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MODELING THE LINKAGE BETWEEN DOMESTIC AND INTERNATIONAL MARKETS

by

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Modeling the Linkage Between Domestic and International Markets*

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Abstract

Since the early 1970s, it has become increasingly apparent that the linkages between domestic and international agricultural markets are extremely significant in determining the behavior of trade volumes and prices. Institutional factors and numerous policy measures influence this linkage in most countries. The basic concept employed in modeling market linkage has been the price transmission elasticity, and the basic tool, the price transmission equation.

This paper reviews the use of the price transmission concept in agricultural trade modeling. Four widely used types of models are discussed: (1) the derived excess demand equation; (2) the directly-estimated excess demand equation; (3) the elasticity of substitution and market share equations; and (4) structural models.

The major conclusion of the paper is that the price transmission elasticity provides a useful, if sometimes incomplete, description of the linkage between domestic and international markets. A number of important considerations affect the estimation and use of the elasticity. Furthermore, there are several cases for which the price transmission elasticity may provide an incomplete description of the degree to which the domestic market is affected by changes in international prices.

Introduction

As the volume of international trade in agricultural commodities has increased, economists and policymakers have become increasingly aware of the importance of the types of linkage which may exist between domestic and international markets. Market linkage affects the response of the volume of trade to changes in economic conditions, the level and stability of export prices and earnings, and the level of activity in the domestic agricultural economy. Particular interest in the nature of

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domestic/international market linkage has been stimulated by the extent of policy intervention in agriculture which conditions economic response. Varying degrees of market insulation affect not only the behavior of domestic agricultural markets, but also influence the behavior of markets internationally.

This paper discusses how domestic and international market linkages are typically incorporated in four widely-used types of commodity trade models:

(1) the derived excess demand equation;

(2) the directly-estimated excess demand equation;

(3) the elasticity of substitution and market share equations; and

(4) structural models.

Linkage Defined

In discussing the linkage question, two variants may be identified (figure 1). The world-domestic linkage determines how changes in the international market (e.g. generated by the effect of an exogenous disturbance) affect the domestic market. This type of relationship has dominated much of the literature, particularly that which has been concerned with the analysis of how domestic prices in a particular country respond to changes in international prices. The domestic-world linkage conditions how changes in the domestic market affect the international market (e.g. through the impact of an exogenous domestic disturbance on a country's volume of trade). This type of linkage has not received as much attention, possibly because there are relatively few countries for which changes in the domestic market might have internationally significant implications. However, the rarity of the large country case does not mean that the combined effect of the domestic-world linkages in a number of small countries is insignificant.

Figure 1. The Two Components of Domestic-International Market Linkage.

	Domestic Market	International Market
World-domestic linkage	← Price effect	Exogenous disturbance
Domestic-world linkage	Exogenous disturbance	Trade volume effect →

Although figure 1 provides a useful simplification, it does not capture the complexity of real world relationships. Particularly for the large country, we cannot break down the two types of market linkage into separate components. The two may be related if not simultaneously, then recursively.

Linkage in the Derived Excess Demand Equation

As mentioned above, a great deal of interest has focused on the world-domestic linkage, for example, through the elasticity of import demand with respect to world prices. Let us consider the simple but widely used derivation of the excess demand elasticity, assuming that imports and the domestically-produced commodity are perfect substitutes.[1]

[1] Note that equation (2) defines the excess function in a single market. Some special issues exist in the use of the excess function facing a single exporter or importer in the rest of the world. Limitations of time and space prevent these issues from being addressed directly. They are discussed briefly in an appendix.

Given $M = D - S$, (1)

where M is imports, D is domestic demand and S denotes domestic supply, then denoting price by P

$$\frac{\partial M}{\partial P} = \frac{\partial D}{\partial P} - \frac{\partial S}{\partial P} ,$$

$$\frac{\partial M}{\partial P} \cdot \frac{P}{M} = \frac{\partial D}{\partial P} \cdot \frac{P}{M} - \frac{\partial S}{\partial P} \cdot \frac{P}{M}$$

$$= \frac{\partial D}{\partial P} \cdot \frac{P}{D} \cdot \frac{D}{M} - \frac{\partial S}{\partial P} \cdot \frac{P}{S} \cdot \frac{S}{M}$$

$$\eta_{MP} = \eta_{DP} \cdot \frac{D}{M} - \eta_{SP} \cdot \frac{S}{M} . \qquad (2)$$

Hence, the elasticity of excess (import) demand with respect to world price is equal to the difference between the elasticity of domestic demand weighted by the ratio of demand to imports, and the elasticity of domestic supply weighted by the ratio of supply to imports. This equation can easily be expanded, for example, to incorporate the response of inventories to changes in world price.

In equation (2) it is assumed that no differentiation is necessary between domestic and world prices, i.e., that the elasticity of price transmission (η_{PP^W}, where P^W denotes world price) is unity. To allow for the possibility that this might not be the case, we can rewrite equation (2) as

$$\eta_{MP} = \eta_{DP} \cdot \eta_{PP^W} \cdot \frac{D}{M} - \eta_{SP} \cdot \eta_{PP^W} \cdot \frac{S}{M} . \qquad (3)$$

Clearly the market linkage reflected in equation (2) is extremely simple. Given the assumption of perfect substitution, the equation merely reflects the dual effect of price adjustments in domestic supply and demand on the quantity traded.

There are several cases in which equation (2) will still hold even if the linkage between world and domestic prices is influenced by institutional or policy factors:

Case 1 - conversion from foreign to domestic currency

Assume that $P = r\,P^W$, $\quad r > 0$,

where r = the number of domestic currency units per unit of foreign currency.

Then $\dfrac{\partial P}{\partial P^W} = r$,

and $\eta_{PP^W} = \dfrac{\partial P}{\partial P^W} \cdot \dfrac{P^W}{P} = \dfrac{rP^W}{rP^W} = 1.$

Case 2 - ad valorem tariff or subsidy, or a percentage marketing margin

In this case $P = (1 + t)P^W$, $\quad -1 < t < +\infty$,

where t = the proportionate tariff/subsidy or marketing margin.

Then $\dfrac{\partial P}{\partial P^W} = 1 + t$,

and $\eta_{PP^W} = \dfrac{(1 + t)\ P^W}{(1 + t)\ P^W} = 1.$

However, there are a number of other cases when the linkage between domestic and international prices will be modified by institutional or policy factors:

Case 3 - A specific tariff or subsidy or a fixed marketing margin

In this case $P = P^W + t$, $\quad -P^W < t < +\infty$,

where t = the specific tariff/subsidy or fixed margin.

Then $\dfrac{\partial P}{\partial P^W} = 1$,

and $\eta_{PP^W} = \dfrac{Pw}{Pw + t}$.

Note that for $t > 0$, $\eta_{PP^W} < 1$;

and for $t < 0$ (the subsidy case), $\eta_{PP^W} > 1$.

Case 4 - A variable levy

In this case $VL = MIP - P^W$,

where VL = variable levy and MIP = minimum import price.

Then $P = P^W + VL = MIP$,

$$\frac{\partial P}{\partial P^W} = 0 \text{ and } \eta_{PP^W} = 0.$$

Case 5 - Import quota

Assuming that the quota ($\bar{q}$) is binding, i.e., $P > P^W$ then $M = \bar{q}$ and $\eta_{PP^W} = 0$.

Case 6 - Deficiency payment

Assuming that P^W is less than the target price (P^T),

then $\eta_{PP^W} = 0$ for the supply side of equation (3),

and $\eta_{PP^W} = 1$ for the demand side of equation (3),

hence $\eta_{MP^W} = \eta_{DP} \cdot \frac{D}{M}$.

Before moving on to the directly-estimated excess demand equation, it is worth noting that the value of the price transmission elasticity has often been inferred by direct estimation rather than being derived analytically. The use of the concept in this way is left for the later discussion of structural models.

The Directly-Estimated Excess Demand Equation

The derived excess demand equation explicitly recognizes the properties of linkage between the domestic and international market, but only as much as it takes into account the relationship between domestic producer/consumer prices and world market prices. By considering such price linkages, explicit recognition may be made of the effects of some types of policies or institutional arrangements upon trade. The same cannot be said of directly-estimated excess demand or supply functions.

Estimates of the excess demand equation have typically been based upon time series data, although a few more recent examples have used pooled cross-section time series to derive the excess equation for a group of similar countries (e.g. Jabara). In time series applications, two alternative models have been used:

<u>(1) the perfect substitutes model</u>

e.g., $M = f(P^W, Y, Z)$, (4)

where Y is income and Z denotes additional exogenous factors, and

<u>(2) the imperfect substitutes model</u>

e.g., $M = g(P^W, P, Y, Z)$. (5)

In the perfect substitutes case, those policies or institutional factors which influence price transmission are assumed to be captured in the estimated coefficient on the price variable, although without an explicit specification of underlying structural assumptions it is not obvious what the coefficient might include. In the imperfect substitutes case, the question of price transmission is complex. This model assumes that two price determination processes occur -- one for the price of the domestic good one for the price of the imported good. Since both these prices are included on the right-hand side of equation (5), the two processes are assumed to be independent.

In the past, considerable attention has been focused on whether imports and <u>world</u> price are simultaneously related (an issue which also affects the validity of equation 4). In the large country case, this assumption is unlikely to hold exactly, although if most of the variation occurs in world excess supply rather than domestic excess demand the degree of bias introduced in estimation may not be severe (Orcutt). The particular problem with the imperfect substitutes case is that it is highly unlikely that the determination of domestic price (P) will be independent of world price (P^W), even if the latter is exogenously determined. In other words, a price transmission relationship between P^W and P is likely to exist but this is not explicitly recognized. If the country is a large country, the situation is even worse because both P^W and P are likely to be strongly simultaneously related.

If we are willing to accept the assumption that imports and domestic production are relatively homogeneous and are able to use the perfect substitutes model, the situation is less complex, but the usefulness of the model is still dependent on what the estimated coefficient on price actually captures. In most cases, the content of the coefficient is not made clear because the structural equations underlying the reduced form are not specified. One of the few exceptions to the rule is the work of Abbott. Specification of the structural form makes it painfully clear what simplifying assumptions are necessary to derive an empirically tractable reduced form. It also highlights the amount of information which is lost through the inability to identify structural parameters from the reduced-form coefficients. However, it at least permits the likely content of the reduced-form coefficients to be identified.

There are some additional advantages of the direct estimation approach which should be noted. First such an approach lends itself to the incorporation of dynamic properties, in particular lagged responses, which affect the relationship between trade volumes and domestic or international variables. Although lagged response is often specified in an ad hoc way, without reference to underlying structural and policy factors that create rigidities, it has frequently been found that a better explanation of response (in a statistical goodness of fit sense) can be achieved by incorporating lags.

Second, the directly-estimated excess demand equation often incorporates both types of market linkages identified earlier, i.e., the world-domestic linkage (through the world price variable) and the domestic-world linkage (through income and other domestic shift factors). For example, in highly insulated markets where government pricing or support policies have a substantial effect, domestic production may appear as a variable in the equation. This not only reflects the fact that production is essentially predetermined in the current period, but that production affects inventory response which in turn affects imports.

Third, the excess function may be used to reflect direct government intervention at the frontier through state trading, import licensing or foreign exchange control. These measures imply that imports are not only a function of traditional economic variables such as prices and incomes but are subject to direct government regulation.

In the past, it has often been considered that the direct estimation of an import equation is merely a somewhat suspect short-cut alternative to the estimation of a complete set of structural equations. However, for developing countries facing foreign exchange constraints, or countries operating with state trading regimes this is unlikely to be the case. In fact, the directly-estimated import equation may have an <u>essential</u> role to play in capturing market linkage in the context of structural models.

Elasticity of Substitution and Market Share Approaches

Before turning to the question of linkage in structural models, some discussion is necessary of various other single equation models which are variants on the imperfect substitution theme. Two widely used variants are the elasticity of substitution model and the market share model.

The elasticity of substitution model is given by

$$\frac{M^i}{M^j} = h\left(\frac{P^i}{P^j}\right), \tag{6}$$

where $M^{i,j}$ denote imports from suppliers i,j, respectively, and $P^{i,j}$ denote the price of imports from suppliers i,j, respectively.

The market share equation is typically expressed as

$$m^i = k\left(m^i_{-n}, \frac{P^i}{P^o}\right), \tag{7}$$

where m^i is the share of the ith importer in total imports and P^o is an index of prices of all other competing suppliers.

I will not attempt to give an extensive critique of these models, since this may be found elsewhere (e.g., Leamer and Stern; Sarris). Both of these approaches, and in fact a number of related ones based upon the Markov model and the multinomial logit models (e.g., Atkin and Blandford; Durham and Lee) provide only limited information about the linkage between domestic and international markets. It is possible to determine the effect of changes in international prices upon imports from particular suppliers. The estimated coefficients may reflect not only the nonhomogeneous nature of alternative sources of supply, but also the pass-through of the prices of imperfect substitutes to the domestic market. However, these equations are even more limited than the imperfect substitutes excess demand equation (5) in that they do not reflect the impact of changes in the domestic market upon suppliers. Insofar as these effects are not neutral with respect to sources of supply, then the equations will provide an imperfect representation of the linkage between domestic and international markets.

Linkage in Structural Models

Spatial and nonspatial equilibrium models are the two most widely used structural modeling approaches in the analysis of international commodity trade. In spatial models, the approach most commonly adopted is to reflect the domestic-world price linkage through the matrix of transfer costs or through restrictions on the responsiveness of supply or demand to changes in world price. This type of approach has been thoroughly described in the agricultural economics literature by Schmitz and Bawden. Given the time constraint, I will direct most of my remarks to nonspatial model linkage.

A typical structure for a nonspatial model is:

Supply	$S = f^S (P_{-n}, Z^S)$	(8)
Demand	$D = f^D (P, Z^D)$	(9)
Inventories	$I = f^I (P, Z^I)$	(10)
Linkage	$P = f^P (P^W)$	(11)
Closing identity	$M = D - S + \Delta I$	(12)

This model determines net trade but unlike the spatial model does not generate an interregional pattern of trade flows.

In this type of model, considerable attention has been directed recently toward the estimation of the domestic-world price linkage equation. The price transmission elasticity, which is derived from this type of equation, may also be used in the calculation of the indirect excess demand elasticity referred to above.

One of the major advantages of the direct estimation of the price transmission elasticity is that it allows us to collapse the effects of a number of policy or institutional factors affecting world-domestic price linkage into a single summary measure. The major disadvantage of this approach is that it is difficult to identify separately the contribution of the various factors which influence price transmission.[2] Furthermore, the estimated elasticity reflects an average of the effects of these factors. It is clearly inappropriate to use this estimate when significant changes in policies affecting price linkage have occurred. For this reason, although the elasticity is frequently estimated using annual data, quarterly or even monthly data may be more appropriate.

There are several additional observations that should be made about the estimation and use of price transmission elasticities:

(1) In general, remarkably few attempts have been made to place prior restrictions on the functional form of the price transmission equation, or indeed to evaluate ex post the reasonableness of the results. Specific considerations need to be given to: (a) the structure of price margins and the way they are determined; (b) the degree of homogeneity between imported and domestic products; (c) the policy instruments used in particular countries and how they might be expected to influence price transmission. Failure to consider these factors may lead to results which are difficult to explain or are even

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2 Following the analytical discussion of the price transmission elasticity earlier in this paper, it is possible in many cases to place prior restrictions on the value of the elasticity or to decompose, at least partially, the separate contribution of policy/institutional factors. This requires a thorough evaluation of the trade and domestic policy environment of individual countries. It is more time consuming but ultimately more useful than simply experimenting with alternative regression equations of domestic on world price.

counter-intuitive. For example, in one study Collins generally found low price transmission elasticities for wheat in member countries of the European Community, a result consistent with theoretical analysis of the effect of a variable levy system. On the other hand, in a more recent study Josling found surprisingly high elasticities. The reason for this paradox is straightforward -- Josling's short sample period was dominated by the early 1970s, during which world wheat prices were increasing. Collins' somewhat longer sample period included both increasing and decreasing world-price periods. Changes in European Community support prices were much more sensitive to upward movements in world prices, hence the difference in the estimated elasticities.

(2) It must be recognized that the price transmission equation is only an approximation, and is likely to be sensitive to a number of factors. Specific characteristics of the estimated elasticity which may be important are: (a) asymmetry -- particularly where administered internal prices respond to world prices; (b) nonconstancy -- even if the elasticity is exogenously determined, it may change with changes in the policy environment; (c) endogeneity -- the elasticity may itself be a function of changes in world prices.

(3) The estimation of the price transmission elasticity alone may not be sufficient to capture fully the linkage between the domestic market and the world market. Three examples may be cited:

(a) Government inventories -- In the case when domestic prices are controlled and the government manages inventories, price-responsive variation in traded volumes may be possible with no variation in domestic price. For example, the government may dispose of surpluses when world prices rise, or make precautionary purchases in order to ensure food security objectives when prices fall. This situation characterizes that for grains in many developing countries.

(b) Production/consumption taxes, subsidies or restrictions may be sensitive to world prices, e.g., in the New Zealand case for input subsidies or in the U.S. case for voluntary acreage restrictions. These may influence trade even if domestic prices do not vary.

(c) State trading -- foreign exchange allocation may influence the volume traded as world prices vary, even with domestic prices constant. One of the few examples where the effect of foreign exchange control upon imports has received substantial coverage is the work of Nabli.

Many of the same issues which affect the modeling of market linkage in the nonspatial price linkage models find a direct parallel in spatial price equilibrium models. In these models also, the representation of linkage as simply the relationship between domestic and world prices may be insufficient to capture the full effect of policy and institutional factors on domestic and international markets. However, due to the simplified domestic market structures that we are usually forced to use in spatial models in order to ensure computational tractability, there is probably less that we can do to remedy the situation.

The question of linkage is also relevant in those structural models which directly incorporate nonhomogeneous commodities (e.g., Armington). Even though a single world price no longer exists in such models, the domestic price of each commodity subgroup will not only be affected by the possibilities of substitution between alternative sources of supply, but also by the factors which influence the linkages between domestic markets and prices at the frontier. The type of model recently developed by Goodman seems to be particularly appropriate for the inclusion of such factors because it specifically incorporates a domestic structural model, in addition to a system of demand equations for the set of competing domestic and imported commodities.

Conclusions

In conclusion, our ability to deal with the complexity of the linkage between domestic and international markets has improved substantially in recent years but there is still a long way to go. Capturing the relationship between domestic and world prices is clearly an important part of the problem, but for many countries this is likely to provide only a partial representation of the influence of institutional and policy factors on domestic-international market linkage.

Some would see the most profitable future avenue for research in this area in the full endogenization of policy choice through the use of policy objective functions (Paarlberg and Abbott; Sarris and Freebairn), or game theory (Karp and McCalla). Others would see it in a more heuristic representation of the way in which policy instrument levels are varied in response to economic or other circumstances (Blandford). In either event, an improved ability to model different types of market insulation is clearly a high priority, particularly if we wish to be able to contribute more effectively to the debate on how such policies might be changed in order to improve the functioning of international markets.

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Appendix: Special Issues in the Derivation of the Excess Trade Function Facing a Single Country

One particular variant of the excess function which has been widely used is the derived elasticity which faces a single large exporter or importer in world markets. This was the original case discussed by Horner and subsequently popularized in the United States by Tweeten. For a large exporter, we may define

$$\eta_{MP}^{i+1} = \sum_i \frac{Di}{M_i^{i+1}} \cdot \eta_{PiP} \cdot \eta_{DPi} - \sum_i \frac{Si}{M_i^{i+1}} \cdot \eta_{PiP}\, \eta_{SPi} \qquad \text{(A1)}$$

where η_{MP}^{i+1} denotes the price elasticity of demand for imports supplied by the i+1th country, i.e., the demand elasticity in the "rest of the world"; M_i^{i+1} denotes imports by the ith country of exports from the i+1th country; η_{PiP} is the price transmission elasticity in the ith country; η_{DPi}, η_{SPi} denote the demand and supply elasticities, respectively, in the ith country; and Di, Si denote demand and supply, respectively, in the ith country.

This function implies that the price elasticity of export demand for a given commodity facing a single exporter depends on the proportion of total demand it supplies in each country (M/D), the volume it supplies relative to competing supplies in each country (M/S), the domestic demand and supply elasticities, and the price transmission elasticities. Note that in the case of the "small exporter" M_i^{i+1} tends toward zero and η_{MP}^{i-1} tends toward infinity, hence the elasticity is only relevant for the large country case.

Transport Costs

It was argued by Horner that this variant of the excess function could incorporate the effect of transport costs. Thus, with respect to demand we may define

$$P_i = P + t_i^{i+1} \tag{A2}$$

where t_i^{i+1} denotes transport costs to the ith demand point from the i+1th country (the exporters' transport costs), and

$$P_i = P + t_i^{i+1} - t_i^{i} \tag{A3}$$

where t_i^{i} denotes the transport cost to the ith demand point from the ith supply point (competing suppliers' transport costs). The excess function in this case becomes

$$\eta_{MP}^{i+1} = \sum_i \frac{D_i}{M_i^{i+1}} \cdot \frac{P}{P+t_i^{i+1}} \cdot \eta_{DPi} - \sum_i \frac{S_i}{M_i^{i+1}} \frac{P}{P+t_i^{i+1}-t_i^{i}} \cdot \eta_{SP}^{i}. \tag{A4}$$

It implies that if competing suppliers' transport costs to the demand points are larger than those of the exporter (i+1) the effective elasticity of supply is larger and the excess demand elasticity facing the exporter is increased.

At first sight, this appears to be an attractive way to incorporate the effect of transport costs and hence locational advantage on excess demand. Unfortunately, the treatment is not straightforward. Whereas there is a vector of transport costs from the i+1th country (i cost values to the i demand points), there is a matrix of such values for competing sources of supply (i x i values, from i supply points to i demand points).[3] As a result, the treatment of transportation costs is difficult unless some cost average relating to competitors is used. This average will itself be variable if the supply elasticities of competitors are not of equal magnitude.

[3] Note that the interpretation of the excess function in this case is simplified if <u>excess</u> elasticities are used on the right-hand side of equation A4.

Nonhomogeneous Products

The excess function assumes that imports and domestic supplies are perfect substitutes for one another. Although this may be a questionable assumption in the specification of the excess demand elasticity for a single country (c.f. the difference between the directly-estimated perfect and imperfect substitutes models), it is more of an issue in the multi-country case.

Cronin has suggested that the problem can be overcome by using the price transmission elasticity to reflect the fact that domestic and imported products are less than perfect substitutes in consumption. In order to adopt this approach, it would be necessary to replace the domestic demand elasticities in A1 by excess demand elasticities in order to prevent the domestic supply of a particular consuming region from being treated as a different (nonperfectly substitutable) product in the same way as the supply from second countries. It would also be necessary to assume that all imports are equally dissimilar from the competing domestic product in each importing region, since a single price transmission elasticity applies to each demand region. Finally, the value of the price transmission elasticity would probably need to be estimated empirically, since its value cannot be derived simply by analytical means.

Taplin has further extended the Cronin approach by attempting to incorporate directly the relevant cross-elasticities of demand into the excess demand equation. This increased the size of the expression substantially and is only made tractable by assuming that the elasticity of supply in competing exporters is zero.