Volume Title: Trade Policy Issues and Empirical Analysis

Volume Author/Editor: Robert E. Baldwin, ed.

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-03607-3

Volume URL: http://www.nber.org/books/bald88-2

Publication Date: 1988

Chapter Title: Trade Restraints, Intermediate Goods, and World Market Conditions

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Chapter URL: http://www.nber.org/chapters/c5852

Chapter pages in book: (p. 233 - 256)

8 Trade Restraints, Intermediate Goods, and World Market Conditions

Val Eugene Lambson

Much of what is produced is not for final consumption. Products that are outputs from one process are often inputs in another, and a large portion of world trade is conducted in markets for such intermediate goods. Protectionist measures for industries producing these commodities can take different forms. In addition to the usual array of tariffs and quotas, domestic content requirements can be imposed.

When analyzing protection, most authors focus on the domestic price, factor use, and output effects of introducing a particular protective measure. Work on models with intermediate goods has followed this tradition. Sanyal and Jones (1982), for example, study the effects of imposing a tariff on an intermediate good in a general equilibrium context. In a partial equilibrium framework, Grossman (1981) analyzes the effects of domestic content legislation when domestic and foreign inputs are perfect substitutes in production. Mussa (1984) considers the possibility that domestic and foreign inputs might not be perfect substitutes in production. In addition to the case of perfect competition, he analyzes the effects of domestic content requirements when monopoly is present. Krishna and Itoh (1988) look at domestic content legislation in oligopolistic industries.

Another possible approach to analyzing protection, which is followed in this chapter, is to explore the effects of changes in economic conditions once protective policies are in place. Using a general equilibrium

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The author is indebted to Robert Baldwin, Christopher Flinn, Ronald Jones, Mark Kennet, Anne Polivka, and J. David Richardson. Remaining shortcomings are the author's responsibility.

framework, this chapter posits a change in a country's terms of trade and contrasts its effects on domestic prices, factor use, and consumption under four methods of protecting an import-competing sector that produces intermediate goods. The four methods of protection are (1) a tariff, (2) a quota, (3) a domestic content requirement defined in physical units, and (4) a domestic content requirement defined in value-added terms. Although any of these methods can be implemented with the goal of protecting a domestic industry, the behavior of the economy in the face of changing trading terms depends significantly on which protective policy is selected.

Section 8.1 exposits the general equilibrium model employed. A small country is assumed to have two production tiers. The input tier uses an industry-specific factor and labor to produce intermediate goods (inputs), while the output tier uses a different industry-specific factor, labor, and intermediate goods to produce final goods (outputs). Both inputs and outputs are traded on world markets. The small country imports inputs and exports outputs. Foreign and domestically produced inputs are perfect substitutes. Perfect competition is assumed throughout.

Section 8.2 reports the effects of terms-of-trade changes when protectionist measures are imposed. Perhaps the most interesting result is how the world and domestic prices of inputs are correlated. When a tariff is imposed the two prices, constrained to differ by the constant tariff rate, move together. Under a quota, by contrast, a change in the world price has no effect on the domestic price (although it does affect domestic welfare). When a domestic content requirement in physical units is imposed, the two prices are negatively correlated. Finally, if a domestic content requirement is implemented in value-added terms, the sign of the correlation seems to be ambiguous.

The results in section 8.2 report only the signs of the various effects. It is also interesting to have some feel for what their magnitudes might be. Section 8.3 explores a numerical example where the parameter values for the assumed Cobb-Douglas production technologies are derived from the 1977 input-output tables published by the *Survey of Current Business*. (Of course, the economy examined in section 8.3 should not be construed to be a good representation of the economy of the United States.) In addition to reporting the effects of terms-of-trade changes on employment and price in the input tier, the tables list the welfare effects of those changes in the presence of protection. It is shown that the magnitude of the welfare effects of changing trading terms depends on which protective measure is in place.

8.1 A Simple General Equilibrium Model

Assume that all production takes place in two stages. In the first stage, labor is combined with a specific factor to manufacture intermediate goods called *inputs*. In the second stage, labor and another specific factor are combined with inputs to produce final products called *outputs*. Industries that manufacture inputs comprise the *input tier* while industries that manufacture outputs comprise the *output tier*. Both inputs and outputs are traded competitively on the world market, and the country is sufficiently small that it cannot affect world prices. The country imports inputs and exports outputs. In the interest of tractability, differing factor intensities across industries in a given tier are ignored. This allows aggregation of the industries within the input tier and output tier, respectively, and simplifies the analysis considerably.

Let the level of input production be denoted by X_I. Inputs are produced using a specific factor, the supply of which is denoted by V_I, and labor. Labor is mobile between tiers. The amount of labor employed in the input tier is L_I.

Let the level of output production be denoted by X_O. Outputs are manufactured using a specific factor, the supply of which is denoted by V_O, inputs, the use of which is denoted by X_I^c, and labor. The amount of labor employed in the output tier is L_O.

The production functions in the input and output tiers are, respectively,

$$X_I = f(V_I, L_I), \text{ and} \tag{1}$$

$$X_O = g(V_O, L_O, X_I^c). \tag{2}$$

It is assumed that f and g are strictly concave functions exhibiting constant returns to scale. Derivatives of the production functions will be denoted by subscripts, for example, $g_{23} \equiv \partial^2 g/\partial L_O \, \partial X_I^c$. It is assumed throughout that $g_{23} \geq 0$, but most of the results are valid for general concave, linear homogenous production functions, and they are all valid as long as g_{23} is not too negative.

Let outputs be numeraire, so P is the relative price of inputs domestically, and P^* is the relative price of inputs on world markets. Four protectionist policies will be considered: a tariff, a quota, a domestic content requirement denominated in physical units (DCP), and a domestic content requirement denominated in value-added terms (DCV). If a tariff is imposed then the domestic price is given by

$$P = (1 + t)P^*, \tag{3.T}$$

where t is the tariff rate. If a quota is imposed then imports are constrained as follows:

$$X_I^c - X_I \leq q, \tag{3.Q}$$

where q is the quota level. If a domestic content requirement denominated in physical units is implemented then the economy must satisfy

$$X_I / X_I^c \geq k. \tag{3.DCP}$$

This says that a fraction, k, of the produced inputs used domestically must be manufactured domestically. Finally, if domestic content legislation is written in value-added terms then

$$P^*(X_I^c - X_I) \leq (1-j)X_O\,, \tag{3.DCV}$$

that is, domestic factors and inputs must make up at least a fraction, j, of value added.

It is assumed throughout that firms choose to exactly fulfill any requirements, so equations (3.Q), (3.DCP), and (3.DCV) hold with equality. Firms take all prices as given, and profits are maximized in each industry subject to any policy constraints. Hence, in the input tier V_I and L_I must solve

$$\max Pf(V_I,L_I) - r_IV_I - wL_I\,,$$

where r_I is the return to the specific factor and w is the return to labor. The first-order conditions require, of course, that

$$r_I = Pf_1(V_I,L_I), \text{ and} \tag{4}$$

$$w = Pf_2(V_I,L_I). \tag{5}$$

In the output tier the pertinent maximization problem depends on the policy restrictions imposed. Let X_I^* be the quantity of inputs imported, that is, $X_I^c = X_I + X_I^*$, and let r_O be the return to the specific factor used in the output tier. Then V_O, L_O, X_I, and X_I^* must solve

$$\max g(V_OL_O,X_I^c) - r_OV_O - wL_O - PX_I - P^*X_I^*\,,$$

subject to equation (3.T) under a tariff, subject to equation (3.Q) under a quota, subject to equation (3.DCP) if a domestic content requirement is imposed in physical units, and subject to equation (3.DCV) if a domestic content requirement is imposed in value-added terms. The first-order conditions arising from the above maximization problem are presented below. (First-order conditions corresponding to the same factor are given the same equation number along with letters that denote the policy being imposed. For example, equation (6.T,Q) is the first-order condition for the specific factor in the output tier when either a tariff or a quota is imposed while equation (6.DCP) is the first-order condition for the same factor when a domestic content requirement in physical units is implemented.)

Under a tariff or a quota the first-order conditions imply

$$r_O = g_1(V_O,L_O,X_I^c), \tag{6.T,Q}$$

$$w = g_2(V_O,L_O,X_I^c), \text{ and} \tag{7.T,Q}$$

$$P = g_3(V_O,L_O,X_I^c). \tag{8.T,Q}$$

Note that in (8.T,Q) the marginal revenue product of inputs is set equal to the domestic price of inputs. In the case of a tariff, $P = (1 + t)P^*$ and the same price is paid for domestic inputs as for foreign inputs. In the case of a quota $P > P^*$, but the *marginal* unit of inputs is purchased domestically.

If a domestic content requirement is legislated in physical units then the pertinent first-order conditions imply

(6.DCP) $$r_O = g_1(V_O, L_O, X_I^c),$$

(7.DCP) $$w = g_2(V_O, L_O, X_I^c), \text{ and}$$

(8.DCP) $$kP + (1 - k)P^* = g_3(V_O, L_O, X_I^c).$$

Note that equations (6) and (7) are the same, respectively, under tariffs, quotas, and domestic content requirements in physical units. The same is *not* true for equation (8). This is because under a domestic content requirement denoted in physical units, the marginal unit of inputs is partially foreign and partially domestically produced. The fraction of the marginal unit that is domestically produced is k. (For a fuller discussion of these relations see Grossman 1981.)

Finally, if a domestic content requirement is denoted in value-added terms then the first-order conditions of the appropriate maximization problem imply

(6.DCV) $$r_O = \{1 + (1 - j)[(P - P^*)/P]\}g_1(V_O, L_O, X_I^c),$$

(7.DCV) $$w = \{1 + (1 - j)[(P - P^*)/P]\}g_2(V_O, L_O, X_I^c), \text{ and}$$

(8.DCV) $$P = \{1 + (1 - j)[(P - P^*)/P]\}g_3(V_O, L_O, X_I^c),$$

where j is the fraction of value added that must be domestically produced. Note that all three equations differ from their counterparts for the other cases. (For a fuller discussion see Grossman 1981.)

To close the model, balanced trade is assumed, that is,

(9) $$X_O + P^*X_I = X_O^c + P^*X_I^c,$$

where X_O^c is the amount of the output consumed in the country. Let $L \equiv L_I + L_O$ be total labor in the economy. If $L - L_I$ is substituted for L_O in the above systems of equations, there result four systems of nine equations in the nine unknowns X_I, X_O, X_I^c, X_O^c, r_I, r_O, w, L_I, and P. (Which nine equations are appropriate depends, of course, on the policy that is implemented.) In the next section these systems of equations are employed to derive the effects of a change in P^* on P, L_I, and X_I^c when the various protectionist policies are implemented.

8.2 Terms-of-Trade Effects in the Presence of Protection

The analysis of tariffs contains no surprises, but a few results are presented so they can be contrasted with those that are obtained for alternative protectionist measures. With a tariff imposed, the domestic and world prices of inputs are related by equation (3.T). Obviously, then, $\partial P/\partial P^* > 0$. The relationships between the world price and other domestic variables are also easy to ascertain. Combining equations (3.T), (5), and (7.T,Q) yields

$$(10) \qquad (1 + t)P^* f_2(V_I, L_I) = g_2(V_O, L - L_I, X_I^c).$$

Substitute equation (3.T) into equation (8.T,Q) to write

$$(11) \qquad (1 + t)P^* = g_3(V_O, L - L_I, X_I^c).$$

Finally, equations (1), (2), and (9) imply

$$(12) \qquad g(V_O, L - L_I, X_I^c) + P^* f(V_I, L_I) = X_O^c + X_I^c .$$

Now equations (10)–(12) constitute a system of three equations in the three unknowns L_I, X_I^c, and X_O^c. Totally differentiate all three with respect to P^* and solve for $\partial L_I/\partial P^*$, $\partial X_I^c/\partial P^*$, and $\partial X_O^c/\partial P^*$. Then the posited properties of the production functions imply that an increase in the world price of inputs when a tariff is in place (or when there is no protection at all, that is, when $t = 1$) has the following effects: employment of labor in the input tier rises (and hence, so does production in the input tier), employment of produced inputs declines, and domestic consumption of outputs (i.e., welfare) declines.

Now consider a quota that restricts the importation of inputs from abroad. Although for any tariff there is a quota that will yield equivalent protection to the input tier, an increase in the world price of inputs has none of the effects when a quota is in place that it has when a tariff is in place except that domestic consumption falls. The reason is that as long as the pattern of trade is not reversed, all the margins remain unaffected by a world price change because the marginal unit of inputs used in the output tier is domestically produced. Under a quota, the link between the world price and the domestic price of inputs is broken.

Specifically, use equations (5) and (7.T,Q) to write

$$(13) \qquad P f_2(V_I, L_I) = g_2(V_O, L - L_I, X_I^c).$$

In addition, substitute equation (1) into equation (3.Q) to write

$$(14) \qquad X_I^c - f(V_I, L_I) = q.$$

Finally, equation (8.T,Q) is reproduced here as equation (15) for the reader's convenience:

(15) $$P = g_3(V_O, L - L_I, X_I^c).$$

Now equations (13)–(15) constitute three equations in the three unknowns P, X_I^c, and L_I. Note, however, that these equations are entirely independent of P^*. Changes in the world price of inputs when there is a quota in effect have no effect on domestic production decisions. They do, however, affect domestic consumption. Differentiation of the budget constraint (9) establishes that

(16) $$\partial X_O^c / \partial P^* = X_I - X_I^c < 0.$$

Although no production decisions are affected, the price paid for the (constant) level of imports increases, resulting in a decrease in domestic consumption of outputs.

Economies with domestic content requirements in place behave differently, when faced with a terms-of-trade change, than do economies where tariffs or quotas are implemented. Furthermore, the difference depends on whether the requirements are imposed in terms of physical units or value added. First consider the case of a domestic content requirement denominated in physical units. Substitute equation (1) into equation (3.DCP) to write

(17) $$kX_I^c = f(V_I, L_I).$$

Now require that the marginal revenue product of labor be equated across tiers, that is, combine equations (5) and (7.DCP) to write

(18) $$Pf_2(V_I, L_I) = g_2(V_O, L - L_I, X_I^c).$$

Finally, equation (8.DCP) is reproduced here as equation (19) for the reader's convenience:

(19) $$kP + (1 - k)P^* = g_3(V_O, L - L_I, X_I^c).$$

Now equations (17)–(19) constitute a system of three equations in the unknowns P, L_I, and X_I^c. The usual methods verify that the derivative of each of these variables with respect to P^* is negative. The negative correlation between the domestic input price and the world input price contrasts with the positive correlation between them under a tariff and the absence of correlation between them under a quota. The same pattern holds for the correlation between the amount of labor employed in the input tier (and hence, the level of input production) and the world input price. By contrast, the correlation between input use and the world input price is the same as under a tariff. These results are summarized in table 8.1.

To gain some intuition consider figure 8.1, which illustrates two production possibility frontiers. The outer production possibility frontier

Table 8.1 **Some Effects of Terms-of-Trade Changes**

	$\delta P/\delta P^*$	$\delta L_I/\delta P^*$	$\delta X_I^C/\delta P^*$
Tariff	+	+	–
Quota	0	0	0
Domestic content (physical units)	–	–	–
Domestic content (value added)	?	+	–

describes the production set given the level of inputs (foreign and domestic) employed in the output tier before a price change. Suppose the economy produces at point A on that frontier. When P^* rises, the level of inputs used in the economy declines. The inner production possibility frontier describes the production set of the economy given the lower level of inputs. If the same level of inputs were produced as before, then production would occur at point B and the domestic price of inputs, as reflected in the slope of the inner frontier, would be lower. However, if the level of inputs used falls, and if equation (3.DCP) holds with equality as assumed, use of domestically produced inputs must fall proportionally. So production actually occurs at a point like *C*, yielding a domestic price of inputs that is lower still. Hence there are

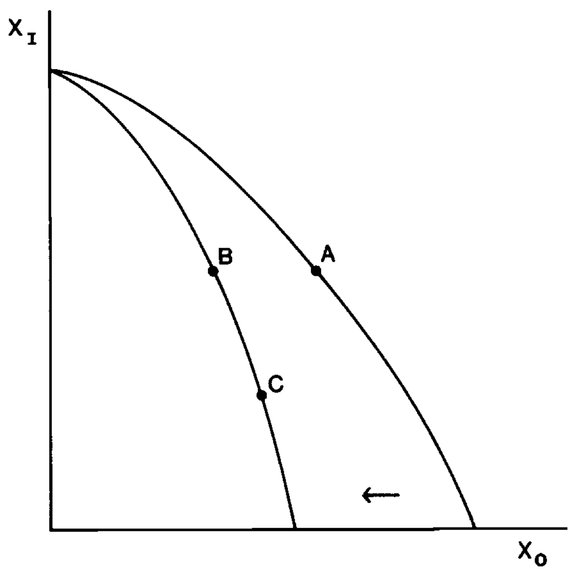

Fig. 8.1 Domestic content, physical units

two effects. First, since fewer produced inputs are used, the economy is comparatively less able to produce outputs. Second, since the ratio of domestically produced inputs to total inputs is constant, fewer inputs are produced at home. Both of these effects work in the same direction, resulting in a fall in P.

When the domestic content requirement is defined in terms of value added, the economy behaves differently once again. For that case, combine equations (5) and (7.DCV) to write

$$(20) \quad Pf_2(V_I,L_I) = \{1 + (1 - j)[(P - P^*)/\mathrm{P}]\}g_2(V_O,L - L_I,X_I^c).$$

Substitute equation (1) into equation (3.DCV) to write

$$(21) \quad P^*[X_I^c - f(V_I,L_I)] = (1 - j)X_O \,.$$

Finally, equation (8.DCV) is reproduced here as equation (22) for the reader's convenience:

$$(22) \quad P = \{1 + (1 - j)[(P - P^*)/P]\}g_3(V_O,L - L_I,X_I^c).$$

Now equations (20)–(22) are a system of three equations in the variables P, X_I^c, and L_I. Dividing (20) by (22) eliminates P:

$$(23) \quad f_2(V_I,L_I) = g_2(V_O,L - L_I,X_I^c)/g_3(V_O,L - L_I,X_I^c).$$

Now equations (21) and (23) are a rather tractable two-equation system in L_I and X_I^c that can be used to show that $\partial L_I/\partial P^* > 0$ and $\partial X_I^c/\partial P^* < 0$. So, although an increase in the world price causes a decrease in the use of inputs just as it does when domestic content is counted in physical units, it causes an *increase* in the domestic *production* of inputs. The intuition is as follows. When P^* rises, the same level of foreign input use would violate the constraint (3.DCV). Hence there is a tendency for substitution away from imported inputs and into domestically produced inputs. Of course, the higher world price causes a decrease in the total derived demand for inputs. Nevertheless, the net effect is for the production of domestically produced inputs to rise.

To derive the sign of $\partial P/\partial P^*$ when domestic content requirements are denominated in value-added terms, the three-equation system (20)–(22) can be differentiated and the resulting system solved for $\partial P/\partial P^*$. That exercise yields a sign for $\partial P/\partial P^*$ which appears to be ambiguous. Some insight can be gained from figure 8.2 where, as before, the outer and inner production possibility frontiers describe the economy's production set given the level of inputs employed in the economy before and after an increase in the world price, respectively. As before, the decrease in the level of inputs used causes the production possibility frontier to rotate in. However, now labor flows *into* the input tier. Hence the two effects work in opposite directions. (In the Cobb-Douglas case considered in section 8.3, $\partial P/\partial P^*$ is positive.) A note of caution is in

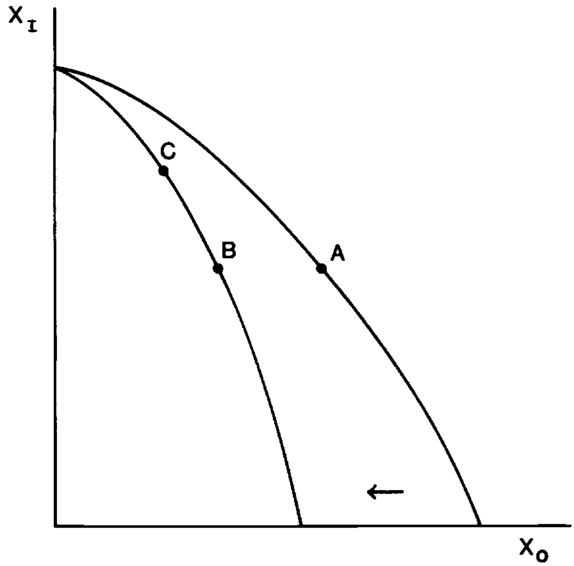

Fig. 8.2 Domestic content, value added

order as to the use of figure 8.2. While in figure 8.1 the slope of the production possibility frontier reflects the domestic price ratio, the same does not hold for figure 8.2. (These two facts can be seen from equations (5) and (7.DCP) and from equations (5) and (7.DCV), respectively.)

8.3 A Simulation

To get some idea of the magnitude of the effects described in section 8.2, consider a simple economy possessing a Cobb-Douglas technology in each tier, so that the production functions are given by

(24) $$X_I = FL_I^{\alpha}V_I^{1-\alpha}, \text{ and}$$

(25) $$X_O = GL_O^{\beta_1}(X_I^c)^{\beta_2}V_O^{1-\beta_1-\beta_2}$$

For the purposes of the numerical example that follows, values for the parameters of equations (24) and (25) were derived from the 1977 input-output tables published by the *Survey of Current Business*. Attention was focused on the industries comprising the first seventy-nine columns of those tables. It is unfortunate for the purposes of this chapter that the disaggregation in the tables is not on the basis of intermediate and final products; in each industry some of the production is of intermediate goods and some of the production is of final goods. However, for each industry, i, total intermediate demand and total final demand are given. For the purposes of this example, assume that all imports reported in the input-output tables are of intermediate goods. Let ϕ_i be the fraction of output in each industry that is attributed to intermediate demand. Though imperfect, ϕ_i will be used as a measure of the fraction of value added in industry i that resulted from intermediate goods production. Multiplication of value added in each industry, i, by ϕ_i and summation over all industries yield a measure of the total production of intermediate goods, X_I. Similarly, multiplication of value added in each industry, i, by $(1 - \phi_i)$ and summation over all industries yield a measure of the total production of final goods, X_O. The input-output tables also give wages and other factor payments in each industry but, once again, do not divide them between intermediate and final good production. Multiplication of these figures by ϕ_i and $(1 - \phi_i)$ and summation over industries yield estimates, in dollar units, of how much labor and "other factors" (to be interpreted as immobile specific factors) are used in the input tier and in the output tier, respectively. That is, these calculations yield estimates of V_I, V_O, L_I, and L_O. Consistent with the earlier assumption that all imports are of intermediate goods, assume that input use in the economy is $X_I^c \equiv X_I + \Sigma_i m_i$. These estimates can then be used to derive the factor shares, α, β_1, and β_2. Plugging all of these results into equations (24) and (25) determines values for F and G. The resulting values of α, β_1, β_2, L, V_I, V_O, F, and G are to be found near the bottom of table 8.2.

Consider a small, undistorted economy with production functions and factor endowments as derived above and listed near the bottom of table 8.2. Table 8.2 also reports the values of input production, X_I, input consumption, X_I^c, output production, X_O, output consumption,

Table 8.2 **The Undistorted Economy**

P^*	X_I	X_I^c	X_O	X_O^c	k	j
.1	.04	9.45	3.94	3.00	.005	.76
.2	.12	3.78	3.15	2.42	.03	.77
.3	.22	2.19	2.74	2.15	.10	.78
.4	.33	1.47	2.45	2.00	.22	.81
.5	.44	1.07	2.23	1.91	.41	.86
.6	.54	.81	2.03	1.87	.66	.92
.7	.63	.64	1.86	1.85	.99	.99
	$\alpha = .53$		$\beta_1 = .29$		$\beta_2 = .24$	
	$L = .96$		$V_I = .35$		$V_O = .46$	
		$F = 2.00$		$G = 3.36$		

Notes: Value of X_I, X_I^c, X_O, X_O^c, L, V_I, and V_O are in trillions of dollars. Rounding is to two decimal places.

X^c_O, domestic content in physical units, k, and domestic content in value-added terms, j, for such an economy facing world prices ranging from .1 to .7. Note that if world input prices exceed .7 by very much, the country will export inputs instead of importing them.

Table 8.3 reports the results of imposing an ad valorem tariff on the input tier for three different world prices. For the different world prices and different tariff rates the first five columns report the equilibrium levels of input production, input consumption, output production, output consumption (i.e., welfare), and domestic price, respectively. The final column reports the elasticity of labor employment in the input tier with respect to a change in the world price of the input. The elasticity of the domestic input price with respect to the world input price is, of course, always one by equation (3.T). The welfare costs of imposing an ad valorem tariff are easily determined from the table. For example, when the world price is .4, domestic welfare without a tariff (i.e., X^c_O when $(1 + t) = 1$) is \$2.0 trillion. If a 25 percent tariff is imposed, this figure falls to \$1.98 trillion.

It is well known that given perfectly competitive markets without distortions there is an equivalent quota for every tariff. As argued in section 8.2, however, economies with different policies in place will behave differently when faced with terms-of-trade changes. Table 8.4 reports the elasticities of equilibrium output consumption for different

Table 8.3 **Ad Valorem Tariffs**

	X_I	X^C_I	X_O	X^C_O	P	η_{L_I}
$P^* = .2$						
$(1+t) = 1.0$	.12	3.78	3.15	2.42	.2	3.60
$(1+t) = 1.5$	.22	2.19	2.74	2.35	.3	3.61
$(1+t) = 2.0$	.33	1.47	2.46	2.23	.4	3.64
$(1+t) = 2.5$	.44	1.07	2.23	2.10	.5	3.69
$(1+t) = 3.0$	.54	.81	2.03	1.98	.6	3.75
$(1+t) = 3.5$	.63	.64	1.86	1.86	.7	3.83
$P^* = .4$						
$(1+t) = 1.00$	.33	1.47	2.45	2.00	.4	3.64
$(1+t) = 1.25$	.44	1.07	2.23	1.98	.5	3.69
$(1+t) = 1.50$	.54	.81	2.03	1.92	.6	3.75
$(1+t) = 1.75$	.63	.64	1.86	1.86	.7	3.83
$P^* = .6$						
$(1+t) = 1.00$	.54	.81	2.03	1.87	.6	3.75
$(1+t) = 1.05$	.57	.75	1.98	1.87	.63	3.77
$(1+t) = 1.10$	.59	.70	1.93	1.86	.66	3.80
$(1+t) = 1.15$	.62	.65	1.88	1.86	.69	3.82

Notes: Values of X_I, X^C_I, X_O, X^C_O are in trillions of dollars. Rounding is to two decimal places.

Table 8.4 **Welfare Effects of Terms-of-Trade Changes**

	η_{xc_0} (Ad Valorem Tariff)	η_{xc_0} (Specific Tariff)	η_{xc_0} (Quota)
$P^* = .2$			
$P = .2$	$-.30$	$-.30$	$-.30$
$P = .3$	$-.32$	$-.27$	$-.17$
$P = .4$	$-.37$	$-.24$	$-.10$
$P = .5$	$-.47$	$-.22$	$-.06$
$P = .6$	$-.61$	$-.22$	$-.03$
$P = .7$	$-.81$	$-.23$	$-.001$
$P^* = .4$			
$P = .4$	$-.23$	$-.23$	$-.23$
$P = .5$	$-.27$	$-.24$	$-.13$
$P = .6$	$-.36$	$-.26$	$-.06$
$P = .7$	$-.49$	$-.28$	$-.002$
$P^* = .6$			
$P = .6$	$-.09$	$-.09$	$-.09$
$P = .63$	$-.11$	$-.10$	$-.06$
$P = .66$	$-.13$	$-.12$	$-.03$
$P = .69$	$-.15$	$-.13$	$-.01$

world prices and different levels of protection when protection takes the form of an ad valorem tariff, a specific tariff, or a quota. The domestic prices in the first column refer to the domestic prices that result from the protection, whatever its form. For example, the first row in the section headed $P^* = .2$ reports that when no protection is imposed, that is, when $P = .2$, the elasticity of equilibrium output consumption is $-.30$. The second row of the same section reports that when the domestic price is increased to .3 then the elasticity is $-.32$ if protection is by an ad valorem tariff, $-.27$ if protection is by a specific tariff, and $-.17$ if protection is by a quota.

Table 8.4 indicates that the welfare effects of terms-of-trade changes are of greatest magnitude under ad valorem tariffs and of smallest magnitude under quotas. The intuition follows from the analysis in section 8.2. When a quota is in place, changes in the world price of the input do not cause any reallocation of productive resources in the economy. An increase in that price reduces welfare only by increasing the price that the country must pay for its fixed level of imports. Given a tariff, however, an increase in the world price induces labor to flow into the input tier, where the country is at a comparative disadvantage. This intensifies the welfare loss relative to the quota case. Finally, note that the magnitudes of welfare changes are greater under an ad valorem tariff than under a specific tariff. This is because the specific tariff, being a per unit tax, becomes proportionally less important when prices rise than does an ad valorem tariff.

Table 8.5 reports the effects of terms-of-trade changes when domestic content requirements are imposed in physical units. The first five columns are as in table 8.3; the last three columns report the elasticities of the domestic price, labor employment in the input tier, and output consumption, respectively, with respect to changes in the world price of inputs. Note that the elasticity of the domestic price of inputs with respect to the world price of inputs can be significant; when $P^* = .2$ and $k = .1$, for example, $\eta_P = -1$. Table 8.6 reports similar results for domestic content requirements denominated in value-added terms. Since domestic content requirements are not, by themselves, equivalent to tariffs, direct comparisons of welfare elasticities are not as meaningful as they are in table 8.4. Nevertheless, if one makes the comparison in terms of domestic prices it appears that the welfare effects of terms-of-trade changes are smaller under quotas than under domestic content legislation. For example, in table 8.5 with $P^* = .2$, elasticities range from $-.24$ to $-.01$ for protection that yields domestic prices from .46 to .71,

Table 8.5 **Domestic Content in Physical Units**

	X_I	X_I^C	X_O	X_O^C	P	η_P	η_{L_I}	$\eta_{X_O^C}$
$P^* = .2$								
$k = .1$	.31	3.14	2.95	2.39	.46	−1.00	−1.30	−.24
$k = .2$	.45	2.25	2.66	2.30	.62	−.52	−.64	−.16
$k = .3$	.51	1.71	2.45	2.21	.68	−.32	−.38	−.11
$k = .4$	.55	1.38	2.30	2.13	.70	−.21	−.25	−.08
$k = .5$	.58	1.15	2.18	2.07	.71	−.14	−.16	−.06
$k = .6$	.59	.99	2.09	2.01	.71	−.10	−.11	−.04
$k = .7$	.61	.87	2.02	1.97	.71	−.07	−.07	−.03
$k = .8$	.62	.77	1.96	1.93	.71	−.04	−.04	−.02
$k = .9$	.63	.69	1.90	1.89	.71	−.02	−.02	−.01
$P^* = .4$								
$k = .3$	.40	1.34	2.37	2.00	.48	−.69	−.85	−.19
$k = .4$	.47	1.17	2.26	1.98	.56	−.46	−.56	−.14
$k = .5$	.52	1.04	2.17	1.96	.61	−.31	−.37	−.11
$k = .6$	.55	.92	2.09	1.94	.64	−.21	−.24	−.08
$k = .7$	.58	.83	2.02	1.92	.66	−.14	−.16	−.05
$k = .8$	.60	.75	1.96	1.90	.68	−.08	−.09	−.03
$k = .9$	.62	.69	1.90	1.87	.69	−.04	−.04	−.01
$P^* = .6$								
$k = .7$	.55	.79	2.01	1.89	.62	−.21	−.24	−.07
$k = .8$	.58	.73	1.95	1.87	.65	−.12	−.14	−.05
$k = .9$	.61	.68	1.90	1.86	.68	−.05	−.06	−.02

Notes: Values of X_I, X_I^C, X_O, and X_O^C are in trillions of dollars. Rounding is to two decimal places.

Table 8.6 **Domestic Content in Value-Added Terms**

	X_I	X_I^C	X_O	X_O^C	P	η_P	η_{L_I}	$\eta_{X_O^C}$
$P^* = .2$								
$j = .8$	.15	3.17	3.02	2.41	.23	.81	3.03	−.30
$j = .825$	.18	2.72	2.90	2.39	.27	.77	2.88	−.29
$j = .850$	.21	2.30	2.78	2.36	.31	.71	2.65	−.28
$j = .875$	.26	1.91	2.64	2.31	.35	.62	2.32	−.26
$j = .90$	.31	1.56	2.50	2.25	.40	.50	1.89	−.24
$j = .925$	.38	1.26	2.35	2.17	.47	.35	1.37	−.20
$j = .950$	.46	1.01	2.19	2.08	.54	.21	.84	−.15
$j = .975$	.55	.80	2.02	1.97	.62	.09	.36	−.08
$P^* = .4$								
$j = .825$	.35	1.41	2.42	2.00	.42	.32	1.59	−.22
$j = .850$	.38	1.26	2.37	1.99	.45	.27	1.33	−.20
$j = .875$	.42	1.13	2.27	1.98	.49	.21	1.07	−.18
$j = .9$	.46	1.01	2.19	1.97	.53	.16	.82	−.15
$j = .925$	.50	.90	2.10	1.95	.58	.11	.58	−.12
$j = .950$	.55	.80	2.02	1.92	.62	.07	.35	−.08
$j = .975$	.59	.71	1.94	1.89	.66	.03	.16	−.04
$P^* = .6$								
$j = .925$	.55	.80	2.02	1.87	.61	.02	.35	−.08
$j = .950$	.57	.74	1.96	1.87	.64	.01	.22	−.06
$j = .975$	.60	.68	1.91	1.86	.67	.01	.01	−.03

Notes: Values of X_I, X_I^C, X_O, and X_O^C are in trillions of dollars. Rounding is to two decimal places.

while in table 8.4 with $P^* = .2$, elasticities range from −.10 to −.001 for quotas resulting in domestic prices from .4 to.7.

8.4 Concluding Remarks

The simulation in section 8.3 reports the comparative statics effects of world price changes on a small open economy when producers of all intermediate goods are protected. Obviously, as both Dixit and Grossman assert in their comments on this chapter, in the more likely event that less sweeping measures are considered, one would want to focus on the particular industries in question. Of course, a careful empirical application of this theory to, for example, the United States economy would require a more complex model and more detailed data than were used here. The results reported in section 8.3 are best interpreted as being illustrative in nature.

The results derived above demonstrate that, although two policies may be equivalent in a static sense, they may behave very differently in the face of changes in market conditions. Hence, if it is difficult to change policies once they are in place, the criteria for choosing a policy should include how it will cause the economy to behave in the future, given what is likely to occur.

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Comment Avinash K. Dixit

This chapter compares the performance of alternative methods of content protection when the world price can change after the policy has been fixed. This is very useful in drawing our attention to a dimension of "robustness" of policy that is seldom analyzed. Major policy changes are infrequent, therefore, the design of policy should bear in mind its suitability to a variety of future circumstances where it will be in force. The idea should have much wider applicability, but the analysis needs to be taken further before it can be used in this way.

In quite general notation, the equilibrium of an economy is determined given the world prices p^* and policy instruments z. Let x denote some variable of economic interest, such as the consumption of the output good, or the rental rate for the specific factor in the input tier. Now x is a function $x(z,p^*)$. What Lambson does is to compare the partial derivatives $x_2\ (z,p^*)$ for different instruments z. What can we learn from this? Presumably the variable x is a maximand or a target of policy. If we choose z having in mind one value of p^* and then a higher value emerges, then x might overshoot, or move the wrong way, depending on the sign of $x_2\ (z,p^*)$.

This is not as systematic as one would like. We should view the problem as one of decision making under uncertainty. We must fix z before p^* is realized, but we have a subjective or objective distribution

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over it, and some attitude to risk about x. The simplest such problem would be to maximize $E[U(x(z,p^*))]$. Another might be to maximize Prob $\{x(z,p^*) > \underline{x}\}$ where $\underline{x}$ is a target level.

If the uncertainty in p^* is small, Lambson's comparative statics will be a useful component of this more general analysis. Thus we have, approximately,

$$x(z,p^*) = x(z,Ep^*) + (p^* - Ep^*)\, x_2\,(z,Ep^*).$$

Therefore

$$\mathrm{Var}[x(z,p^*)] = \mathrm{Var}[p^*] \cdot [x_2\,(z,Ep^*)]^2.$$

The policymaker can then choose z to maximize a quadratic utility function over x. Alternatively,

$$\text{Prob}\,\{x(z,p^*) > \underline{x}\} = \text{Prob}\,\{p^* > Ep^* + [\underline{x} - x(z,Ep^*)]/x_2(z,Ep^*)\},$$

which enables us to calculate the approximate policy to ensure fulfillment of the target with maximum probability.

Once uncertainty is made explicit, it becomes important to introduce markets to deal with it. Even with the aggregate or systematic uncertainty that is inherent in p^*, the real incomes of different factors are affected differently. They therefore have the desire to trade Arrow-type securities whose payoff is conditional on p^*. Such markets are feasible since p^* is easily observable. The equilibrium, and therefore the policy analysis, should be conducted relative to such a market structure.

Turning to the specific problem of content protection, I think this whole literature needs to distinguish two concepts: protection of the input tier and protection to value added in the output tier. When we think of content protection for the automobile industry, we mean a requirement that a greater proportion of transmissions, chassis, engines, and so forth be of domestic manufacture, not that the industry use a certain proportion, whether in physical or value terms, of domestic steel. In fact, an import tariff or quota on steel will reduce the effective rate of protection to the domestic auto industry.

Of course, this is in part a matter of definition: if auto parts are classified in the input tier and only the final assembly stage in the output tier, content protection may properly be modeled as protection of the input tier. Therefore, theoretical work may legitimately blur the distinction. However, in empirical work, an appropriate choice of definitions becomes crucial. Here Lambson's formulation seems unfortunate. He assumes that all imports are of intermediate goods and chooses his parameter values accordingly. Now in 1984, out of a total of $341 billion of U.S. merchandise imports, $39 billion were road vehicles (excluding parts), $14 billion were clothing and accessories, $5 billion were footwear, and $3.6 billion were toys and sporting goods. If all these goods, comprising almost 20 percent of all imports, are to be intermediate, the output tier must be essentially only retailing. This makes content protection, or protection of the input tier, virtually tantamount to general protection for manufacturing. I doubt if that is what most people would understand by the term.

In reality, what we understand by the scope of the input and output tiers differs very widely across industries, depending on the extent of vertical integration, organization of labor, or even pure historical custom. This leads me to think that aggregate economywide equilibrium models are not really the best way to do empirical work on content protection. An industry-by-industry approach would allow more precision in capturing the kind of protection that is relevant in each context. It would also allow a more accurate specification of demand and cost conditions, and so improve the calculation of the efficiency and distributive effects of the policies.

Comment Gene M. Grossman

This chapter is a fine example of the Rochester school of trade theory. Lambson constructs a simple, tractable general equilibrium model to study various trade policies that might be used to protect producers of intermediate inputs. Unlike much of the literature that focuses on the implications for resource allocation of different policies set to achieve some common objective, Lambson is concerned with what happens when policies are already in place and some external conditions change. In particular, he studies how changes in the terms of trade affect equilibrium in the domestic market when tariffs, quotas, or two types of content protection schemes are used to protect intermediate-goods producers. A main finding is that a fall in the international price of intermediates causes the local price of intermediates to fall when a tariff is in effect, has no impact on domestic prices under a quota regime, and actually causes the local price of intermediates to rise when a physical content protection scheme is in place.

My remarks are in three parts. First, I provide an interpretation of Lambson's results that makes use of some simple, partial equilibrium, supply and demand diagrams. These diagrams helped me to understand

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the findings and also convinced me that they would survive in alternative but equally reasonable specifications of the general equilibrium structure. Second, I argue that the general equilibrium approach perhaps is not the most appropriate for the question at hand, especially when it comes time for the empirical application presented in the last section of Lambson's chapter. Finally, I offer some suggestions for possible extensions of the research reported here.

Interpretation of Results

The theoretical portion of Lambson's chapter stresses that foreign price changes will have qualitatively different effects on the domestic intermediate goods market when different policies are used to protect that industry. This point is seen most clearly, I believe, when we consider how the *net* derived demand curve for domestic intermediates shifts in response to the terms-of-trade change under the alternative policies. In figure C8.1, I have shown the equilibrium in the domestic market for locally produced intermediate goods under a tariff regime. The curve labeled DD′ is the total derived demand for intermediates by domestic final-goods manufacturers, and SS′ is the supply of intermediates by local producers. Under a tariff, imports are available in perfectly elastic supply at the tariff-augmented international price, so initially the net (or residual) derived demand for the domestic input is given by ACD′. When the world price of imported intermediates falls to p_l^*, the net derived demand shifts to A′C′D′, causing the domestic price to fall to $p_1^*(1 + t)$. As is well known, incipient *substitution* toward imports causes demand for the domestic product to fall, thereby exerting downward pressure on the local price.

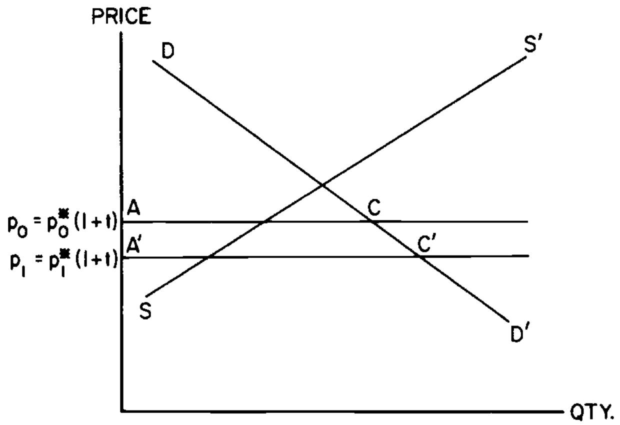

Fig. C8.1 Tariff protection

Contrast this result with that for a quota, illustrated in figure C8.2. Here the net demand curve at the initial world price of foreign intermediates is given by ABCD'. This curve is found by subtracting from total demand DD' the fixed amount of the quota, BC, for all domestic prices exceeding the world price of intermediates. Now when the world price falls to p_1^*, the net demand for domestic intermediates becomes AB'C'D'. As is clear from this figure, this shift has no effect on the equilibrium price of the domestic product. The reason, of course, is that substitution toward the now cheaper import is not possible when the quota is binding, so the fall in p^* induces no change in demand.

Next consider the case of a physical content protection scheme (PCP). In Grossman (1981) I described the construction of the net derived demand curve associated with this policy instrument, as depicted in figure C8.3. To review briefly, a PCP requires domestic manufacturers to use at least a specified proportion $1 - k$ of domestic intermediates (relative to imported intermediates) in their production processes. Again let DD' be the total demand for intermediates by domestic manufacturers, and note that this curve is drawn as a function of the *effective* price of an intermediate good faced by the final-goods sector. As an intermediate step, we construct the curve labeled DE by finding all quantities that are a fraction $1 - k$ of total demand along DD'. Then, the relevant portion of the net derived demand curve is found by vertically displacing DE, so that a weighted average of the domestic price on the net derived demand curve and the (given) international price p^* (with $1 - k$ and k as the weights) gives the corresponding price on the curve DE. Take the point X, for example. When the domestic price is given by the ordinate of this point, the weighted average of the domestic

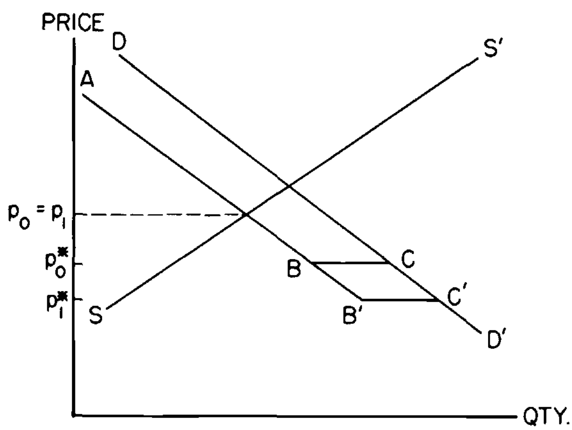

Fig. C8.2 Quota protection

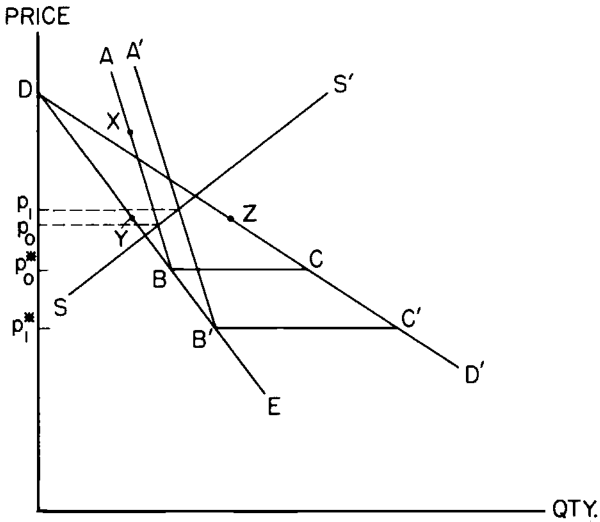

Fig. C8.3 Content protection

and foreign price is given by the ordinate of Y, on DE. This is the effective price of intermediates faced by domestic manufacturers, so total demand is given by the abscissa of Z on DD'. But then the PCP requires that at least a fraction $1 - k$ of this amount be purchased domestically. By construction, this quantity is given by the abscissa of Y and hence X. (Note that the complete net derived demand curve is given by ABCD', where the policy is not binding along BCD'.)

When the international price falls to p_1^*, the net demand curve shifts to A'B'C'D'. This increase in demand in the relevant region causes the domestic price to rise, thus confirming Lambson's result. How do we account for this finding? Because the PCP requires that imported and domestic inputs be used in fixed proportions, the two intermediate goods become complements, rather than substitutes, when the policy is in effect. The fall in p^* induces domestic manufacturers of final goods to expand their production. Substitution between the intermediates does not take place, but the "output effect" implies an increase in demand for the domestic product.

Finally, consider the value-added content scheme (VACP). Here there are two effects working in opposite directions. The fall in p^* means that more foreign intermediates can be imported without the content constraint being violated. Hence, substitution of imported for domestic intermediates takes place. At the same time, because the fall in p^* eases the constraint, local final-goods producers have an incentive to expand their outputs by purchasing more inputs of all kinds. Evidently, the net impact of the output and substitution effects is ambiguous, as Lambson has shown.

General versus Partial Equilibrium Modeling

As should be clear from the logic of the discussion, Lambson's theoretical results would survive in many alternative general equilibrium models to the one he chooses. But where the theory is robust to model specification, the empirical calibration is not likely to be so. In practice, content protection always is applied at the level of a specific industry and enforced on a firm-by-firm basis. Indeed, it is hard to imagine what would be meant by an economywide content protection scheme. Are we to imagine that the economy as a whole is to achieve a certain average domestic content? If so, how would such a scheme be implemented? If the content requirement is to apply to each and every firm, surely the constraint would have differential impacts across sectors.

The general equilibrium structure forces Lambson to treat all imports as intermediates. While he justifies this approach with appeal to the notion of "middle products" as developed by Sanyal and Jones (1982), it is hard to imagine how French wine could be made to conform to a 60 percent domestic content requirement, even after allowance is made for domestic value added in packaging and retailing.

An alternative approach would have been to follow the partial equilibrium modeling outlined above. Then, detailed consideration could have been given to each of two or three industries for which content protection has been proposed. While some points of detail would be different (there would be no need to have balanced trade between intermediates and final goods at the industry level), the general message would have been preserved and the numbers would have been more informative.

Extensions of the Research

Given the evident inertia in the policy-setting apparatus, the question raised by Lambson of the "robustness" of trade policy to a changing economic environment is an important one. Lambson's work might be fruitfully extended using the following general approach. First, one could state explicitly the assumed objective of trade policy. Next, the various instruments that might be used to achieve that objective would be identified. The policy control variables then would be set at the levels needed to achieve the objective. Finally, shocks to the environment are introduced, and implications for domestic *welfare* are compared. The approach could apply not only to changes in the terms of trade, but also to shifts in domestic supply and demand conditions. This would provide an additional basis for ranking policies beyond the usual, static, deadweight-loss measures: which policy will cause least harm if conditions change before the policymakers have a chance to act again?

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