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Trade Policy and Factor Returns

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The imposition of international trade restrictions, both tariff and non-tariff, by many countries around the world has almost become a way of life. Generally these restrictions have been imposed for the express prupose of benefiting some particular factor or input in the production of the protected commodity. For example, the U.S. Meat Import Act of 1964 (P.L. 88-482) focused on protecting domestic livestock prices which, in turn, was intended to benefit the income farmers received for their labor and management services. There has been little attempt in the economic literature to explain the impact that protection has had upon factor prices[1] even though the question of how protection affects resource allocation in terms of the production structure and resource movement has received exhaustive attention in recent years. (See [1] and [2]).

The purpose of this paper is to show what effects protection does have upon factor prices so as to determine whether the real and intended impacts that protection has upon a particular input or factor of production are the same. First a theoretical model will be presented which shows that the change in returns to an input or factor of production can be expressed as a function of own, cross and product price elasticities of demand for the input, the input supply elasticity and the change in the tariff rate on output (or the tariff equivalent of the quota). The model is followed by an application based on the U.S. import quota on beef (now temporarily suspended).

The Model

The change in factor demand due to a tariff on output for a particular industry can be expressed as follows. There are n factors of production (or inputs), X_j (j = 1, ..., n), which are demanded for the production of Z. The demand for any factor, X_j, can be expressed as a function of the marginal productivity of a factor -- as indicated by the slope of the production function -- A_j, the price of the product produced by the industry, P, and the prices of the n inputs P_j (j = 1, ..., n).

[1] Massel [5] has attempted to do so but under the unrealistic assumption of fixed proportions of inputs in production.

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In algebraic notation this can be expressed as:

$$(1)\quad X_j = X_j\,(A_j;\ P;\ P_1,\ \ldots,\ P_n)$$

By making a linear approximation for the change in demand for X_j following a change in output and/or input prices and ignoring changes in marginal productivity (i.e., technology is constant), the following obtains:

$$(2)\quad dX_j = \frac{\partial X_j}{\partial P} \cdot dP + \frac{\partial X_j}{\partial P_1} \cdot dP_1 + \ldots + \frac{\partial X_j}{\partial P_n} \cdot dP_n$$

By multiplying both sides of equation(2) by the reciprocal of X_j, the first term on the right hand side of (2) by P/P and the remaining terms by P_i/P_i $(i = 1, \ldots, n)$. The relative change in the use of factor X_j can be expressed:

$$(3)\quad \frac{dX_j}{X_j} = \frac{\partial X_j}{\partial P} \cdot \frac{P}{X_j} \cdot \frac{dP}{P} + \frac{\partial X_j}{\partial P_1} \cdot \frac{P_1}{X_j} \cdot \frac{dP_1}{P_1} + \ldots + \frac{\partial X_j}{\partial P_n} \cdot \frac{P_n}{X_j} \cdot \frac{dP_n}{P_n}$$

By letting $t = dP/P$, where t indicates the tariff rate on output, the relative change in the demand for X_j by industry k can be expressed in terms of elasticities, the tariff rate on output and the change in factor prices induced by the output tariff.

$$(4)\quad \left(\frac{dX_j}{X_j}\right)_d = \eta_j . t + \sum_{i=1}^{n} E_{ji} \cdot \frac{dP_i}{P_i}$$

where η_j = the elasticity of demand for factor X_j with respect to change in product price (usually positive)

E_{ji} = for $i = j$, the own price elasticity of demand for X_j (usually negative)

= for $i \neq j$, the cross price elasticity for X_j (positive for substitutes and negative for compliments)[2]

In determining the change in factor supply due to a tariff on output, the supply of a factor is expressed only as a function of the factor price, i.e.

$$(5)\quad X_j = X_j\,(P_j)$$

By a similar procedure to that presented above, the change in the quantity supplied of a factor due to a change in price is:

[2] The E_{jj}'s are analogous to total elasticities, taking account of all direct as well as indirect or secondary effects of changes in P_i on all other inputs.

$$(6)\quad \left(\frac{dX_j}{X_j}\right)_s = \frac{dP_j}{P_j} \cdot S_j$$

where $S_j = \frac{\partial X_j}{\partial P_j} \cdot \frac{P_j}{X_j}$ = elasticity of supply of factor X_j with respect to factor price (usually positive)[3]

In equilibrium the change in the quantity of X_j demanded by industry k will equal the change in the quantity supplied of X_j to the industry, and since the quantity demanded equals the quantity supplied before the imposition of the tariff, then

$$(7)\quad \left(\frac{dX_j}{X_j}\right)_s = \left(\frac{dX_j}{X_j}\right)_d$$

To achieve this equilibrium there will have to be a change in factor returns to induce the appropriate shift of resources.[4] By substituting equations (6) and (4) into (7) and rearranging, the change in factor returns that can be attributable to a change in the tariff rate on output becomes

$$(8)\quad \frac{dP_j}{P_j} = \frac{\eta_j \cdot t + \sum_{\substack{i=1 \\ i \neq j}}^{n} E_{ji} \cdot \frac{dP_i}{P_i}}{(S_j - E_{jj})}$$

Since $j = 1, \ldots, n$, there will be n such equations for the industry containing n unknowns, dP_j/P_j, so that a unique solution for the change in factor returns from imposing a tariff on output does exist. The model presented is applicable to a partial equilibrium setting and since most policy decisions are usually made under such circumstances, the model has practical significance.

Some interesting conclusions become immediately obvious from equation (8).

(i) The greater the elasticity of supply of a factor of production the less will be the effect of an import duty imposed on a commodity derived from that factor. This suggests that returns to those factors with an inelastic supply such as land, will bear most of the burden of changes in tariffs on farm commodities, ceteris paribus.

(ii) In most cases the change in factor returns will be in the same direction as the change in the tariff. There are two exceptions:

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[3] In a limiting case where factors of production are infinitely elastic in supply, the change in factor returns will equal the tariff rate on the factors.

[4] Equation (7) does not infer that the rates of change of supply and demand for a factor are the same.

-- if the factor supply is infinitely elastic, the change in factor returns will be zero

-- if X_j is complimentary with other factors of production (i.e. the E_{ij}'s < 0) then for a change in factor returns to be in the same direction as the change in the tariff rate, the expression

$$\sum_{\substack{i=1 \\ i \neq j}}^{n} E_{ji} \cdot \frac{dP_i}{P_i} < \eta_j \cdot t$$

must hold.

(iii) If dP_j/P_j is estimated for different industries subject to tariff changes and ranked by order of magnitude, the resource X_j will flow from those industries where dP_j/P_j is low to those industries where dP_j/P_j is high, ceteris paribus.

An Application of the Model

The United States Meat Import Act of 1964 (P.L. 88-482) is used as a case study to illustrate the use of the model. The procedure adopted is to assume that the quota will be reimposed in 1975 at a level consistent with the trend established from 1965 to 1970. This quota level of imports is subtracted from the projected unrestricted supply of imports for 1975[5] to yield a projected reduction in the imports of frozen beef in 1975 of 670 million pounds which is attributable to the reimposition of the quota.

Since the imports of beef are primarily of low quality, the production of beef is divided into two groups -- high grade beef (steers and heifers raised in feedlots) and low grade beef (culled dairy cattle and beef breeding cattle). The data required for equation (8) pertinent to the two grades of beef is presented below.

The Tariff Rate. The tariff equivalent of the change in the quota policy is found by first determining the change in the retail price level attributable to the imposition of the quota. By allowing for marketing margin, the change in price (tariff level) at the farm level can be easily derived.

Three retail price-forecasting equations are estimated for high grade beef, low grade beef and other meats (pork and chicken). These equations are of the form

$$P = f\left(\sum S_i, Q_{hg}, Q_{lg}, Q_{om}, Y\right)$$

where

P = the retail price of either high grade beef, low grade beef or other meat (cents per lb.)

[5] The unrestricted supply was projected for those countries or regions which, as a result of health regulations, have been the major suppliers to the U.S. in recent years, namely Australia (50 percent), New Zealand (20 percent), Central America (12 percent), Ireland (7 percent) and Canada (3 percent).

S_i = seasonal dummy variable (S_i = 1 for quarter i, i = 1,2,3.)

Q_{hg}, Q_{lg}, Q_{om} = per capita disappearance of high grade beef, low grade beef and other meats, respectively (lbs.)

Y = per capita personal disposable income ($)

The results from estimating these three equations using ordinary least squares are presented in Table 1. The quota imposition will cause a reduction in the supply of low grade beef of 670 million pounds (9.7%) in 1975 which in turn will result in a rise in the retail price for high grade beef of 1.0%, for low grade beef of 2.2% and for other meats of 0.9%. It is assumed that these price changes are passed on in total to producers[6], since farmers receive about 64% of the retail price for meat,[7] the "at-farm" change in price is estimated to be 1.56% for high grade beef and 3.44% for low grade beef (other meats being ignored). These estimates represent the "tariff equivalent" of the quota.

Table 1: Price Forecasting Equations, Linear in Logs, 1959-1969 (Quarterly)

Dependent Variable	Independent Variables								R^2
	Constant	S_1	S_2	S_3	Q_{hg}	Q_{lg}	Q_{om}	Y	
P_{hg}	0.8301	-0.0063 (0.0129)	0.0045 (0.0129)	0.0132* (0.0099)	-0.6627** (0.1113)	-0.1056* (0.0735)	0.0171 (0.1679)	0.8682** (0.1308)	.87
P_{lg}	0.4542	0.0097 (0.0165)	0.0178 (0.0165)	0.0339** (0.0127)	-0.9136** (0.1423)	-0.2296* (0.0939)	0.2748 (0.2164)	0.9378** (0.1671)	.76
P_{om}	1.5798	-0.0455** (0.0160)	-0.0435** (0.0160)	-0.0209** (0.0124)	-0.6125** (0.1384)	-0.0972 (0.0913)	-0.8173** (0.2088)	0.9200** (0.1626)	.80

* t statistic significant at α = .01 level

** t statistic significant at α = .05 level

[a] Values in parentheses are the standard errors of the estimate.

[6] This assumes that all factors (or inputs) supplied to the slaughtering, processing and distribution activities for meat have an infinite supply elasticity, so that the retail price change will be passed on in total to the farm level.

[7] Using average figures for the last six years [8, 1970].

Elasticity Estimates. In an attempt to reduce the number of elasticity estimates required by equation (8), it was assumed that the cross elasticity terms, E_{ij}'s, are equal to zero. Therefore (8) becomes:

$$(10) \quad \frac{dP_j}{P_j} = \frac{\eta_j \cdot t}{S_j - E_{jj}}$$

This means that the estimates of changes in factor returns will only be crude approximations.

The various elasticities, and respective sources, are presented in Table 2. These elasticity estimates refer to all of U.S. agriculture and are therefore only approximations for the beef industry.

Changes in Factor Returns. The percentage changes in factor returns are presented in Table 3. As the income of ranches consists of returns from the sale of cull cows (25%) and feeder cattle (75%)[8] the tariff rate applicable to the ranch is a weighted average of the change in the farm price of feeder cattle and the change in the farm price for low grade beef (t = 1.75% for the ranch).

The returns to all factors increase as a result of imposing the quota (except those infinitely elastic in supply). The protection afforded labor from reimposing the quota is very small. Real estate values could be expected to increase moderately as a result of imposing the quota. This latter result supports the oft referred to hypothesis that trade restrictions will be capitalized into the value of fixed assets, i.e. real estate.

Other Effects of Reintroducing the Quota. The impact on retail prices mentioned above will mean that consumers must pay slightly higher prices for meat. If one is willing to assume that a higher proportion of low grade beef is consumed by low income families then reintroduction of the quota will have the unfavorable income distribution feature of making low income families worse off than high income families. The small increase in meat prices will mean that, consumers generally will be on a lower indifference curve.

In addition to the impact on U.S. consumers, those countries supplying imports of meat to the U.S. will also suffer via lost foreign exchange earning. This loss of foreign exchange will occur as the external suppliers divert their exports from the more profitable U.S. market to other less profitable world markets for beef.

[8] See [7, p. 79].

Table 2: Elasticity Estimates for the Ranch and the Feed Lot

	Own Price (E_{jj})		Product Price (n_j)		Supply (S_j)	
	S.R.[a]	L.R.[a]	S.R.[a]	L.R.[a]	S.R.	L.R.
Fertilizer and lime	-0.6	-1.8	0.5	2.4	e	e
Machinery operating expenses	-1.0	-1.5	0.5	2.5	e	e
Miscellaneous current operating expenses	-0.3	-0.5	0.3	2.5	e	e
Machinery inventory	-0.2	1.0	0.2	2.6	e	e
Feeder cattle	-0.8[b]	-1.5[b]	0.7[b]	2.0[b]	0.12[f]	1.80[f]
Feed grains	-0.8[b]	-1.5[b]	0.7[b]	2.0[b]	0.17[g]	1.56[g]
Breeding stock	-0.2[c]	-1.0[c]	0.2[c]	2.5[c]	-0.12[f]	1.80[f]
Labor[d]	-0.1	-0.5	0.1	1.0	0.10[h]	0.36[h]
Real estate	0	0	0.1	0.3	0.036[i]	0.112[i]

[a] Tweeten and Quance [1, p. 350].

[b] Estimates for feeder cattle and feed grains are those for "feed, seed, and livestock" [6, p. 350].

[c] Estimates for breeding stock are those for "crop and livestock inventory [6, p. 350].

[d] "Labor" refers to the services of both management and labor of farm families.

[e] Assumed to be infinite at least as far as the beef industry is concerned.

[f] Supply elasticity for animal units [6, p. 349].

[g] Supply elasticity for all crops [6, p. 349].

[h] Supply elasticity of family labor on farms, using net farm incomes as the relative price variable [3, p. 252].

[i] Jackson [4, p. 79].

Table 3: Percentage Change in Factor Returns

Input	Feedlot		Ranch	
	S.R. Change	L.R. Change	S.R. Change	L.R. Change
Fertilizer and lime	0	0	0	0
Machinery and operating expenses	0	0	0	0
Miscellaneous current operating expenses	0	0	0	0
Machinery inventory	0	0	0	0
Feeder cattle	1.19	.95	a	a
Breeding stock	a	a	1.12	1.56
Labor	.78	1.81	.88	2.03
Real estate	4.33	4.18	4.86	4.69
Feed grains	1.13	1.02	a	a

[a]Does not apply.

The conclusions reached from applying this model to the U.S. beef quota are that reintroducing the quota will only bring modest benefits to U.S. beef producers with the resultant higher level of prices being capitalized into the value of farms and ranches. If it is deemed to be in the national interest to provide protection for beef producers, income support payments would be preferable to an import quota since the former would eliminate the price effects on consumers and permit overseas producers to increase their exports.

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