INTERRELATED PRODUCTS AND THE EFFECTS OF AN IMPORT TARIFF

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This article demonstrates that when a second product is introduced into the traditional single-product, partial equilibrium model, the predictions of the impact of a tariff on prices are no longer determinate In contrast to the traditional single-product partial equilibrium framework in a two-or-more product, partial equilibrium model, an import tariff may raise, lower, or leave unchanged the price in either country examined The empirical result depends on the relationships between own- and cross-price elasticities The empirical example developed illustrates these relationships and shows how critical the values of own- and cross-price elasticities are to empirical policy analysis

Keywords

Partial equilibrium analysis
Metzler's Paradox
Cross elasticities
Import tariff
Trade policy

Empirical trade research devoted to national commodity policies has multiplied in recent years as more economists recognize the importance of national commodity policies on world agricultural trade Most empirical research on trade has been confined to single-product partial equilibrium analysis, despite interrelationships among agricultural commodity markets [1] If confined to a single-product partial equilibrium framework, analysis of changes in commodity policies will yield erroneous estimates of the magnitude of their impacts when products are interrelated It is also possible that using a single-product partial equilibrium model may result in errors in predicting the direction of changes in endogenous variables with respect to policy changes The final result is an important empirical issue which can affect policy recommendation

In this article, we compare the effects of an increase in an import tariff on prices by using different models of world commodity trade to illustrate how the choice of model and the values of the parameter estimates can affect the predicted outcome The single-product partial equilibrium model assumes that a shift in policy in one commodity market will not affect prices in any other market In this framework, imposing an import tariff unambiguously lowers the price in the exporting country and raises the price in the tariff-imposing country We contrast this result with the two-product general equilibrium model, which assumes that the prices and quantities of all products and factors are determined simultaneously The directions of the changes in prices that result when a tariff is imposed cannot be determined *a priori* in this model

A general equilibrium model can be cumbersome to employ in empirical research because of its restrictive assumptions Consequently, empirical research which takes some of the relevant simultaneities into account relies on a third framework—the multiproduct, partial equilibrium model We demonstrate that, once the second product is added to the single-product, partial equilibrium model, a tariff's impacts cannot be determine *a priori*

SINGLE-PRODUCT, PARTIAL EQUILIBRIUM MODEL

The most commonly used model in empirical agricultural trade research is the single-product, partial equilibrium model This model assumes a world market for commodity i, which is homogeneous, that consists of two (or more) large countries which trade in a competitive market The prices of all other commodities produced and consumed in both countries are treated as exogenous For simplicity, it is also assumed there are no transportation or handling costs and that prices for good i in both regions are expressed in terms of a common currency This model is specified as

Country 1

$$D_{1i} = f(P_{1i}), \quad (1)$$

$$S_{1i} = g(P_{1i}), \quad (2)$$

$$X_{1i} = S_{1i} - D_{1i}, \quad (3)$$

Country 2

$$D_{2i} = h(P_{2i}), \quad (4)$$

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[1] For a review of this literature, see (*12*)

$$S_{2i} = k(P_{2i}), \quad (5)$$

$$M_{2i} = D_{2i} - S_{2i}, \quad (6)$$

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$$X_{1i} = M_{2i}, \quad (7)$$

$$P_{2i} = P_{1i}(1 + T_i), \quad (8)$$

where,

- D_{1i} = the quantity demanded of good i in country 1,
- S_{1i} = the quantity supplied of good i in country 1,
- X_{1i} = the quantity of good i exported by country 1,
- P_{1i} = the price of good i in country 1,
- D_{2i} = the quantity demanded of good i in country 2,
- S_{2i} = the quantity supplied of good i in country 2,
- M_{2i} = quantity of good i imported by country 2,
- P_{2i} = the price of good i in country 2,
- T_i = the *ad valorem* tariff rate on good i

Suppose that, to satisfy pressure for protecting domestic producers of good i, country 2 raises its *ad valorem* import tariff on good i The impacts of the increased tariff on prices in countries 1 and 2 can be determined by totally differentiating the entire model

Country 1

$$dD_{1i} = f_i dP_{1i}, \quad (9)$$

$$dS_{1i} = g_i dP_{1i}, \quad (10)$$

$$dX_{1i} = dS_{1i} - dD_{1i}, \quad (11)$$

Country 2

$$dD_{2i} = h_i dP_{2i}, \quad (12)$$

$$dS_{2i} = k_i dP_{2i}, \quad (13)$$

$$dM_{2i} = dD_{2i} - dS_{2i}, \quad (14)$$

International Linkages

$$dX_{1i} = dM_{2i}, \quad (15)$$

$$dP_{2i} = (1 + T_i)dP_{1i} + P_{1i}dT_i \quad (16)$$

Simplifying equations (9-14) through substitutions produces the total differentials of the excess supply and excess demand schedules

$$dX_{1i} = (g_i - f_i)dP_{1i}, \quad (17)$$

$$dM_{2i} = (h_i - k_i)dP_{2i} \quad (18)$$

Using the international linkages, (15) and (16), and solving for the change in price in country 1 (the exporter) resulting from a change in the tariff rate, dP_{1i}/dT_i yields

$$dP_{1i}/dT_i = (h_i - k_i)P_{1i} / (g_i - f_i) - (h_i - k_i)(1 + T_i) \quad (19)$$

Solving for the price change in country 2 resulting from a change in the import tariff rate, dP_{2i}/dT_i, results in

$$dP_{2i}/dT_i = (g_i - f_i)P_{1i} / (g_i - f_i) - (h_i - k_i)(1 + T_i) \quad (20)$$

The direction of the change in prices resulting from an increase in the import tariff can be determined We can find the direction if we assume that demand schedules slope downward and supply schedules have a positive slope--that is, f_i and h_i are negative, and g_i and k_i are positive It is also assumed that $T_i \geq 0$, and $P_{1i} > 0$ The numerator of equation (19) is unambiguously negative, while the denominator is positive Therefore, $dP_{1i}/dT_i < 0$, an increase in the import tariff unequivocally lowers the price of good i in the exporting country In equation (20) the numerator and the denominator are positive Consequently, $dP_{2i}/dT_i > 0$, or an increase in the import tariff raises the price of i in country 2 and protects producers of i in the country imposing the tariff

Therefore, when analyzing the impacts of an increase in an import tariff using the single-product, partial equilibrium model, one always obtains unambiguous results The price of the commodity in the exporting country declines when the tariff is increased, while the price in the importing country rises to protect domestic producers of good i

We demonstrate that, once the second product is added to the single-product, partial equilibrium model, a tariff's impacts cannot be determined a priori

THE METZLER PARADOX

Whereas most empirical research on trade relies on the approach just discussed, international trade theory is based principally on the two-product, general equilibrium model The one-product model treats one good in an economy of *n* goods, whereas the simple two-product, general equilibrium model assumes those two products represent all goods produced and consumed in the economy The one-product, partial equilibrium model abstracts from all factor market adjustments by assuming that producing the product consumes such a small fraction of each factor that the industry is in effect a price taker in all factor markets The general equilibrium model assumes that two factors are used in producing the two products, that they are allocated to equate the values of their marginal products in both uses, and that both are always fully employed Any change in the volume of either good produced changes the price of both factors, which shifts the supply schedules of both goods and changes the income of the factor owners

The one-good, partial equilibrium model also assumes that expenditures on the product represent an imperceptibly small fraction of consumer income Therefore, any change in the quantity of the product purchased will not affect the quantities or prices of any other products purchased The general equilibrium model, in contrast, assumes both goods are "large" components of consumer expenditures, and anything, such as a tariff, which alters consumption of one product shifts the demand curve for the other product as well This changes its price and shifts the demand schedule for the product on which the tariff is imposed

For each country, the two product, general equilibrium model contains linear homogeneous production functions for the two goods Assumptions include given endowments of two factors of production, full employment conditions, four marginal productivity conditions which state that the value of the marginal product of each factor in each use must equal its price, and a demand sys tem which ensures that all income is spent on the two goods

In 1949, Metzler illustrated that in the two-product, general equilibrium model, the signs of the tariff impacts illustrated above in the single-product, partial equilibrium model are no longer unambiguous He showed that in the two-sector, general equilibrium model an import tariff could lower the relative price of the import good in the tariff imposing country under certain circumstances (7)

Assume that country 2 imposes an *ad valorem* import tariff on good i and redistributes the tariff revenue to consumers in country 2 as a lump sum income subsidy The impact of the tariff can be found by treating the two-product, gen eral equilibrium model like that discussed earlier in the single-product, partial equilibrium model The first step is to reduce the model to its offer curves, which are the general equilibrium analogs of the excess demand and excess supply schedules in the partial equilibrium framework Taking the total differential of the system and solving for the change in relative prices with respect to the tariff results in the following equation [2]

$$\frac{d(P_i/P_j)}{dT_i} = \frac{(e_1 + m_2 - 1)(P_i)}{(e_1 + e_2 - 1)(P_j)}, \tag{21}$$

where

e_1 = country 1's general equilibrium elasticity of import demand (defined as a positive value),

e_2 = country 2's general equilibrium elasticity of import demand (defined as a positive value),

m_2 = country 2's marginal pro pensity to spend income on its import good (i)

$(m_2 - 1)$ = country 2's marginal propensity to spend income on its export good (j)

The Marshall-Lerner condition, the stability condition of the gen-

[2] See (*3*, pp 247 249) for the complete derivation of (21) Derivations can also be found in (*11*, pp 240-243) or (*4*, pp 473 480)

eral equilibrium system, states that the sum of the import demand elasticities must exceed unity, that is, $e_1 + e_2 > 1$ Therefore, if the market is stable, the denominator of (21) is positive The numerator of (21) is divided into a price effect, e_1, and a real income effect, $(m_2 - 1)$ The import tariff imposed by country 2 raises the relative price of good *i* to its consumers through the price effect However, this lowers their real income, thus, the income effect offsets part of the increase in the relative price of good *i* This is reinforced as part of the tariff revenue collected on imports of good *i* is spent by consumers on good *j*, $(m_2 - 1)$ The normal result is for $e_1 + m_2 > 1$ and for the numerator thereby to be positive A tariff on good *i* then protects its producers, $d(P_i/P_j)/dT_i > 0$

Metzler's contribution was to demonstrate that this result need not necessarily hold Suppose demand for good *i* in country 1 is extremely inelastic, that is, e_1 is very small Then the tariff on good *i* could *lower* its relative price, in effect failing to protect producers For this to occur, for the numerator of (21) to be negative, the marginal propensity to spend income on its import good, m_2, must be low Since $m_1 + m_2 = 1$, the marginal propensity to spend income on its export good *j*, $(m_2 - 1)$, must be relatively high Under these conditions, if $e_1 < m_2 - 1$, the shift in demand in favor of *j* is strong enough to swamp the price effects of the tariff, and the relative price of *i* in the tariff-imposing country declines Thus, predicting even the direction of the price effects of a tariff is an empirical issue Unless we can estimate the magnitude of the elasticity of demand for imports by country 1 and the marginal propensity to spend income on the import good, the impact of a tariff on good *i* cannot be determined *a priori*

To apply the two-sector, general equilibrium model, one must be able to aggregate all goods into two product groups, for example, agricultural products versus all other goods, and all countries into two regional aggregates, for example, the United States versus the Rest-of-the World One should also recognize that the model assumes full employment of both factors of production Difficulties in product aggregation and the full-employment assumption tend to make this model intractable for empirical work, although it remains a useful theoretical tool Moreover, the analyst often wants more specific product disaggregation than the set of all agricultural products Therefore, to analyze trade issues with interrelated products, the analyst must employ a two-or-more-commodity, partial equilibrium model

TWO-PRODUCT, PARTIAL EQUILIBRIUM MODEL

In this section, we show that the general equilibrium income effect is not the only influence that can produce an indeterminate solution One can also occur when the partial equilibrium model is expanded to include more than one product, because of the cross-price effects which are introduced (*2, 9*)

Assume for simplicity two countries trade two commodities which are imperfect substitutes for one another and whose prices and quantities are not determined simultaneously with those of other goods in the economy

Let the model be

Country 1

$$D_{1i} = f(P_{1i}, P_{1j}), \qquad (22)$$

$$S_{1i} = g(P_{1i}, P_{1j}), \qquad (23)$$

$$X_{1i} = S_{1i} - D_{1i}, \qquad (24)$$

$$D_{1j} = a(P_{1j}, P_{1i}), \qquad (25)$$

$$S_{1j} = b(P_{1j}, P_{1i}), \qquad (26)$$

$$X_{1j} = S_{1j} - D_{1j}, \qquad (27)$$

Country 2

$$D_{2i} = h(P_{2i}, P_{2j}), \qquad (28)$$

$$S_{2i} = k(P_{2i}, P_{2j}), \qquad (29)$$

$$M_{2i} = D_{2i} - S_{2i}, \qquad (30)$$

$$D_{2j} = c(P_{2j}, P_{2i}), \qquad (31)$$

$$S_{2j} = w(P_{2j}, P_{2i}), \qquad (32)$$

$$M_{2j} = D_{2j} - S_{2j}, \qquad (33)$$

International Linkages

$$X_{1i} = M_{2i}, \qquad (34)$$

$$X_{1j} = M_{2j}, \qquad (35)$$

to analyze trade issues with interrelated products, the analyst must employ a two-or-more-commodity, partial equilibrium model

$$P_{2i} = P_{1i}(1 + T_i), \qquad (36)$$

$$P_{2j} = P_{1j}(1 + T_j) \qquad (37)$$

Assume country 2 levies an *ad valorem* import tariff on good i, but does not change its policy on good j Totally differentiating the system of equations and reducing the number of equations by substitutions produces the differentials of the excess demand and excess supply schedules

$$dX_{1i} = (g_i - f_i)dP_{1i} + (g_{ij} - f_{ij})dP_{1j}, \qquad (38)$$

$$dX_{1j} = (b_j - a_j)dP_{1j} + (b_{ji} - a_{ji})dP_{1i}, \qquad (39)$$

$$dM_{2i} = (h_i - k_i)dP_{2i} + (h_{ij} - k_{ij})dP_{2j}, \qquad (40)$$

$$dM_{2j} = (c_j - w_j)dP_{2j} + (c_{ji} - w_{ji})dP_{2i} \qquad (41)$$

Using the international quantity linkages to equate (38) to (40), and (39) to (41) yields

$$(g_i - f_i)dP_{1i} + (g_{ij} - f_{ij})dP_{1j} = (h_i - k_i)dP_{2i} + (h_{ij} - k_{ij})dP_{2j}, \qquad (42)$$

$$(b_j - a_j)dP_{1j} + (b_{ji} - a_{ji})dP_{1i} = (c_j - w_j)dP_{2j} + (c_{ji} - w_{ji})dP_{2i} \qquad (43)$$

Substituting the international price linkages for dP_{2i} and dP_{2j}, rearranging, and simplifying yields two equations

$$AdP_{1i} + BdP_{1j} = CdT_i + DdT_j, \qquad (44)$$

$$EdP_{1i} + FdP_{1j} = GdT_i + HdT_j, \qquad (45)$$

where

$$\begin{aligned}
A &= (g_i - f_i) - (h_i - k_i)(1 + T_i),\\
B &= (g_{ij} - f_{ij}) - (h_{ij} - k_{ij})(1 + T_j),\\
C &= (h_i - k_i)P_{1i},\\
D &= (h_{ij} - k_{ij})P_{1j},\\
E &= (b_{ji} - a_{ji}) - (c_{ji} - w_{ji})(1 + T_i),\\
F &= (b_j - a_j) - (c_j - w_j)(1 + T_j),\\
G &= (c_{ji} - w_{ji})P_{1i},\\
H &= (c_j - w_j)P_{1j}
\end{aligned}$$

The supply and demand schedules are assumed to be well behaved, such that, for the demand schedules, the own-price partial derivatives are negative, $f_i, h_i, a_j, c_j < 0$, while for the supply functions the direct partials are positive, that is, $g_i, k_i, b_j, w_j > 0$ Commodity j is assumed to be an imperfect substitute for good i in both demand and supply If the share of expenditure on both goods is low, the income effect will not outweigh the substitution effect in the Slutsky condition, and the cross price effects in demand are positive that is, $f_{ij}, h_{ij}, a_{ji}, c_{ji} > 0$ The two products are assumed to compete for the same inputs so that, in the supply functions, a negative relationship between the changes in quantity of one good supplied and the price of a substitute good is expected, that is, $g_{ij}, k_{ij}, b_{ji}, w_{ji} < 0$ Given these expected signs on the partial derivatives, the signs of A to H can be determined

$$\begin{array}{ll}
A > 0 & E < 0\\
B < 0 & F > 0\\
C < 0 & G > 0\\
D > 0 & H < 0
\end{array}$$

The system of two equations, (44) and (45), has two unknowns, dP_{1i} and dP_{1j}, and the equations can be solved using Cramer's Rule Recall that it is assumed that $dT_j = 0$, hence,

$$\frac{dP_{1i}}{dT_i} = \frac{CF - GB}{AF - EB}, \qquad (46)$$

$$\frac{dP_{1j}}{dT_i} = \frac{AG - CE}{AF - EB} \qquad (47)$$

The changes in prices resulting from the increase in the tariff on good i can be evaluated based on the signs of A to H assigned above In (46) the signs of both numerator and denominator are indeterminate The denominator, AF − EB, is the difference between two positive values, AF and EB AF is composed of all the own-partial derivatives, whereas EB is composed solely of cross-price partial derivatives Hence, the sign of the denominator depends on the relative strengths of the own- and cross-price effects' The numerator, CF − GB, is the difference between two negative values, CF and GB, hence, its sign is also indeterminate CF consists of the own-partial derivatives, whereas GB contains cross-partial derivatives Thus, if all the cross-partial derivatives are less than the own-partial derivatives, the denominator will be positive and the numerator will be negative Hence, the tariff would lower the exporter's price This is the normally expected result

However, closer inspection of the terms shows that it is theoretically possible for the exporter's price of the good on which the tariff is imposed to rise In the numerator, $(g_i - f_i)$ and $(b_{ji} - a_{ji})$ are omitted, while they appear in the denominator Consequently, if the own-price effects for good i in country 1 are low while the cross-price effects in country 1's market for good j are strong, both numerator and denominator could be negative and a perverse (positive) result could occur

Similarly, in (47) the signs of both numerator and denominator are indeterminate The denominator is the same as in (46) as has been shown The numerator, AG − CE, is the difference between two positive numbers, AG and CE Therefore, the sign of the numerator of (47) is also ambiguous Examining the numerator shows that AG and CE both include own-partial and cross-partial derivatives Consequently, no *a priori* basis exists for determining the impact of a tariff levied against i on the price of good j in country 1

Returning to equations (42) and (43), and substituting the international price linkages for dP_{1i} and dP_{1j}, the change in country 2's prices resulting from an increase in the import tariff can be determined

$$A'dP_{2i} + B'dP_{2j} = C'dT_i + D'dT_j, \quad (48)$$

$$E'dP_{2i} + F'dP_{2j} = G'dT_i + H'dT_j, \quad (49)$$

where

$$A' = \frac{(g_i - f_i) - (h_i - k_i)}{(1 + T_i)} > 0,$$

$$B' = \frac{(g_{ij} - f_{ij}) - (h_{ij} - k_{ij})}{(1 + T_j)} < 0,$$

$$C' = \frac{(g_i - f_i)P_{1i}}{(1 + T_i)} > 0,$$

$$D' = \frac{(g_{ij} - f_{ij})P_{1j}}{(1 + T_j)} < 0,$$

$$E' = \frac{(b_{ji} - a_{ji}) - (c_{ji} - w_{ji})}{(1 + T_i)} < 0,$$

$$F' = \frac{(b_j - a_j) - (c_j - w_j)}{(1 + T_j)} > 0,$$

$$G' = \frac{(b_{ji} - a_{ji})P_{1i}}{(1 + T_i)} < 0,$$

$$H' = \frac{(b_j - a_j)P_{1j}}{(1 + T_j)} > 0$$

Still assuming $dT_j = 0$, and solving by Cramer's Rule produces

$$\frac{dP_{2i}}{dT_i} = \frac{C'F' - G'B'}{A'F' - B'E'}, \quad (50)$$

$$\frac{dP_{2j}}{dT_i} = \frac{A'G' - C'E'}{A'F' - B'E'} \quad (51)$$

In equations (50) and (51), the signs of both the numerators and denominators are indeterminate The denominators of both (50) and (51) are the positive product composed of cross partial derivatives, $B'E' > 0$, subtracted from the positive product composed of direct partial derivatives, $A'F' > 0$ The result is an indeterminate sign of the denominator for both price changes

The numerator of (50) is the difference between two positive terms, $C'F'$ and $G'B'$ Hence, its sign is indeterminate The numerator includes neither the direct partial derivatives from country 2's market for i, $(h_i - k_i)$, nor the cross partials from country 2's market for j, $(c_{ji} - w_{ji})$ The expected result based on the single-product partial equilibrium model is that the price of good i in country 2 will rise as a result of its imposing an import tariff on i If, however, the own-price effects in country 2's market for i are low and the cross-price effects for good i are large, the denominator may be negative, while the numerator remains positive In this case the tariff could lower the price of good j are large, tariff imposing country, and thereby produce a paradoxical result similar to Metzler's, but with no income effect

In equation (51), the numerator is the difference between two negative terms $A'G'$ and $C'E'$ are composed of own- and cross-partial derivatives and their signs also cannot be determined *a priori*

When the model is expanded beyond two commodities, this indeterminate solution occurs under increasingly less severe conditions

Despite the absence of the general equilibrium income effects necessary for the Metzler paradox, the indeterminate result can be obtained in the two-product, partial equilibrium model When the model is expanded beyond two commodities, this indeterminate solution occurs under increasingly less severe conditions

AN EMPIRICAL COMPARISON OF THE ONE- AND TWO-PRODUCT, PARTIAL EQUILIBRIUM MODELS

Based on the theoretical development of the single-product, partial equilibrium model and the two-product, partial equilibrium model, two potential sources of error may enter into the analysis First, if we assume the markets are interrelated, using the single-product model will bias the predicted magnitude of impacts from the import tariff and may result in erroneous predictions of the direction of price changes Second, the empirical estimates of the elasticities used in the analysis are of critical importance If the quality of the estimates is in doubt, the researcher should evaluate carefully the effects of errors through sensitivity analysis of the relative size of the elasticities

In this section, we make two comparisons We compare the price impacts of a tariff on one good using the one and two-product, partial equilibrium models to illustrate the conclusions reached above Because a wide range of elasticity estimates exists in the literature, particularly for cross price effects, these calculations are made using two different elasticity sets

For this illustration, we use the world wheat and coarse grains markets Assume the world market for grain is divided into two regions, the United States and the Rest-of-the-World (ROW), where the United States exports both wheat and coarse grains to the Rest-of-the-World Suppose a policymaker wants to know the impact of a 20-percent increase in an *ad valorem* wheat import tariff levied by the Rest-of-the-World [3]

One set of regional longrun demand and supply elasticities for grains is presented in (*10*) Weighting the regional elasticities based on 1975 to 1979 average regional shares of world wheat and coarse grains supply and disappearance (table 1), we derive the internal demand and supply elasticities for the Rest-of-the-World (table 2), which provide the partial derivatives shown in table 4 as estimate 1

A second set of elasticity estimates is available from econometric estimation done by the U S Department of Agriculture on the Cross Commodity Model [4] While (*10*) shows the cross-price elasticities considerably smaller than the own-price elasticities, these results show much larger cross-price effects relative to the own-price effects For example, the Cross Commodity Model reports an own-price elasticity of export demand for U S wheat of -0 481, however, the cross elasticity for the price of feed grains is 0 854 Several other examples of large cross-price elasticities and low own-price elasticities can also be found in that model This suggests that the choice of elasticities can yield considerably different conclusions regarding the impact of a tariff

This problem emphasizes the need for sensitivity analysis To illustrate, we present a second set of elasticities for the Rest of the-World in table 3 which have relatively higher cross-price elasticities as implied by the Cross Commodity Model [5] The own price elasticities for wheat in the Rest-of-the World are more inelastic The demand elasticity is changed from –0 25 to –0 2, while the supply elasticity is lowered from 0 25 to 0 1 The cross-price elasticities for wheat relative to the coarse grains price are raised to levels exceeding the own-price elasticities to be consis

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[3] Tariffs are not the main protectionist device in the world wheat market, most importers rely instead on nontariff barriers The 20-percent import tariff used in this analysis can be interpreted as the tariff equivalent of a nontariff barrier for purposes of illustration The "Rest of the-World" is an aggregate region consisting of importers and non-U S exporters with existing trade barriers

[4] Copies of the current status of the model can be obtained from the National Economics Division, ESS

[5] The elasticities shown in table 3 are not those in the Cross Commodity Model, but are hypothetical elasticities calculated by the authors to illustrate the implications of relatively higher cross elasticities as implied by the estimates in the Cross Commodity Model

Table 1—World wheat and coarse grains supply and utilization balances, 1975/79 average

Item	Wheat	Coarse grains
	Million metric tons	
United States		
Beginning stocks	23 05	26 02
Production	55 12	200 20
Supply	78 17	226 22
Exports	30 42	51 52
Use	21 60	138 60
Ending stocks	26 40	33 68
Demand	48 00	172 28
Rest-of-the-World		
Beginning stocks	52 70	43 18
Production	341 62	500 80
Supply	394 32	543 98
Imports	30 42	51 52
Use	364 82	552 65
Ending Stocks	59 68	45 30
Demand	424 50	597 95
	Real dollars	
Price per ton	103 94	81 12

Source (*13*)

Table 2—Internal longrun demand and supply price elasticities for wheat and coarse grains

Region and commodity	Demand price		Supply price	
	Wheat	Coarse grains	Wheat	Coarse grains
	Elasticity			
United States				
Wheat	-0 20	0 10	0 20	-0 15
Coarse grains	10	- 40	- 05	30
Rest of-the-World				
Wheat	- 25	10	25	- 06
Coarse grains	10	- 35	- 05	31

Source Based on (*10*)

tent with the relationships of the econometric estimates, both cross elasticities are set at 0 3 in absolute value In the coarse grains market in the Rest of-the-World, the cross-price elasticities are raised to levels slightly below the own-price elasticities both 0 3 in absolute value None of these changes in elasticities exceeds the magnitude of changes that a researcher may experience during econometric estimation, and none of their values lies outside the range one might expect *a priori* The associated partial derivatives are presented in table 4 as estimate 2

The change in prices resulting from a change in the import tariff in the single-product, partial equilibrium model are shown by equations (19) and (20) for the exporting and importing countries, respectively In the two-product, partial equilibrium model, changes in the prices of the two commodities in the exporting country are derived from equations (46) and (47) In the importing country, the price changes resulting from the tariff change are shown in equations (50) and (51) The two sets of partial derivative estimates contained in table 4 (estimates 1 and 2, respectively), are substituted into (19), (20), (46), (47), (50), and (51) to calculate the price changes resulting from a 20-percent increase in the Rest-of-the-World wheat tariff Table 5 contains the price changes under the two sets of elasticities

Under the first set of elasticities, in which the cross-price elasticities for both coarse grains and wheat are considerably smaller than the own-price elasticities, the price

Table 3—Alternative set of price elasticities for wheat and coarse grains[1]

Region and product	Demand price		Supply price	
	Wheat	Coarse grains	Wheat	Coarse grains
	Elasticities			
United States				
Wheat	−0 2	0 10	0 20	−0 15
Coarse grains	1	− 40	− 05	30
Rest-of-the-World				
Wheat	− 2	30	10	−.30
Coarse grains	3	− 35	− 30	31

[1] These elasticities are not the set used in the Cross Commodity Model of the National Economics Division, ESCS, but rather are hypothetical elasticities calculated by the authors to illustrate the implications of relatively higher cross elasticities which are implied by estimates in that model

Table 4—Partial derivatives calculated from price elasticities[1]

Item	Wheat market			Coarse grains market		
	Variable	Estimate 1	Estimate 2	Variable	Estimate 1	Estimate 2
			Derivatives			
United States						
Demand	f_i	−0 0924	−0 0924	a_j	−0 8495	−0 8495
	f_{ij}	0592	0592	a_{ji}	1657	1657
Supply	g_i	1504	1504	b_j	8366	8366
	g_{ij}	− 1445	− 1445	b_{ji}	− 1088	− 1088
Rest-of-the-World						
Demand	h_i	−1 021	− 8168	c_j	−2 5799	−2 5800
	h_{ij}	5233	1 5700	c_{ji}	5733	1 7260
Supply	k_i	9484	3794	w_j	2 0788	2 0788
	k_{ij}	− 2917	−1 4580	w_{ji}	− 2617	−1 5700

[1] Based on tables 1, 2, and 3

Table 5—Price impacts of a 20-percent import tariff on wheat in one- and two-product, partial equilibrium models, alternative elasticity assumptions

Product/region	First set of elasticities		Second set of elasticities	
	One-product model	Two-product model	One-product model	Two-product model
	Dollars/metric ton			
Wheat				
United States	−18 51	−18 75	−17 28	−26 41
Rest-of-the-World	+2 38	+2 03	+3 51	−5 64
Coarse grains				
United States	—	− 54	—	−4 07
Rest of-the-World	—	− 54	—	−4 07

— = not applicable

impacts of the wheat tariff in the one-product and two-product models are nearly identical In the single-product model, the tariff on wheat lowers the U S wheat price by $18 51 per ton When the coarse grains market is added to the model, the import tariff lowers U S prices by $18 75 per ton, or $0 24 per ton more than in the single-product model Similarly, in the Rest-of-the-World, the tariff raises the wheat price by $2 38 per ton if the single-product model is used, and by $2 03 per ton with the two-product model The small magnitudes of the cross elasticities result in only a decline of $0 54 per ton in coarse grain prices because of the wheat tariff

Little difference exists in the predictions of the one- and two-product models These results may appear to suggest that little reason exists not to conduct tariff analysis one product at a time However, these results depend on the relatively low cross-price effects in the first set of elasticities

The second set of elasticities used for illustration exhibits a pattern of much larger cross-price effects and somewhat smaller own price elasticities Repeating the calculations of the effect of a tariff on wheat under the two models with this second set of elasticities results in considerably different predicted impacts on wheat and coarse grain prices In this case the single product model predicts a decline in the U S wheat price of $17 28 per ton resulting from the 20-percent wheat tariff When the analysis is performed with the two product model, the predicted price decline is $26 41 per ton, or $9 13 per ton more than the decline forecast by the single-product model Because of the relatively large cross-price effects, if the researcher relied on the single-product model in this case, the forecast decline in the price of wheat in the United States would be underestimated by 9 percent

The effect of the tariff on prices in the Rest of-the-World (table 5) shows an even more serious difficulty The single-product model predicts that wheat producers in the Rest-of-the World receive protection from the wheat import tariff through a price increase of $3 51 per ton However, the two-product, partial equilibrium model predicts that the wheat price in the Rest-of-the-World *declines* $5 64 per ton Thus, the relatively large cross-price elasticities in the second set of elasticities produces an effect analogous to the Metzler paradox in the general equilibrium model The imposition of the tariff on wheat by the importing country lowers the price of wheat in that country, consequently injuring its producers who had pressed for the tariff protection

The paradoxical result occurs because the own-price effects dominate the cross-price effects in the numerator of equation (50), but the low own-price elasticities for wheat in the Rest-of-the-World and the high cross-price elasticities reverse the sign of the denominator

Had the researcher relied on the single-product model using the second set of elasticities for the analysis, the conclusions on the price impacts of the wheat tariff would have been in error The decline in U S wheat prices would be underestimated by $9 per ton The price of wheat in the Rest-of-the-World would decline by $5 64 per ton, rather than rising by $3 51 per ton This illustrates that when large cross-price effects exist, the analyst must use the two-product

The researcher can use sensitivity analysis to evaluate the effect of differing sets of elasticities on the magnitude and direction of impacts, particularly when the researcher doubts the quality of the empirical estimates

model The difference in results from the two different elasticity sets clearly demonstrates the need for good quality estimates not only of the relevant own-price effects but also of the cross-price effects

CONCLUSIONS

When the traditional single-product partial equilibrium model is expanded to include other products, the estimated signs of the impacts of a policy shift are indeterminate and depend on the relative sizes of the own- and cross-price elasticities In the single-product, partial equilibrium model an import tariff unambiguously lowers prices in the exporting country, while protecting producers in the importing country through higher prices The two-product, general equilibrium model shows that changes in real income in the tariff-imposing country may contradict the determinate results of the single-product, partial equilibrium model Despite the absence of real income effects in the two-product, partial equilibrium model, the indeterminate results of the general equilibrium model may hold because of cross-price effects When these are relatively large, the single-product model's estimates of the magnitudes of impacts from tariff will be inaccurate at best and may err in predicting the direction of the effects

The empirical examples illustrate why these theoretical conclusions are important for policy researchers The net impacts of a policy depend on the relative size of the cross elasticities When the cross elasticities are relatively low, errors associated with using a single-product, partial equilibrium model are small, as in the case of the first set of elasticities If, however, the cross-price effects are large relative to the own-price effects, as in the second scenario, using the single product model will lead to errors of magnitude, and in this example, a further error occurs in predicting the direction of the price changes

Given the importance of the cross-price elasticities to the predictions, the quality of the estimates is critical Yet, cross-price effects are often treated as a secondary concern by researchers Variables known to be relevant are often omitted because they are statistically insignificant or have the "wrong" sign when regressions are run Often researchers do not scrutinize their values for plausibility

Our analysis shows that the researcher involved in policy research must carefully evaluate the relationships among the price elasticities in the model The researcher can use sensitivity analysis to evaluate the effect of differing sets of elasticities on the magnitude and direction of impacts, particularly when the researcher doubts the quality of the empirical estimates

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