have recently been made to increase taxes or tariffs in the energy sector. The most notable proposals have concentrated on: (1) an increase in tariffs on crude oil imports by $5 or $10 per barrel (roughly a tariff of 25 to 50 percent of the value of the imported oil); 1/ (2) an increase in taxes on final petroleum products by between 5 and 25 cents per gallon (roughly between 5 and 25 percent of the value of a gallon of gasoline). 2/ Domestic petroleum product refiners, however, have also sought an import tariff that is limited to imports of refined petroleum products. 3/ During the 1970s, proposals to increase the import tariffs on crude oil were commonly offered as devices to counteract the power of the OPEC cartel. In the late 1980s, however, the most prominent proposals to increase taxation in these sectors are being offered as a means of reducing the large US federal budget deficit and its twin trade deficit. In addition, some argue that it will help the US become energy independent, 4/ and will be relatively painless due to the recent decline in energy prices. Opponents argue that these taxes would be very costly to the US economy in terms of lost US welfare and in terms of adverse impacts on other sectors.

Due to conflicting concerns, President Reagan recently asked the Department of Energy to study whether any policy changes were warranted due to the fall in the price of energy products. Without proposing specific policies, that study drew the vague conclusion that allenge to policymakers is to utilize the market where possible and rwise find appropriate cost-effective action to the nation's energy problems (Department of Energy, 1987, p. 3). The purpose of this paper is to study explicitly cost-effective and welfare-effective methods of dealing with revenue generation through taxation of the crude oil and petroleum products sectors.

Previous quantitative studies have mostly been partial equilibrium exercises. Most made the unrealistic assumption that the demand for gasoline is perfectly inelastic in the short-run, and very inelastic in the long-run. Typically, the tax consequences were dealt with by adopting the rule of thumb that one billion dollars of revenue will be generated for the US government for each one cent per gallon tax on gasoline and diesel fuel. Given that a tax on gasoline has strong economy-wide linkages, it is useful to obtain estimates based in a general equilibrium context where interactive effects are accounted for. 5/

It is only recently that two general equilibrium studies by Boyd and Uri (1988a, 1988b) address the issue of taxation and the fiscal deficit. They have analyzed the welfare and revenue implications of a $5 per barrel import tariff on crude oil, and a 15 cents per gallon excise tax on gasoline. Boyd and Uri (1988b) find that the rule of thumb of one billion dollars of revenue for every cent of gasoline tax is an overestimate by about 50 percent, that is, the government can be expected to realize about one-half of a billion dollars per one cent tax on gasoline. In addition, they estimate that US welfare falls by about twice the amount of the gain in US Treasury revenues from a gasoline tax.

The purpose of this paper is to reexamine the welfare, fiscal, and employment implications of: (1) a 25% import tax on imported crude oil; and (2) a 15% excise tax on petroleum products. The estimates are derived from a 12 sector computable general equilibrium (CGE) model for the US economy calibrated to 1984. Our estimates are derived under the assumption that the existing voluntary export restraints (VERs) prevailing in 1984 in the textiles and apparel and automobile sectors would remain in effect. 6/ More importantly, we go beyond the existing literature by answering the question: what is the least costly combination (in terms of US welfare) of taxes and tariffs on the crude oil and petroleum product sectors to generate a given amount ($20 billion) of US government revenue.

The remainder of the paper is organized as follows. Section 2 presents the model and selected elasticity specifications. Section 3 reports on new welfare, revenue and trade balance estimates of the proposed tax rates mentioned above. Section 4 reports results on the set of least costly taxes in the crude oil and petroleum products sectors that would raise $20 billion in government revenue. Conclusions follow in section 5.

2. The Model and the Elasticity Specification

The simulation model is a neoclassical, perfect competition, static CGE 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. This stylized representation of government behavior is of course simplistic, but it adds great transparency to the estimation of the welfare costs of alternative taxation schemes designed to raise government revenue. The economy also has a fixed endowment of labor and capital, and faces an exogenous balance of trade expressed in foreign currency units, so as to help interpretation of the welfare effects of alternative taxation schemes. Our static representation of the economy allows us to abstract from investment, thereby further simplifying the welfare analysis. Thus the components of final demand only include consumer demand and intermediate demand.

2.1 The Model

Before sketching the model formulated in Table 1, it should be noted that the simulations which apply to 1984 take as given the most important foreign trade restrictions then in existence, namely the U.S. VERs on Japanese autos and the quotas on U.S. textile and apparel imports. 7/ We view these quotas as relatively important elements in our analysis since this implies that imports of these products are fixed, thereby adding a strong second best flavor to our estimates. Though less important quantitatively, we also assume that the existing tariff structure remains in place. To simplify the notation and presentation of the model, we do not list among the equations those that determine the rents ($RENT_k$ in equations 24 and 25) which accrue to foreigners, but the reader should be aware that the value of the transfer to foreigners implied by the U.S. system of quotas and VERs depends on the value of the real exchange rate which is endogenous.

The following notation is adopted throughout. 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 normalizing constants. Parameters and policy variables are denoted by Greek or lower case Latin letters. There are i, j = 1, ..., n sectors of which k = 1, ... l are traded and the remainder, m = l + 1, ..., n are non-traded. In the application l = 11 and there is one non-traded sector.

The functional forms used throughout are the linear expenditure system (LES) to denote the preferences for the representative consumer, the constant elasticity of substitution (CES) function to represent capital-labor substitution and substitution between domestic and foreign intermediates, and the constant elasticity of transformation (CET) to model export supply. 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.

The equations describing the model appear in Table 1. The welfare function is the Stone-Geary utility function associated with the consumer demand equations described in equations (19)-(20). Our measure of the welfare cost of a policy change is given by the equivalent variation (EV) measure defined as:

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

where superscripts o and 1 refer to the equilibrium before and after the counterfactual trade policy experiment, p is the tax inclusive vector of final goods prices, IU is the indirect utility function, and C is the cost or expenditure function. 8/

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

Table 1

U.S. General Equilibrium Model

0. Welfare Indicator

$$W = \prod_{i,k} (CD_i - \lambda_i^d)^{\beta_i^d} (CM_k - \lambda_k^m)^{\beta_k^m}$$

1. Unit Cost

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

$$= \quad PVC_i \quad + \quad INTC_i$$

2. Factor Markets

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

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

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

(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 1 (continued)

5. Cost Prices

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

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

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

6. Definition of Internal Prices of Traded Goods

(14) $PE_k = PWE_k\ ER$

(15) $PD_i = \tilde{P}D_i\ (1+tx_i)$; $tx_i > 0$; $i \in$ petroleum products and crude oil

(16) $PM_k = PWM_k\ (1+tm_k)\ (1+prc_k)\ (1+tx_k)\ ER$; $prc_k > 0$ for autos and textiles

7. Import Supply; Export Demand

(17) $PWE_k = \overline{PWE}_k$

(18) $PWM_k = \overline{PWM}_k$ or $VTM_k = \overline{VTM}_k\ (PWM_k)^{\phi_k}$; $\phi_k > 0$; $\phi_k < \infty$ for crude oil

8. Consumer and Intermediate Demands

(19) $CD_i = LES_i\ (PD_i,\ Y;\ \lambda^d_i,\ \beta^d_i)$

(20) $CM_k = LES_k\ (PM_k,\ Y;\ \lambda^m_k,\ B^m_k)$

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

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

Table 1 (continued)

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

(23) $$GR = \sum_k (PWM_k \; tm_k \; (CM_k + VTM_k) \; ER$$

$$GR_2 = \sum_i (\tilde{PD}_i D_i tx_i) + \sum_k PWM_k \; tx_k \; (1+tm_k) \; ER \; (VTM_k+CM_k)$$

(24) $$\bar{B} = \sum_k (PWE_k E_k - PWM_k \; (CM_k + VTM_k)$$

$$- \sum_k (RENT_k) \; / \; ER$$

(25) $$Y = W\bar{L}S + R\bar{K}S + GR_1 + GR_2 + \sum_k (RENT_k) - \bar{B} \; ER$$

10. Market Equilibrium

(26) $$PX_i = CV_i$$

11. Numeraire

(27) $$1 = \sum_j PD_j \; XD_j^o \; / \; \sum PD_j^o \; XD_j^o$$

Table 1

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	n^2
VD_{ji}	=	Domestic intermediate purchases	n^2
VM_{ji}	=	Imported intermediate purchases	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
PX_k	=	Unit revenue of traded goods	m
PD_i	=	Unit price of domestically sold goods	n
PC_{ij}	=	Unit price of composite intermediates	n^2
PN_i	=	value-added price of sector i	n
PE_k,PWE_k	=	Domestic and border price of exports	m
PM_k(PWM_k)	=	Domestic (border) price of imports of sector k	2m
$RENTC_k$	=	Rents on imports subject to quotas	2m
VTD_i,VTM_k	=	Total domestic and import intermediate demands	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+7m+5

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

domestic market as imperfect substitutes. This assumption of product differentiation, which has found considerable support at the disaggregate level is commonly used in applied general equilibrium analysis and is also adopted in many of the partial equilibrium estimates cited in section 2. On the export side, the assumption of product differentiation is reflected in the constant elasticity of transformation (CET) function between domestic and foreign sales. The choice of functional forms implies that σc and σt are respectively the (compensated) price elasticities of demand for imports and price elasticities of supply of exports.

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 (equations 5 and 6). To give an example, no substitution is allowed between purchases of crude oil and other manufacturing intermediates, but substitution in purchases is allowed between domestic and foreign crude oil 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 domestic and foreign produced consumer goods (equations 19 and 20).

Apart from the existing quotas on textiles and autos, the only distortions are the existing tariffs on imports. Of course this is a simplification of the existing structure of distortions, but for the purpose of studying the effects of taxation on crude oil and petroleum products, this simplification makes results easier to interpret.

With respect to the petroleum industries, note that we allow for the possibility of an upward sloping supply curve of imports for crude oil which has been suggested by Anderson and Metzger (1987). Also note that positive excise taxes apply only to the two petroleum industries, oil and gas and petroleum products, and that the excise tax is imposed on top of the existing tariff rates (equal to 0.2% for oil and gas and 3.1% for petroleum products).

In the experiments reported in section 3, we take the domestic sales tax (tx_i) and tariffs on the oil and gas and petroleum products sectors as an exogenous policy instrument. We ask what are the revenue and welfare effects of imposing taxes and tariffs at the proposed levels. On the other hand, in the experiments reported in section 4, we ask what are the values of tx_i and tm_i, for the oil and gas and the petroleum products sectors which maximize welfare given by the Stone-Geary indicator subject to the constraint that we must increase government revenue by $20 billion.

2.2 Elasticity Specification for the Energy Sectors 9/

The model has twelve sectors: Agriculture; Mining; Crude Oil and Natural Gas; Food; Textiles and Apparel; Automobiles; Steel; Other Manufacturing; Other Consumer Goods; Petroleum Products; Traded Services; Non-Traded Services. The classification provides for a disaggregation of mining and manufacturing so as to encompass five important policy sectors: automobiles, textiles and apparel, and steel on which VERs have recently been in effect; and crude oil and natural gas and petroleum products which are the subject of the policy experiments in this paper. Because the model is calibrated to 1984, we assume that existing import quotas on textiles and apparel and automobiles would remain in effect under the alternative taxation schemes analyzed here.

The structure of demand, the level of output and employment and the selected elasticities for the two energy sectors appear in table 2. The structure of demand indicates that imports are a larger share of domestic supply in the oil and gas sector and the oil and gas sector is also the more labor intensive sector. All sales from the oil and gas sector are sales to other sectors. Thus, an increase in that sector s relative price will have a negative supply effect on sectors which use oil and gas intensively as an intermediate input, in particular, for the petroleum products sector where purchases from the oil and gas sector comprise 56.3 percent of its total costs.

Turning to the elasticity estimates in the bottom half of table 2, we use Caddy's (1976) estimate of 0.8 for the elasticity of substitution between capital and labor for both sectors. Likewise, we use an identical estimate of 2.4 for the compensated price elasticity of demand for intermediate imports (Stern, Francis and Schumacher (1976)). A compensated price elasticity of supply of US exports of 3 is assumed for both sectors. The insignificant value of exports in both sectors, and earlier experiments reported in de Melo and Tarr (1988), suggest that results are quite insensitive to a wide range of values for this parameter. The price elasticity of final demand for domestic and imported petroleum products is assumed to be -0.92 (an average of estimates of (-0.79) reported in Shiells, Deardorff and Stern (1986) and of (-0.96) reported in Stern, Francis and Schumacher (1976)). Finally, a price elasticity of final demand of -0.5 is assumed for crude oil (Bohi and Russell (1978)) and petroleum products.

Table 2:

Production, Demand Structure and Elasticities in US Petroleum Industry

		Oil + Gas	Petroleum Products
Production and Demand (1984 US$ billion)			
Gross Output (XD)		157.3	217.2 (56.3%) a/
Employment (L)		619.0	204.0
Domestic Final Demand Sales (CD)		0.07	45.7
Intermediate Sales (VD)		156.4	167.3
Imports:	Intermediates (VM)	43.6	16.6
	Final Demand (CM)	0.02	4.5
Price and Substitution Elasticities			
Capital-Labor (σp)		0.8	0.8
Imports:	Final demand (uncompensated)	-0.5	-0.9
	Intermediates (σc)	2.4	2.4
Domestic:	Final demand (uncompensated)	-0.5	-0.9
Export Supply (σt)		2.9	2.9

a/ Percent of (direct) total costs attributable to intermediate purchases from the oil and gas sector.

In most simulations, we rely on the above values for elasticities which we refer to as the central elasticity case. However, to check on the sensitivity of results, we also carried out experiments for low elasticity and high elasticity cases. The low (high) elasticity case is obtained by reducing (augmenting) the values of the elasticities in table 2 by one standard deviation. Finally, we also experiment with values of 1 and 3 for the foreign elasticity of supply of imported crude oil, which are in the range suggested by Anderson and Metzger (1987).

3. Revenue and Welfare Effects of Proposed Taxation of US Petroleum Industries

We report first in section 3.1 the revenue, welfare and employment effects of tariffs on imports of oil and gas products and of a domestic sales tax on petroleum products for the central elastic , case. Next, in section 3.2, we establish the likely upper and lower bounds of the welfare costs per dollar of government revenue generated and also per additional percent of taxation.

3.1 Revenue Employment and Welfare Estimates

Table 3 shows that about five times more revenue would be generated by the proposed excise tax on petroleum products than by the import tariff on oil and gas. This is to be expected since the excise tax applies to all domestic sales amounting to $234 billion, whereas the import tariff has a much smaller base of $43.6 billion. It is also noteworthy that the excise tax on petroleum products is much less distortionary than the import tariff on oil and gas products. Thus, an excise tax on petroleum products raises about five times more revenue than a tariff on

Table 3:

Revenue, Welfare and Employment Effects of Taxation on the US Petroleum Industry

Experiment	Increase in Government Revenue (billion $ 1984)	Change in Welfare (billion $ 1984)	Employment Change (thousand work-years)		Economy Wide Employment Relocation (thousand work-years)
			Oil + Gas	Petroleum Products	
25% import tariff on oil + gas (E-1)	7.29	-1.86	63.88	-2.32	153.64
15% excise tax on domestic sales of petroleum products (E-2)	34.99	-0.32	-7.01	-4.33	32.67
(E-1) + (E-2)	42.78	-2.34	56.12	-6.51	162.07

a/ One-half of the sum of the absolute value of the employment changes (expressed in thousand work years).

imported oil and gas products at a welfare cost which is only 37 percent of the welfare cost of raising revenue by the import tariff. The reasons for this large discrepancy between the two revenue-raising instruments is that an excise tax applies to all sales and is therefore non-discriminatory by source. We elaborate on this point below.

The employment effects of the import tariff on oil and gas products shows that this method of raising government revenue would have labor relocation effects across the entire economy. The last column of table 3 is a measure of the total economy-wide relocation of workers. The value of that measure shows that interindustry effects are strong, since 153.6 thousand workers would be relocated but among these only 66.2 thousand would be relocating in the energy industries. The economy-wide relocation effect is even stronger for the proposed sales tax on petroleum products: only 11.3 thousand workers relocate within the energy industries, whereas 32.7 thousand relocate in non-energy sectors. The relatively smaller effect on employment in the petroleum products sector compared with the tariff on oil and gas imports is due to the non-discriminatory feature of an excise sales tax which applies to domestic as well as to import sales. Since 77 percent of petroleum products sales are to other sectors and we do not allow for substitution in intermediate inputs of a different sector of origin, purchasers of petroleum products cannot shift to other inputs. Such an assumption is of course a simplification which is only likely to hold for the short to medium run.

In interpreting the results in table 3, one should bear in mind that the estimated figure on government revenue from the proposed excise tax is probably an upper bound estimate. This is because an increase in the relative price of oil and gas or of petroleum products would induce users to shift to other sources of energy like coal. The possibility to susbtitute out of petroleum industries in response to an excise tax would both lower the welfare cost of the excise tax and the government revenue raised by the excise tax. Finally note that if the US could be assumed to have monopsony power on oil and gas (an unrealistic assumption), there would be a welfare gain after imposition of the tariff, because of improved terms of trade.

3.2 Relative Efficiency of Proposed Taxes

We now evaluate the relative efficiency of the proposed revenue-raising tax schemes relying on two indicators: (a) welfare cost per dollar of government revenue raised; and (b) billions of dollars of government revenue per additional one percent tax. These indicators appear in columns (3) and (4) of table 4 for simulations under low and high elasticities. We also compare our result with previous estimates.

Low elasticities result in more government revenue and less welfare cost for each tax scheme. Why this is so is shown in figure 1 which illustrates in partial equilibrium the effect of high and low elasticities on the welfare and revenue effect of a tariff on import demand. Initially, equilibrium is at (PM_0, VM_0) with infinitely elastic import supply of intermediates. Ignoring shifts in the (derived) demand for imported intermediates after the imposition of an import tariff, the new equilibrium shifts to (PM_1^L,VM_1) in the low elasticity case and to (PM,VM_1^H) in the high elasticity case. It is clear that the welfare costs, given by $W = 1/2\ (PM_1 - PM_0)\ (VM_1 - VM_0)$, is greater in the high elasticity case, and the government revenue, given by $(PM_1 - PM_0)\ VM_1$, is higher in the low elasticity case. This observation corresponds to the prescription of Pigou (1947, p 105), based on partial equilibrium analysis:

Table 4:

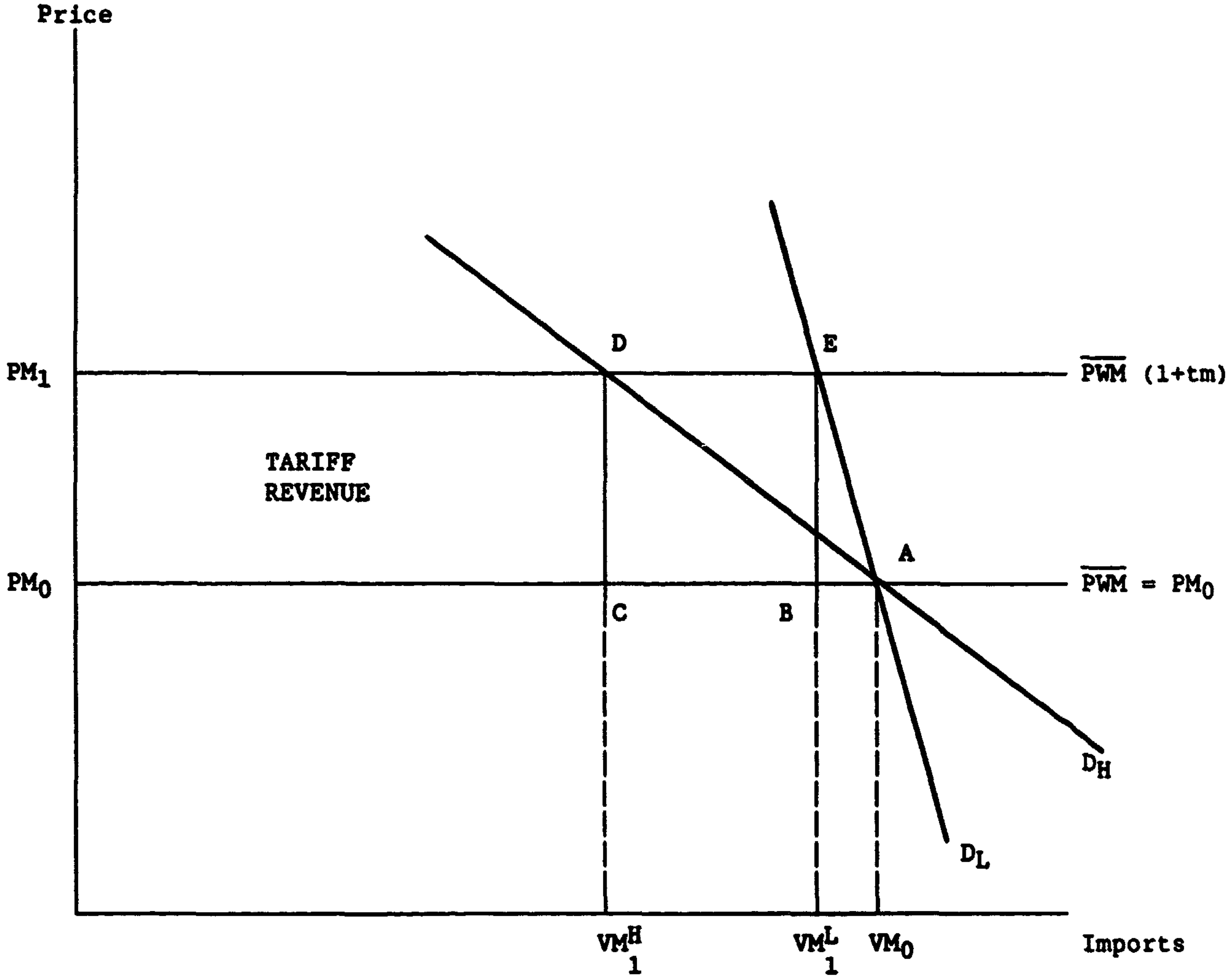
Welfare Costs per Dollar of Tax Revenue
(US$ 1984 billion)

	Elasticity	Change in Government Revenue (1)	Change in Welfare (2)	Welfare / Revenue (2)÷(1)	Billion of Revenue per Additional Percent Tax (4)
25% import tariff on oil and gas	L H	8.9 4.9	-1.0 -3.0	-0.11 -0.61	0.36 0.20
25% import tariff on oil and gas: US has monopsony power in oil and gas	L a/ H a/	8.2 7.8	4.4 1.7	+0.54 +0.22	0.33 0.31
25% excise tax on domestic sales of oil and gas	L H	49.7 47.3	-0.3 -1.1	-0.01 -0.02	1.99 1.89
15% excise tax on domestic sales of petroleum products	L H	35.3 34.4	-0.1 -0.7	-0.00 -0.02	2.35 2.29

Note: the 25% import tariff is added to the existing 0.2% tariff.

a/ Central elasticity case for all parameters except the import supply elasticity (ϵ_s^m) of oil-gas imports (L: ϵ_s^m = 1.0; H: ϵ_s^m = 3.0).

Figure 1: IMPORT DEMAND ELASTICITY AND WELFARE LOSS



Note:

ABE = Welfare loss (low elasticity).

ACD = Welfare loss (high elasticity).

> "the best way of raising a given revenue ... is by a system of taxes, under which the rates become progressively higher as we pass from uses of very elastic demand or supply to uses where demand or supply are progressively less elastic." 10/

Next, it is clear that raising revenue by taxes which do not discriminate by country of origin is more efficient. This is clearly seen by comparing the proposed import tariff on oil and gas with an excise tax on domestic sales of oil and gas. Not only does the excise tax raise far more revenue because it applies to all domestic sales, but it also generates revenue at a much lower welfare cost than an import tariff (see column 3).

3.3 Comparison with Earlier Studies

In their partial equilibrium study for the US Federal Trade Commission, Anderson and Metzger (1987) estimated that a $5 per barrel import tariff on both crude oil and petroleum products will generate $6.7 billion per year for the government, but at a cost of $3.8 billion in dead-weight losses. Since the bulk of the government revenues generated by tariffs in our model derive from the crude oil tariff, our estimate of the government revenue generated is within their range (see table 4). Their implied estimate of the welfare costs per dollar of revenue generated (55 cents) is on the high side of those we present in table 4, but within our range. 11/

Only Boyd and Uri have conducted general equilibrium experiments similar to those discussed in this section. They estimate (1988a) the effects of a $5 per barrel import fee on crude oil and the effects (in

1988b) of a 15 cents per gallon tax on gasoline. These taxes are about equal to our 25 percent import fee on crude oil and 15 percent tax on petroleum products. They estimate that the $5 per barrel import fee on crude oil will result in $3.4 billion of government revenue, and come at a cost of $208 million in lost social welfare. The welfare to government revenue ratio (6.1 percent) is about half the value of our low elasticity estimate (see table 4).

In the case of a 15 cents per gallon excise tax on gasoline, Boyd and Uri (1988b) find that it will generate $8 billion in government revenue at a cost of $15 billion in welfare. Thus: (a) each dollar of government revenue comes at a cost of almost $2 in welfare (compared with less than two cents of welfare costs in our case); and (b) for each one cent (or percent) tax on gasoline, they find the government receives about one-half of a billion dollars in revenue (compared with about $2.30 billion in our case). Since Boyd and Uri apply the tax only on final demand for gasoline, not on intermediate demand, and our experiments apply the excise tax on both intermediate and final demand, we are applying the tax to a base 4.7 times larger. Adjusted for the size of the tax base, our results on dollars of revenue obtained per percent of tax are very close. We choose our formulation rather than theirs, since arbitrage would make it difficult, if not impossible, to tax only final demand for gasoline, and because the proposals to apply a tax on gasoline do not envision excluding intermediate usage from taxation. However, we find it difficult to reconcile our estimate of the ratio of welfare costs per dollar of tax revenues raised from excise taxes with the unusually high estimate of Boyd and Uri. 12/

4. Efficient Taxation of US Petroleum Industries

Partial equilibrium analysis suggests that the least burdensome way to impose excise taxes to raise a given amount of revenue is to levy a set of excise taxes that vary inversely with the elasticity of final demand of the sector. When general equilibrium interactions are taken into account, rules are more difficult to derive, and numerical calculations are computationally difficult to obtain. Consequently, there has been little empirical work on the subject. Two previous numerical exercises of optimal tax or tariff calculations are Harris and MacKinnon (1979) and Dahl, Devarajan and van Wijnbergen (1986). The former paper develops an algorithm for the calculation of optimal taxes and provides largely illustrative examples. The latter paper calculates optimal tariffs for Cameroon, and investigates the conditions under which departures from a uniform tariff structure are optimal. The latter study does not, however, numerically consider the interaction of taxes with tariffs.

We now ask what is the least costly way, in terms of foregone welfare, to raise a specified amount of government revenue. Computationally, we choose the tariff (tm) and the excise tax rate (tx) in the oil and gas and petroleum products industries which maximize welfare subject to the additional constraint that the application of these taxes raise government revenue by $20 billion. To simplify the computation and interpretation of results in this section, assume that VERs are not binding. However, we maintain the existing tariffs in other sectors. Computations are done with the MINOS5 algorithm available from Brooke, Kendrick and Meeraus (1988).

The results of the computation of optimal tax rates appear in table 5. The calculations are labelled O (oil and gas) and O+P (oil and

Table 5:

Optimal Taxes to Raise $20 Billion in Government Revenue
(Central Elasticity Case)

Industry	Taxation	(0)	(P)	(0+P)	(0+P) $\epsilon_m^s = 3.0$
Oil + Gas	tm tx	2.4 9.6		2.7 10.6	36.3 4.9
Petroleum Products	tm tx		2.0 8.7	8.9 -1.4	5.2 -0.3
Change in Welfare (EV)		-0.12	-0.10	-0.07	+2.4

gas + petroleum products) to reflect which industries are being taxed to raise government revenue.

A number of results stand out from a comparison of the alternative least costly taxation schemes to raise $20 billion in government revenue. First, if taxation is allowed in both energy sectors, the welfare cost of raising $20 billion is less than when taxation is only allowed for one sector only. This is an illustration of the principle that a given revenue objective can be achieved at a lower cost with additional tax instruments, because the additional tax instruments can be used to reduce the size of the wedge created by the objective of raising the tax. That is, all the distortion does not fall on one sector causing resources to flow out of the sector. If all sectors could be taxed, distortion-induced resource movements would be minimized.

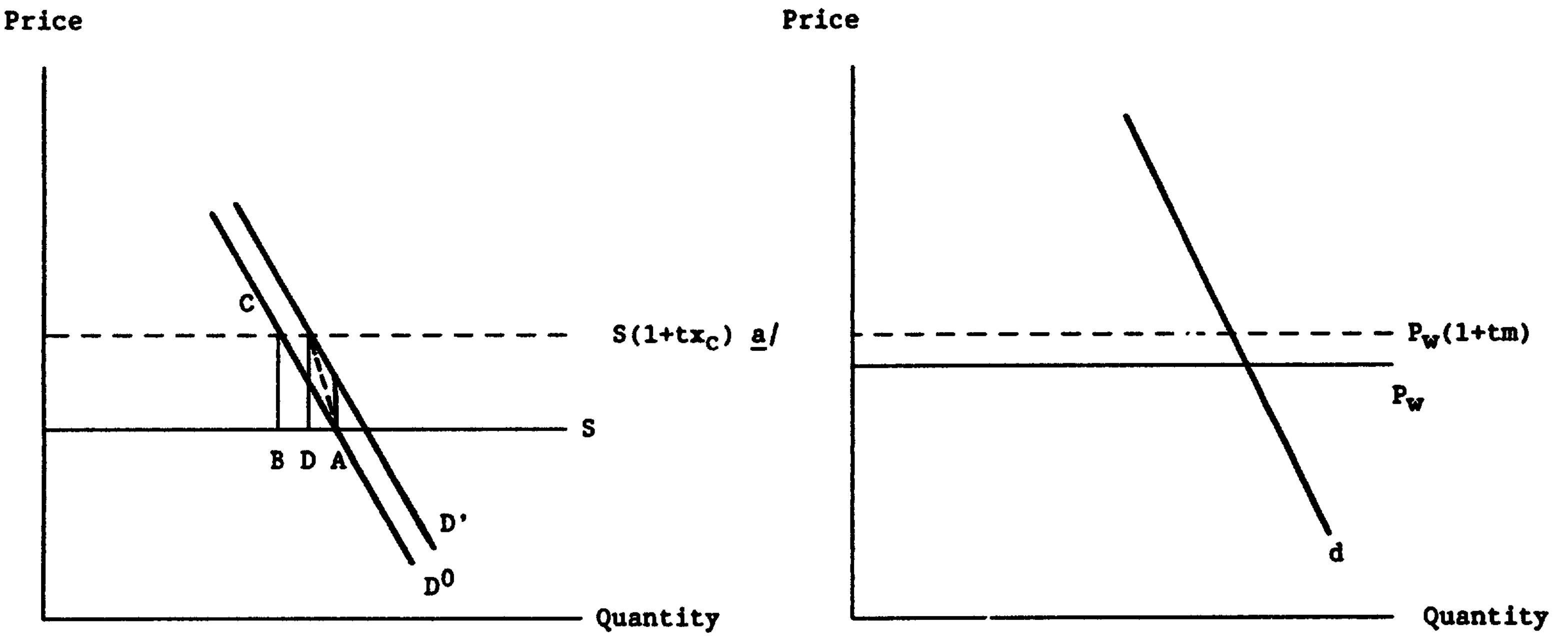
Second, when revenues are raised by taxing only one sector, then an excise tax is less costly than a tariff at the same rate because it is neutral as to source. Thus, the least costly combination of excise tax and import tariff rates will involve a higher excise tax rate than tariff rate. When both instruments can be used for one industry at a time, the optimal combination suggested by the results in columns (O) and (P) is that the excise tax rate should be set at a rate about four times higher than the import tariff rate.

The fact that the excise tax is the preferred instrument to a tariff is an illustration of the principle, shown by Dixit (1985), that domestic goods and factor taxes or subsidies are superior instruments to tariffs for the purpose of raising revenue. This is because a tariff induces domestic resources to flow into the industry when the product can be obtained at a lower relative price through international trade, but the excise tax does not discriminate as to source. The question that naturally arises then is that given that the excise tax is preferred to tariffs, why are there any tariffs (albeit small ones) in the optimum. The answer to this question is that we have limited the use of excise taxes to the two energy sectors, so that other sectors are untaxed. When the energy sectors are taxed, but others are not, resources flow out of the energy sectors and into the rest of the economy. This is a distortion that is reduced through the use of a tariff. This principle is discussed further below, illustrated in figure 2, and derived by Dahl, Devarajan and van Wijnbergen (1986) for the case of zero cross elasticity of final demand. 13/

Third, when both sectors can be taxed simultaneously, the pattern of optimal taxation is strongly influenced by the interdependence between the two sectors. The results in columns labelled (O+P) are understood when one realizes that a tax on crude oil is, in effect, a tax on petroleum products. This results in a second best situation where the output of the petroleum sector is too low, because it is being taxed indirectly, and the non-energy sectors are not being taxed. As above, we understand the reason for the tariffs by recognizing that the sectors that receive relatively high excise taxation require some tariff protection to reduce distortion-induced resource movement. In figure 2, we illustrate the situation in partial equilibrium. A tax on crude oil shifts up the supply curve for the petroleum industry to S(1+tx), creating a distortion (equal to area ABC) in the market for domestic petroleum products. This results in a second best situation where output of the petroleum sector is too low, because the non-energy sectors are not being taxed. A tariff, tm, on imported petroleum products or, for that matter, a subsidy for domestic producers of petroleum products will reduce this distortion. Figure 2 illustrates how the distortion is reduced by raising the tariff on petroleum products. An

<u>Figure 2</u>:

Welfare Impact on Domestic Petroleum Products of a Tariff on Imported Petroleum Products, Given an Excise Tax on Crude Oil



Domestic Petroleum Products

Petroleum Imports

<u>a</u>/ tx_c is the excise tax on crude oil products.

increase in the tariff on imported petroleum products will induce an increase in demand for its principal substitute, domestic petroleum products, from D^0 to D'. This will reduce the distortion costs in the domestic petroleum products industry (caused by the tax on crude oil) from ABC to ADE.

The results in column (O+P) support this interpretation: rates of taxation in oil and gas are at about the same values as in the case where taxation is only on the oil and gas sector, but domestic petroleum production is subsidized by the combination of an import tariff and a small subsidy. Of course, the net effective subsidy on petroleum production is negative and about equal to -4.6 (= 1.4 + [.563 * 10.6]) since purchases from the oil and gas sector comprise 56.3% of total costs of the petroleum products sector.

Fourth, note from the (O+P) column, that the excise taxes and tariff rates are not uniform between the two sectors. It has been shown (see Atkinson and Stiglitz, 1980) that with perfectly inelastic labor supply, a uniform excise tax is optimal for revenue raising purposes. Since a uniform tax on all goods is equivalent to a tax on labor alone, a uniform tax will minimize distortion induced resource movement if labor supply is perfectly inelastic.

With nonconstant labor supply, it is optimal to tax goods that are good substitutes with leisure at a lower rate to minimize distortion-induced consumption of leisure. A fully uniform tax is not possible in our case, because we have not allowed taxation of the non-energy sectors. Analogous to the labor-leisure problem, we want to tax at a lower rate the good that is a better substitute for untaxed goods in the system. Since petroleum products are the better substitute for the other goods, it has the lower tax.

As a final illustration, the last column of table 5 presents results where the US is assumed to possess monopsony power on world oil markets. It considers the effect of an upward sloping supply curve of oil and gas imports on the selection of optimal taxation of both industries. Not surprisingly, the optimal taxation is now dominated by the optimal tariff on oil and gas imports which is set close to the rule of thumb welfare maximizing value $(1/(1+\epsilon_m^s))$. Now the welfare gains from improved terms of trade dominate the calculations and welfare actually increases by $2.7 billion. Given the ability to raise revenue in a welfare enhancing manner through a tariff on crude oil, all other taxes (which are otherwise welfare reducing) are scaled down accordingly. Of course, this last simulation is only illustrative since it ignores both the possibility of retaliation and the case of a non-constant import supply elasticity. Both considerations would lead to a lower optimal tariff rate than the one appearing in table 5.

How much efficiency would be gained by the application of optimal tax rates instead of those proposed? We consider two experiments. First, recall from table 4 that a 15% excise tax on petroleum products would raise $35 billion in government revenue. Allowing the optimal combination of import and excise taxes in petroleum products alone (2.4% and 15.1%, respectively) would reduce the welfare cost of raising $35 billion in revenue from $320 million to $300 million. In this case the welfare gains of optimal taxation are small, since the base experiment used only excise taxes and was close to the optimum. Second, recall from table 3 that $42.8 billion is raised by the combination of a 25% import fee on crude oil and a 15% excise tax on petroleum. The welfare cost of raising $42.8 billion by optimum taxation (with a set of rates proportional to those in column O+P of table 5) falls from $2.34 billion to $276 million. Welfare gains of optimal taxation are much larger in this case because the baseline tax rates bear little relationship to the optimal taxation pattern for the two industries.

5. Conclusions

The estimates in this paper suggest that an import tariff on crude oil imports would be a very inefficient way to reduce the US trade deficit. A tariff would cause much dislocation (an estimated 153 thousand workers would have to relocate) because sectors using crude oil would have to adjust to the 25 percent tariff on oil imports. Moreover, the welfare cost of such a proposed revenue-raising tax scheme would be large, resulting in an estimated welfare loss of 25 cents for every dollar of raised revenue. The paper shows that an excise tax would be a more efficient tax scheme to raise revenue, resulting in both a larger revenue per additional percent tax (because of a larger tax base) and a much lower welfare cost which we estimate in the neighborhood of 1 to 2 cents per dollar of raised revenue.

Besides being an inefficient instrument for raising revenue, an import tariff on crude oil would pose several problematic trade policy issues for the U.S. To begin with, because U.S. tariffs on crude oil are "bound" in the GATT, any rate increase would require compensation on other products. Furthermore, the GATT specifically prohibits the imposition of import fees for fiscal purposes (Article VIII:1(a)). Finally, an oil import fee would also complicate U.S. trade relations with Canada, Mexico, and Venezuela.

The paper also provides estimates of the least costly combination of excise tax and import tariffs in the crude oil and petroleum products sectors to raise a predetermined amount of government revenue. Because taxation is restricted to those two sectors only, and because of the linkages between the two sectors, the set of optimal taxes and tariffs is far from uniform. The least costly combination of tariffs and excise taxes in the energy sectors include taxation of crude oil (which has a lower elasticity of net demand than petroleum products and is hence a more efficient revenue-raiser) combined with a tariff and a small subsidy on petroleum products to counteract the distortionary costs induced by the taxation of crude oil which accounts for nearly two-thirds of the value of intermediate purchases by the petroleum products sector.

Footnotes

1/ See the U.S. General Accounting Office (1986) for a survey of these results.

2/ See Committee on Ways and Means (1987), Congressional Budget Office (1988), Alan Greenspan (1988) and the Department of Energy (1987).

3/ See Anderson and Metzger (1987).

4/ The energy independence issue is not an argument for taxation, since with an exhaustible resource such as oil, the faster it is utilized in the present, the less will be available in the future, if prices should rise. Moreover, applying the principle of using the most direct instrument for the noneconomic objective (see Bhagwati and Srinivasan (1969) and Bhagwati (1971)), stockpiling is a less costly alternative, if this argument is taken seriously. See Anderson and Metzger (1987) for further details.

5/ Policy issues relating to the energy sector have previously been addressed in a general equilibrium framework. These studies however, usually related to long-run alternatives to petroleum as an energy input. Examples of earlier efforts include Hudson and Jorgenson (1974), Manne (1976) and Borges and Goulder (1984). These studies, however, do not specifically address the issue of taxation. Manne (1984) provides a critical survey of these earlier studies.

6/ The welfare implications of US VERs negotiated for autos, textiles and steel are examined in de Melo and Tarr (1988).

7/ The welfare costs of these quotas are discussed in de Melo and Tarr (1988).

8/ See Varian (1984) for a justification of this measure.

9/ The elasticity specification for the other sectors is given in the appendix.

10/ See Atkinson and Stiglitz (1980, pp. 366-70) for a detailed discussion.

11/ Because it does not consider the effects on the real exchange rate, other things equal, partial equilibrium analysis will tend to overestimate the welfare costs of tariff increases. That is, in general equilibrium, a tariff increase will induce a reduction in imports. This will have the effect of appreciating the real exchange rate to bring about equilibrium in the balance of trade. In the new equilibrium, exports will be reduced. That reduction in exports is an addition to the consumption of domestic consumers, whose welfare is increased accordingly. Simulations with this model (see de Melo and Tarr, 1988), suggest about a fifty percent overestimate of the welfare costs of tariffs, when the impact on the real exchange rate is ignored.

Anderson and Metzger also consider the case of an upward sloping import supply curve for imported crude oil and for gasoline. Since they assume that a tariff on crude oil not only has the effect of lowering the import supply price of crude oil, but at the same time has the effect of raising the price of imported gasoline, they have competing terms-of-trade effects that neutralize each other.

12/ As we discuss below, both theory and our estimates indicate that excise taxes impose lower welfare costs per dollar of revenue raised than tariffs. This also makes it difficult to explain the welfare results of Boyd and Uri, since their results imply dramatically higher welfare costs per dollar of revenue raised using excise taxes versus tariffs.

13/ In addition, the base data contains a non-uniform tariff structure. When we allow the tariffs in the energy sectors to seek optimal levels, the optimal values will partly offset the distortions of the base tariff structure.

14/ Our selection of elasticities yield comparable substitution possibilities at the intermediate level, but crude oil is a pure intermediate product, so net elasticities of demand are different between the two sectors.

Appendix:

Elasticity Specification

Table A1 describes the complete set of elasticities used in the model for the central elasticity calculations. The "low" and "high" elasticity elasticity results are derived by simulating the model with a set of elasticities derived from those in table A1 by subtracting (adding) one standard deviation.

Table A1:

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	
Crude Oil and Natural Gas	f	c	e	j	a,f,e	2.4	0.8	3.0	.5	.9	
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	22.8%
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	
Petroleum Products	f	c	e	j,e	a,f	2.4	0.8	3.0	.5	.9	
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 de Melo and Tarr (1988).
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 et al. (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).

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