TWO SHORT PAPERS ON THE INCIDENCE OF TARIFFS

Kenneth W. Clements and H.Y. Izan
The University of Western Australia

Discussion Paper No. 81.18
November 1981
THE INCIDENCE OF TARIFFS:
SIMULATION RESULTS*

by

Kenneth W. Clements and H.Y. Izan
The University of Western Australia

Abstract

By simulating a general equilibrium model, it is shown that about two-thirds of the burden of an import tariff is shifted on to exporters.

* We would like to acknowledge helpful discussions with Larry Sjaastad.
1. Introduction

The emerging theory of the tariff incidence defines "true" protection as the tariff-induced rise in the internal price of importables relative to nontraded goods.\(^1\) As expected, true protection is generally far smaller than nominal protection. If, for example, importables and nontraded goods are close substitutes in demand and production, the relative price between them will tend to be fixed. The tariff then lowers the price of exportables in terms of both importables and nontraded goods, causing the real income generated in exportables to fall in terms of both importables and nontraded goods. In this situation the tariff is fully equivalent to an export tax in that the incidence falls on exporters. In the general case, the elasticity of the price of home goods with respect to the domestic price of importables is the proportion of the tariff paid by producers of exportables; this elasticity is known as the incidence parameter \(\omega\).\(^2\)

The objective of this paper is to simulate a general equilibrium model to analyse the size of \(\omega\).

2. The Model

We consider a small open economy which produces exportables, importables and nontraded goods (identified by the subscript \(i=1,2,3\) respectively). We write \(p_i\) and \(q_i^S\) for the price and quantity supplied of good \(i\), \(Y^S = \sum p_i q_i^S\) for the nominal value of output (GDP) and \(y^S\) for the real value. Producers behave as if they choose \(q_i^S = \tilde{q}_i^S\) to maximize \(Y^S\) subject to the transformation function \(f(q_i^S) = y^S\). This gives rise to a supply equation for good \(i\) which can be written in differential form as (Clements, 1980a)

\[
(1) \quad \frac{dw_i^S}{d\log p_i^S} = \Theta_i^S d(\log y^S) + \sum_{j=1}^n \tau_{ij}^S d(\log p_j),
\]

where \(w_i^S = p_i q_i^S / y^S\) is the share in GDP of \(i\); \(\Theta_i^S\) is the \(i\)th marginal supply share; and \(\tau_{ij}^S\) is the \((i,j)\)th supply Slutsky coefficient.

Consumption is modeled by a system of differential demand equations possessing a structure identical to (1). We write \(q_i^d\) for the quantity demanded of good \(i\) and \(Y^d = \sum p_i q_i^d\) for total expenditure. Under general conditions the demand equation for good \(i\) can be written as (Theil, 1980, Chap. 2 and App. B)
where $\pi_i^d = p_i q_i / Y^d$ is the $i$th marginal demand share; $\theta_i^d$ is the $i$th budget share; $d(\log y^d) = \sum_i \pi_i^d d(\log q_i^d)$ is the Divisia index of the log-change of the consumer's real income; and $\pi_{ij}^d$ is the $(i,j)$th demand Slutsky coefficient.

The quantity of exports ($x_1$) is the production of exportables less domestic consumption, $x_1 = q_1^s - q_1^d$. In log-change form this is $d(\log x_1) = (q_1^s / x_1)d(\log q_1^s) - (q_1^d / x_1)d(\log q_1^d)$. Multiplying both sides by $w_1^t = p_1 x_1 / Y^s$ the share of exports in GDP gives the more convenient expression,

$$w_1^t d(\log x_1) = w_1^s d(\log q_1^s) - (Y^s / Y^d) w_1^d d(\log q_1^d).$$

Similarly, the quantity of imports ($x_2$) is the difference between domestic production of importables and domestic demand, $x_2 = q_2^s - q_2^d < 0$. Transforming this to a log-change form similar to (3) gives

$$w_2^t d(\log x_2) = w_2^s d(\log q_2^s) - (Y^s / Y^d) w_2^d d(\log q_2^d),$$

where $w_2^t = p_2 x_2 / Y^s$ is minus the share of imports in GDP.

We take the world prices of the traded goods to be fixed and assume that the import tariff $t$ is the only trade tax, so that

$$d(\log p_1) = 0, \quad d(\log p_2) = d(\log T),$$

where $T = 1 + t$. The price of nontraded goods is determined by equilibrium in that market which can be expressed as

$$w_3^s d(\log q_3^s) = (Y^d / Y^s) w_3^d d(\log q_3^d).$$

Starting from a position of free trade and with world prices constant, the economy's budget constraint can be written as

$$d(\log y^d) = d(\log y^s).$$

It also follows that $y^d = y^s$.

The complete model is made up of eqs. (1)-(7), which determine the production of the three goods $w_1^s d(\log q_1^s)$, consumption $w_1^d d(\log q_1^d)$,
exports \( w_1^d(\log x_1) \), imports \( w_2^d(\log |x_2|) \), domestic prices \( d(\log p_i) \) and real income \( d(\log y^d) \). The exogenous variables are real GDP \( d(\log y) \) and the tariff rate \( t \).

3. Results

To simulate the model we use values of the shares obtained from U.S. post-war data; these are given in Table 1. We assume that the consumer is preference independent with respect to the three goods, so that the demand Slutsky coefficients can be written as \( \eta_{ij}^d = \psi^d \delta_{ij} (\delta - \delta_i^d) \), where \( \psi^d < 0 \) is the income flexibility and \( \delta_{ij} \) is the Kronecker delta (Theil, 1975-76). There is now quite a large amount of econometric evidence that \( \psi^d \) is in the neighbourhood of \(-0.7\); we use this value in most of the computations.

### TABLE 1

**BASIC DATA FOR TARIFF SIMULATION**

<table>
<thead>
<tr>
<th>Good</th>
<th>Supply</th>
<th>Demand</th>
<th>Trade</th>
<th>Supply</th>
<th>Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exportables</td>
<td>.207</td>
<td>.159</td>
<td>.048</td>
<td>.285</td>
<td>.066</td>
</tr>
<tr>
<td>Importables</td>
<td>.208</td>
<td>.256</td>
<td>-.048</td>
<td>.327</td>
<td>.298</td>
</tr>
<tr>
<td>Nontraded Goods</td>
<td>.586</td>
<td>.586</td>
<td></td>
<td>.388</td>
<td>.636</td>
</tr>
</tbody>
</table>

The data refer to the U.S. for 1952-71. The GDP and budget shares are sample means, from Clements (1980b). To avoid unnecessary complications, all nonessential items in the U.S. data base have been excluded and the resulting shares renormalized so that they have a unit sum. The marginal shares are maximum likelihood estimates, from Clements (1980a,b); asymptotic standard errors are given in parentheses.

For the supply side we assume that the transformation function can be written in the additive form \( f(q_i^S) = \sum f_i (q_i^S) \). The Slutsky coefficients can then be written as \( \eta_{ij}^S = \psi^S \delta_{ij} (\delta - \delta_i^S) \), where \( \psi^S > 0 \) is a coefficient independent of \( i \) and \( j \) (Clements and Izan, 1980). There are very few estimates of \( \psi^S \) available and \( \delta^S \); rather with some sensitivity analysis.
We take income to be constant and simulate a 5 per cent tariff by setting \( t = 0.05 \) and then solving the model for the new equilibrium. The results are given in Table 2. The first three simulations use the Table 1 data with \( \phi^d = -0.7 \) and \( \phi^s \) set successively equal to 1, 0.5 and 1.5.

In the first simulation, the effect of the tariff on production is to decrease exportables by 3.8 per cent, increase importables by 3.3 per cent and increase nontraded goods by 0.2 per cent. The tariff shifts the consumption pattern away from importables toward exportables and nontraded goods, as expected. The effect of the tariff on trade is to reduce the volume of exports and imports by 18.2 per cent. This fall in the volume of trade is quite large in comparison with the 5 per cent tariff, and to a certain extent this is due to the small share of trade in GDP (see Table 1); we return to this issue below.

The nominal price of nontraded goods rises by 3.2 per cent when the tariff is imposed. The price of nontraded goods relative to importables thus changes by \( 3.2 - 5 = -1.8 \) per cent, while relative to exportables it increases by 3.2 per cent. The conclusion is that nontraded goods are a closer substitute for importables than for exportables. The tariff has the effect of protecting the importables sector mainly at the expense of exportables, rather than nontraded goods.

To analyse the sensitivity of the results to changes in the supply parameter \( \phi^s \), in simulations 2 and 3 it is set at 0.5 and 1.5. As can be seen from Table 2, while the production and trade responses do change noticeably, the nontraded goods price is not very sensitive to changes in this parameter.

Next we take both production and consumption to be homothetic, so that everything expands equiproportionally when there is growth. For this simulation we also set \( \phi^s = -\phi^d = 1 \), and the results are given in the second last part of Table 2. As can be seen, these results are qualitatively similar to the others; the trade response is quite close to that of the first simulation; and the price of nontraded goods rises by 2.8 per cent.

The final simulation relates to an economy more open to international trade. This economy is characterized by a smaller nontraded goods sector, one which accounts for 30 per cent of GDP, in contrast to almost 60 per cent before.
TABLE 2
EFFECTS OF FIVE PER CENT TARIFF INCREASE:
PERCENTAGE-CHANGES

<table>
<thead>
<tr>
<th>Good</th>
<th>Production</th>
<th>Consumption</th>
<th>Exports</th>
<th>Imports</th>
<th>Price of Nontraded Goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Table 1 data, $\phi^s = 1, \phi^d = -.7$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exportables</td>
<td>-3.82</td>
<td>1.01</td>
<td>-18.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Importables</td>
<td>3.28</td>
<td>-1.14</td>
<td>-18.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nontraded Goods</td>
<td>0.23</td>
<td>0.23</td>
<td></td>
<td></td>
<td>3.22</td>
</tr>
<tr>
<td>2. Table 1 data, $\phi^s = .5, \phi^d = -.7$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exportables</td>
<td>-1.99</td>
<td>1.06</td>
<td>-11.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Importables</td>
<td>1.55</td>
<td>-1.02</td>
<td>-11.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nontraded Goods</td>
<td>0.16</td>
<td>0.16</td>
<td></td>
<td></td>
<td>3.47</td>
</tr>
<tr>
<td>3. Table 1 data, $\phi^s = 1.5, \phi^d = -.7$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exportables</td>
<td>-5.57</td>
<td>0.99</td>
<td>-24.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Importables</td>
<td>5.09</td>
<td>-1.21</td>
<td>-24.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nontraded Goods</td>
<td>0.26</td>
<td>0.26</td>
<td></td>
<td></td>
<td>3.09</td>
</tr>
<tr>
<td>4. Unitary GDP and income elasticities, $\phi^s = 1, \phi^d = -1^a$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exportables</td>
<td>-2.58</td>
<td>2.89</td>
<td>-18.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Importables</td>
<td>2.29</td>
<td>-2.01</td>
<td>-18.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nontraded Goods</td>
<td>0.12</td>
<td>0.12</td>
<td></td>
<td></td>
<td>2.77</td>
</tr>
<tr>
<td>5. More open economy$^b$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exportables</td>
<td>-2.27</td>
<td>0.80</td>
<td>-6.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Importables</td>
<td>1.94</td>
<td>-0.59</td>
<td>-6.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nontraded Goods</td>
<td>0.45</td>
<td>0.45</td>
<td></td>
<td></td>
<td>3.22</td>
</tr>
</tbody>
</table>

a. Unitary GDP and income elasticities means $\theta^s_i = w_i^s$ and $\theta^d_i = w_i^d$ ($i = 1, 2, 3$),
   where the $w_i^s$'s and $w_i^d$'s are from Table 1.

b. Table 1 $\theta^s_i$'s and $\theta^d_i$'s, $\phi^s = 1, \phi^d = -.7$ and

<table>
<thead>
<tr>
<th></th>
<th>$w_i^s$</th>
<th>$w_i^d$</th>
<th>$w_i^t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exportables</td>
<td>.35</td>
<td>.20</td>
<td>.15</td>
</tr>
<tr>
<td>Importables</td>
<td>.35</td>
<td>.50</td>
<td>-.15</td>
</tr>
<tr>
<td>Nontraded Goods</td>
<td>.30</td>
<td>.30</td>
<td></td>
</tr>
</tbody>
</table>
Also, the share of international trade in GDP is 15 per cent, much larger than the previous 5 per cent. We also use the marginal shares from Table 1, $\phi^s = 1$ and $\phi^d = -0.7$. The results are given in the last part of Table 2. In general, the percentage responses of the production and consumption of the two traded goods are smaller (in absolute value) than in the previous simulations. This is to be expected as these sectors now account for a larger part of the economy. Conversely, the response of nontraded goods is larger. The volume of trade falls by 6.2 per cent, which is much smaller than before.

To calculate the incidence parameter $\omega$ we divide the percentage increase in the price of nontraded goods by 5 per cent (the percentage increase in the domestic price of importables). The values implied by the five simulations are 0.64, 0.69, 0.62, 0.55 and 0.64. The conclusion is that about two-thirds of the burden of the tariff is shifted on to exporters. These results are consistent with those of Sjaastad and Clements (1981) who report direct estimates of $\omega$ for five countries.
FOOTNOTES

1. See Dornbusch (1974), Sjaastad (1980) and Sjaastad and Clements (1981). As discussed in Sjaastad and Clements (1981), true protection is closely related to the Corden (1971, Ch. 5) - Balassa (1971a,b) "net protective rate" which is the tariff rate less the exchange rate appreciation.


4. As the model is linear it can be easily solved by inversion. Note that in Table 2, log-changes have been converted to percentage-changes.

5. It can be shown that as $\phi$ increases, so do the supply responses.

6. The exception is on the production side for simulation 2.

7. Note that the price of nontraded goods increases by 3.2 per cent, exactly the same as in simulation 1; it can be shown that this price change does not depend on the GDP and budget shares.
REFERENCES


MORE ON TARIFFS AND NONTRADED GOODS

by

Kenneth W. Clements*
The University of Western Australia

Abstract

The general equilibrium effects of a small tariff on relative prices are analysed within a demand and supply model which provides further insights into Dornbusch's (1974) results. It is shown that the elasticity of the price of nontraded goods with respect to the tariff is a weighted average of the degree of substitutability between nontraded goods and importables on the supply side and that on the demand side. When complementarity is ruled out, the price of nontraded goods increases with the tariff, but less than proportionally.

* I would like to acknowledge helpful comments by Jeff Carmichael, Jacob Frenkel, Ulrich Kohli and Larry Sjaastad.
The recent theory of the tariff incidence is concerned with the first-order welfare effects on different sectors with respect to the imposition of an import tariff. The key aspect of this theory is the response of the price of nontraded goods. If this price rises equiproportionally with the domestic price of importables, then the tariff serves to protect jointly the importables and nontraded goods sectors at the expense of exportables. Dornbusch (1974) analyses the relationship between the nontraded goods price and the tariff in terms of excess demand elasticities. The objective of this note is to provide some further insights by using the more familiar supply and demand elasticities.

We consider a small open economy which produces exportables, importables and nontraded goods. We write $q^S$ and $q^d$ for the quantity supplied and demanded of nontraded goods and $p_i$ for the nominal price of good $i$ ($i=e$ for exportables, $m$ for importables and $n$ for nontraded goods). Taking real income and the economy’s factor endowment to be fixed and using $\hat{a}$ to denote proportional change ($\hat{a} = dx/x$), the change in the supply and demand of nontraded goods is

\begin{align}
(1) \quad \hat{q}^S &= \eta^S_{p_e} + \eta^S_{m} + \eta^S_{n} \\
(2) \quad \hat{q}^d &= \eta^d_{p_e} + \eta^d_{m} + \eta^d_{n},
\end{align}

where the $\eta^S_i$'s and $\eta^d_i$'s are compensated supply and demand price elasticities for the nontraded goods. These elasticities are subject to the homogeneity constraint

\begin{equation}
(3) \quad \sum_i \eta^S_i = \sum_i \eta^d_i = 0.
\end{equation}

We take the world prices of the traded goods to be fixed and assume that the import tariff $t$ is the only trade tax, so that

\begin{align}
(4) \quad \hat{p}_e &= 0 \\
\hat{p}_m &= t,
\end{align}
where $T = 1 + t$ is the tariff wedge. Equilibrium requires that the nontraded goods market clears ($q^s = q^d$), so that from (1), (2) and (4) we obtain

$$
\hat{p}_n = \omega T,
$$

where

$$
\omega = \frac{\eta_m^d - \eta_m^s}{\eta_n^s - \eta_n^d}
$$

is the elasticity of the price of nontraded goods with respect to the tariff. Since $\eta_n^s > 0$ and $\eta_n^d < 0$, it follows from (6) that the sign of $\omega$ depends on whether $\eta_m^d - \eta_m^s > 0$. At this level of aggregation it seems reasonable to rule out complementarity, so that $\eta_m^d < 0$ and $\eta_m^s < 0$. Therefore $\omega > 0$, meaning that the price of nontraded goods never falls after the imposition of a tariff.

To analyse further the response of the nontraded goods price, consider two extreme cases. First, let importables and nontraded goods be excellent substitutes in demand, so that $\eta_m^d$ is large. From (3), $\eta_m^d$ takes a maximum value of $-\eta_n^d$ when $\eta_n^d = 0$ (nontraded goods and exportables unrelated in demand). In this case (6) becomes

$$
\omega = \frac{1 + \eta_m^s / \eta_n^d}{1 - \eta_n^s / \eta_n^d}
$$

Making the additional assumption that importables and nontraded goods are highly substitutable in supply, $\eta_m^s$ takes a maximum value of $-\eta_n^s$. From (7), we obtain $\omega = 1$. Thus, when importables and nontraded goods are good substitutes in both demand and supply, the nontraded goods price rises equipropotionally with the tariff ($\hat{p}_n = \hat{T}$), keeping the price of importables in terms of nontraded goods constant. High substitutability between the two sectors keeps their relative price constant.
The second case is the converse of the first. When exportables and nontraded goods are highly substitutable in both demand and supply, 
\[ \eta_e = -\eta_n, \eta_m = 0, \eta^s = -\eta^s_n \text{ and } \eta^m = 0. \]
It follows from (6) that \( \omega = 0; \) i.e. the price of nontraded goods remains constant. Here the substitutability between exportables and nontraded goods means that their (nominal) prices are tied together and, since the price of exportables is fixed, so is that of nontraded goods.

These two special cases can be conveniently analysed within a general framework by defining \( \alpha^d = -\eta^d_n/\eta^d_m \), where \( 0 \leq \alpha^d \leq 1 \) determines the degree of substitutability between nontraded goods and importables in demand (with \( \alpha^d = 0 \) corresponding to zero substitution).\(^3\) Similarly defining 
\[ \alpha^s = -\eta^s_m/\eta^s_n \] 
\( 0 \leq \alpha^s \leq 1 \), eq. (6) can be written as
\[ \omega = \beta \alpha^s + (1 - \beta)\alpha^d, \]
where \( \beta = \eta^s_n/(\eta^s_n - \eta^d_n) \). Thus \( \omega \) is a weighted average of the degree of substitutability between the two goods on the supply side (\( \alpha^s \)) and that on the demand side (\( \alpha^d \)). The weight \( \beta \) is the fraction of the sum of the absolute values of the supply and demand elasticities (\( \eta^s_n - \eta^d_n \)) accounted for by the supply side (\( \eta^s_n \)).

Eq. (8) is a convenient and elegant way of summarizing the price structure of the model. The previous two special cases correspond to 
(i) \( \alpha^s = \alpha^d = \omega = 1 \) and (ii) \( \alpha^s = \alpha^d = \omega = 0 \). Since \( \omega \) is a weighted average of two positive fractions, it follows that \( 0 \leq \omega \leq 1 \), i.e., \( 0 \leq \eta^s_n - \eta^d_n \leq 1 \). In words, the price of nontraded goods increases with the tariff, but less than proportionally.

Eq. (8) is a general result, one which does not depend on the substitutability assumption. However, only when complementarity is ruled out are \( \alpha^s \) and \( \alpha^d \) positive fractions; thus the result in the previous paragraph that \( \omega \) is a positive fraction depends on the substitutability assumption.
FOOTNOTES


2. When the tariff revenue is redistributed, the tariff has no income effect.

3. As we are ruling out complementarity, \( \eta^d_m > 0 \) which implies \( \alpha^d > 0 \). From the homogeneity constraint (3), \( \eta^d_e = -(1 - \alpha^d) \eta^d_n \) and for exportables and nontraded goods to be substitutes we require \( \eta^d_e > 0 \), implying \( \alpha^d < 1 \).

REFERENCES

