Marketing-Sector Linkages in Agricultural Products Trade

by

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Abstract

Marketing activities are incorporated into a simple model of bilateral trade in agricultural products. The qualitative properties of three alternative equilibria are considered: trade in processed products, trade in primary products, and trade in both primary and processed products. The independent effects of shifts in retail demand, farm-commodity supply and marketing-services supply are considered. Attention is focused on the extent to which adjustments in farm prices are passed on domestically to the retail sector and internationally to the farm and retail sectors of the foreign economy. The domestic-foreign farm-retail price transmission elasticity is proposed for this purpose. Its relationship to movements in the farm-retail price ratio is considered and the quantitative effects of transportation costs are assessed. Extensions are discussed.

Key words: food marketing, agricultural products trade, elasticities of price transmission.

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Marketing-Sector Linkages in Agricultural Products Trade

An importan' factor influencing the volumes and terms of trade in agricultural products is the organization and performance of the international food-and-fiber marketing system. In both developed and developing economies the transportation, processing, and distribution industries play an increasingly important role in transforming temperate- and tropical-zone agricultural commodities into consumable products delivered to terminal markets. The structure, conduct, and performance of the marketing industries are therefore important in influencing patterns of trade in both primary and processed products.

Currently in the US, value-added in marketing accounts for $320billion, or approximately seventy-six percent of the total value of domestic expenditures on food-and-fiber products (US Bureau of the Census). Most farm commodities undergo some form of processing prior to being traded; those that do not are usually subject to processing prior to final consumption. Hence, the "marketing bill" in the traded-goods sector has become an increasingly significant factor in domestic agriculture, so too has trade itself. For example, gross exports of agricultural products currently account for $62billion (US Bureau of the Census), or approximately thirty-nine percent of the total value of all payments to the farm sector. Value-added in marketing represents a large component of these receipts. A complete understanding of trade patterns cannot be gained solely from analyses that focus exclusively on the farm sector. A detailed knowledge of farm-marketing linkages is imperative for understanding changes in both the patterns and terms of trade.

Incorporating Marketing Activities

Despite the fact that the extant literature largely ignores the significance of marketing linkages, there is general agreement about several of its features: Production of farm commodities occurs in an atomistic sector in which individual producers have a negligible influence on the prices they receive. Production levels may be influenced by certain government policies (e.g., price supports and production controls) and by various institutional arrangements designed to effect equity and efficiency in the marketing system. Product purchases are typically made by a significantly smaller number of agents—either public or private—who process and ship the final product either domestically or abroad. Production in marketing is usually more heterogeneous than that in the farm sector. Significant differences exist among firms in terms of their relative sizes, their degrees of vertical and horizontal integration, and the extent to which they trade on international markets. Due to the relative disparities in the numbers of buyers and sellers in the farm-product market, there is a common presumption that agents may exert market power when procuring the raw commodity. This and other aspects of business activity are influenced by a plethora of regulatory instruments (e.g., antitrust law, grading and hygiene requirements) each of which is designed to influence the quality and stability of supplies of the processed product. At the terminal consumption point in the domestic market that component of processed product destined for foreign consumption is subject to an additional array of forces that can influence the level of international shipments and, thus, the price and quantity of the residual component which is consumed domestically. These forces include exogenous features of the trade environment, such as exchange rates; the structure and performance of the domestic market for the product in the importing country; and the responsiveness of foreign agricultural production to various public policies. A comprehensive treatment of these issues in a marketing-system context has not yet been undertaken.

Gardner and the Farm-Retail Price Ratio

The marketing framework proposed for this project is derived from a model proposed originally by Muth. The Muth framework was first applied to the agricultural marketing industries by Gardner in 1975. Since that time the model has provided a popular basis for analyzing various marketing-system issues. These include determining the distribution of the gains from research (Holloway, 1989), assessing the effects of alternative contractual arrangements on allocative efficiency (Kilmer), and analyzing the effects of noncompetitive behavior in the procurement of farm commodities and the sale of processed products (Holloway, 1991; Holloway and Hertel). Part of the usefulness of the model is derived from its ability to isolate and parameterize two important factors that have a significant impact on equilibria in the food system: the structure of technology in marketing and the business conduct of marketing agents. Both of these factors have a significant impact on the pattern of food-and-fiber products trade. However, in what follows, we ignore the potentially important role of conduct in explaining trade movements. As Gardner has done previously, we will assume that pricing in factor and product markets is competitive.

Gardner assessed the qualitative impact on food-marketing equilibrium of three distinct structural changes: shifts in retail-product demand, shifts in farm-commodity supply, and shifts in the supply of marketing services used in processing. He contrasted the separate impacts of these effects on the quotient of retail and farm prices, a measure he termed the "farm-retail price ratio." Fisher, among others, has questioned the significance of this ratio. Gardner's seminal investigation has afforded this measure a good deal of historical significance, but it has some substantial economic significance as well. Under the assumptions invoked by Gardner the measure represents the unit cost of production of the retail product normalized on the price of the farm commodity. Using frequently invoked restrictions on the nature of technology in marketing, this measure is equivalent to the farmer's share of the food dollar—a measure endowed with some political sensitivity because it gives an indication of the extent to which payments to non-farm activities, including possible monopoly profits, account for the costs of food products. The non-farm share of the food dollar enters public policy debates and, to the extent that it may signify monopsonistic procurement by processors, has been used as a basis for government intervention in some farm-commodity markets. More recently, it is shown that the farm-retail price ratio can be related to the degree to which the market for retail-food products is competitive (Holloway, 1991).

Chambers and the Marketing-Trade Interface

Given these antecedents, it is natural that attempts to incorporate marketing activities should focus some attention on the farm-retail price ratio. This strategy was pursued by Chambers in a previous investigation of farm-retail linkages in agricultural products trade. Chambers' work is one of the first to explicitly incorporate marketing activities. In a two-country model that links equilibrium in a single product market and two factor markets, Chambers derived results about the qualitative impact on the ratio of structural shifts in the international marketing system. He rationalized his focus on the farm-retail price ratio through the following observation: "...it is only processors who simultaneously face both retail price and the farm level price...their supply and derived demand functions are homogeneous of degree zero in all prices...unless the price ratios change, the processors will not adjust their output or their derived demand" (p. 39).

In the Gardner-Chambers set-up the price of nonfarm inputs is assumed endogenous and is therefore permitted to vary in response to changes in quantity adjustments in processing. These adjustments are, themselves, endogenous and are therefore partly the consequence of adjustments in the farm-retail price ratio. It is this endogeneity in Chambers' model that renders the results of his comparative-static experiments indeterminate. Another aspect that obfuscates is Chambers' depiction of processor behavior through the dual profit function and the associated system of derived demands and product supply equations. These aspects of the analysis mitigate the extent to which his experiments yield insights into the likely processes of adjustment occurring in bilateral equilibrium. Understanding the qualitative adjustments is important for two reasons: First, it enables us to gain insights into the processes of adjustment that may occur in actual economies and, additionally, indicates the conditions under which these are likely. Second, it contributes in a pedagogic way to the literature in food-and-fiber marketing in which international trade plays an increasingly important role.

Overview

In the remainder of this paper I formulate a simple model of bilateral trade in both primary and processed products. The spirit of the exercise is similar to Chambers'. My main objective is to derive results to facilitate learning about the processes of adjustment in trade equilibrium in an agricultural setting. I devote the next section of the paper to the development of the model and, subsequently, comparative-static experiments that predict the directions of change in farm and retail prices and in the volume of trade between the two countries.

I consider separately, three regimes: (a) trade in processed products alone, (b) trade in primary products alone, and (c) trade in both primary and processed products. Chambers focused attention on the third of these cases. Attention to the remaining cases is relevant because examples of such equilibria exist in most economies. Many of the signs of the qualitative results are unambiguous and are predictable, however some are not. In the latter cases, the model yields insights into the conditions under which a particular result is likely.

I argue that transportation cost is a significant factor that is often neglected in agricultural trade models. I show how these costs are useful in explaining the pattern of trade and I consider the implications of neglecting them in quantitative analyses of price transmission elasticities. I conclude by discussing possible extensions of the model.

Bilateral Trade Equilibrium

In general, the framework I propose is a modified version of the bilateral trade model considered by Chambers. To keep account of the explicit differences between the two models I discuss each of ten assumptions that play a key role in the comparative-static experiments. For later purposes it will be advantageous to formalize these in the following manner. We begin by delimiting the international trade environment for processed products:

ASSUMPTION 1: TRANSPORTATION AND THE RATE OF EXCHANGE *Transportation costs are zero and the current rate of exchange is one.*

ASSUMPTION 2: THE TRADE ENVIRONMENT FOR PROCESSED PRODUCTS *Two countries trade a retail-food product. Trade is free of intervention of any kind.*

I treat each country symmetrically and index them through the respective superscripts i and j. Without loss of generality, let i denote the home country and let j denote the foreign country. We can now depict the price and quantity linkage equations in the international market for processed products. We will use the corresponding linkages in the primary product market to close the model in the latter part of this section.

Let p^k $k \in \{i,j\}$ denote the price of the processed product in country k and let x^k $k \in \{i,j\}$ denote the corresponding quantity in excess supply. International arbitrage with costless transport and a unitary exchange rate imply:

(1) $$p^i = p^j.$$

At positive prices, which we assume to be the case, aggregate excess supply must be zero:

(2) $$x^i + x^j = 0.$$

The signs of the levels of excess supply is determined by domestic supply and demand conditions. Let y^k $k \in \{i,j\}$ denote domestic supply in country k and let z^k $k \in \{i,j\}$ represent domestic demand, such that:

(3) $$y^i = x^i + z^i,$$

(4) $$y^j = x^j + z^j.$$

About the structure of domestic food demand, we make explicit the following:

ASSUMPTION 3: THE STRUCTURE OF FOOD DEMAND *Consumption of retail-food products is separable from consumption of all other goods. The traded good and the home good are perfect substitutes.*

The separability assumption is implicit in the Muth-Gardner framework. Its main advantage is that it permits us to group the exogenous elements of demand—the prices of non-food items and the level of disposable income—into a single index. The perfect-substitutes assumption is noteworthy because it rules out any form of product differentiation such as that encountered in the popular Armington model.

Under the separability and perfect-substitutes assumption, we can represent domestic food demand in the home and foreign countries, respectively, as follows:

(5) $z^i = D^i(p^i \mid \delta^i)$,

(6) $z^j = D^j(p^j \mid \delta^j)$,

where δ^k $k \in \{i,j\}$ represent the shift variables and the functions $D^k(\ )$ $k \in \{i,j\}$ are assumed to be decreasing with respect to the price of food. Various interpretations of the shift variables are possible. For example, suppose the commodity in question were consumed by groups of agents with Cobb-Douglas preferences. In this case the shift variables represent disposable income. It follows from the homogeneity restrictions on prices that the demand functions assume the specific forms $D^k(\cdot) \equiv D^k((p^k/\delta^k))$ $k \in \{i,j\}$. Hence, these functions are increasing with respect to income. If one relaxes the assumption of representative agents, more general interpretations of the shift variables are possible. In what follows, we simply assume that quantities demanded are positively related to the values of the shift variables

Next, we depart from Chambers' dual representation of production in the processing sector. Reverting to the cost function, we consider production and pricing behavior in the processing sectors as follows:

ASSUMPTION 4: TECHNOLOGY IN FOOD MARKETING *In each country processed product is supplied by industries comprised of an unspecified number of identical firms. Firms produce by combining quantities of a farm commodity u^k $k \in \{i,j\}$, available at prices w^k $k \in \{i,j\}$, with quantities of a non farm input v^k $k \in \{i,j\}$, available at prices r^k $k \in \{i,j\}$. Substitution possibilities in marketing exist. The production technology exhibits constant returns to scale. Entry is free and exit is costless.*

The significance of these assumptions are twofold: First, they presuppose existence of an aggregate technology in each country $F^k(\cdot)$ $k \in \{i,j\}$ and the associated aggregate cost functions $C^k(w^k,r^k,y^k) \equiv \min(u^k,v^k)\ \{w^k u^k + r^k v^k \mid F^k(\cdot) \geq y^k\}$ $\equiv C^k(w^k,r^k)y^k$ $k \in \{i,j\}$. Second, they predispose us to the following assumption, which is central in prior investigations of marketing-group behavior:

ASSUMPTION 5: FOOD MARKETING CONDUCT *Marketing firms in both countries behave competitively in their product markets, setting price equal to marginal cost.*

This assumption plays a crucial role in the ensuing comparative statics. The assumption implies that the product price be equated to the country-specific unit costs as follows:

(7) $p^i = C^i(w^i, r^i)$,

(8) $p^j = C^j(w^j, r^j)$.

Turning to the factor markets, consider first the market for the nonfarm input:

ASSUMPTION 6: NONFARM INPUT AVAILABILITY *Quantities of the nonfarm input are available in perfectly elastic supply to the processing industry.*

It is at this point that we depart substantially from Chambers' framework. In his model the supply of nonfarm inputs to processing occurs inelastically, with increases in supply brought forth only through concomitant increases in price. At that level of generality, the results of all qualitative investigations appear to be ambiguous. This finding is overturned when we assume that nonfarm inputs are available in perfectly elastic supply. This modification should not trouble us to a great extent, especially when considering a narrowly defined commodity. In this case, one suspects that the available supply of nonfarm inputs to processing (e.g., labor, capital, energy, materials) may indeed be highly elastic. In any case, the assumption is usually invoked in empirical work (Wohlgenant). When the industry faces a given price for the nonfarm input, it follows that procurement in this market is competitive. This enables us to depict demands by invoking Shephard's lemma:

(9) $v^i = \partial C^i(w^i, r^i) y^i / \partial r^i$,

(10) $v^j = \partial C^j(w^j, r^j) y^j / \partial r^j$.

Concurrently, we may depict supplies of marketing services, acknowledging that prices are exogenous, as follows:

(11) $r^i = \rho^i$,

(12) $r^j = \rho^j$,

Turning to the farm-commodity market, we assume the following:

ASSUMPTION 7: PROCUREMENT *The farm-commodity input is purchased competitively.*

ASSUMPTION 8: AVAILABILITY *The input is available to the domestic processing industry in less than perfectly elastic supply.*

ASSUMPTION 9: INTERVENTION *Government intervention in the domestic farm economy is absent.*

The assumption of competitive pricing in the farm-commodity market is somewhat less acceptable than it is with respect to food markets. Indeed, a growing literature (Mueller and Marion, Connor *et al.*) suggests a heightened awareness that food manufacturers realize and exert considerable market power with respect to the farm sector. The actual effect of departures from competition—and, consequently, the severity of ignoring it—is complicated by a number of market-structure issues, including the responsiveness of commodity supplies to changes in price and the extent of government intervention. The assumption that farm-commodity supplies are exogenous has been tested empirically using annual data on a number of commodities (Wohlgenant, Thurman). The results are mixed. At the other extreme are a group of studies cited by Castle, which suggest that the cost structure of farming exhibits non-decreasing returns, with consequent ramifications for the shape of the aggregate supply curve. Each of these issues have important implications for the qualitative properties of the equilibria we will consider. Initially, however, we will not depart from the standard model. Consequently, we define demands for the farm commodity through Shephard's lemma

(9) $u^i = \partial C^i(w^i,r^i)y^i / \partial w^i,$

(10) $u^j = \partial C^j(w^j,r^j)y^j / \partial w^j,$

and depict supply behavior as follows:

(11) $s^i = S^i(w^i \mid \alpha^i),$

(12) $s^j = S^j(w^j \mid \alpha^j),$

where s^k $k \in \{i,j\}$ denote quantities supplied, α^k $k \in \{i,j\}$ denote shift variables, and $S^k(\cdot)$ $k \in \{i,j\}$ denote supply functions, which we assume to be increasing with respect to the price of the corresponding commodity. Once again, a variety of interpretations of the shift variables are possible. One is that they represent the price of a variable input in production of the farm commodity (e.g., fertilizer in the case of a plant commodity, feed in the case of an animal commodity). In these cases the zero-degree homogeneity of the supply schedules dictates that the supply functions must then assume the specific forms $S^k(\cdot) \equiv S^k((w^k/\alpha^k))$ $k \in \{i,j\}$. Consequently, supply is a decreasing function of the shift variables. Other interpretations are possible. For example, the shift variable may refer to the capital stock (e.g., land or the current level of the breeding stock). In this case, we would assume supplies to be increasing functions of the shift variables. We assume this to be the case in the comparative-static experiments that follow.

Turning to trade in the primary product, a specification is required of the quantity in excess in the farm-commodity market. Unlike the retail-product market in which excess supplies were used, it is convenient to depict the former in terms of excess demand. Hence, define:

(17) $u^i = m^i + s^i,$

(18) $u^j = m^j + s^j,$

where m^k $k \in \{i,j\}$ represents the volume of trade between the two countries. It is positive if the commodity is imported and negative if it is exported. In line with our symmetric treatment of the two countries we leave unspecified the direction of shipment. Thus:

(19) $$m^i + m^j = 0,$$

represents the quantity-clearing condition in the international market. Finally, the model is closed by specifying the price linkage equation for the farm commodity:

(20) $$w^i = w^j,$$

which follows from our final assumption:

ASSUMPTION 10: THE TRADE ENVIRONMENT FOR PRIMARY PRODUCTS *Trade in the farm commodity is free of intervention of any kind. Transportation costs are zero and prices are equalized at the current rate of exchange.*

Displacements From Equilibrium

The above equations define equilibrium values for twenty endogenous variables: $(p^k, x^k, y^k, z^k, v^k, r^k, u^k, s^k, m^k, w^k)$ $k \in \{i,j\}$. Table 1 summarizes the model.

Table 1. Bilateral Trade Equilibrium In Food-Marketing

Commodity	Home	Trade	Foreign
Food Product			
-price linkage:		$p^i = p^j$	
-commodity clearing:		$x^i + x^j = 0$	
-excess supply:	$y^i = x^i + z^i$		$y^j = x^j + z^j$
-demand:	$z^i = D^i(p^i \mid \delta^i)$		$z^j = D^j(p^j \mid \delta^j)$
-supply:	$p^i = C^i(w^i,r^i)$		$p^j = C^j(w^j,r^j)$
Marketing Input			
-derived demand:	$v^i = \partial C^i(w^i,r^i)y^i / \partial r^i$		$v^j = \partial C^j(w^j,r^j)y^j / \partial r^j$
-supply:	$r^i = \rho^i$		$r^j = \rho^j$
Farm Input			
-derived demand:	$u^i = \partial C^i(w^i,r^i)y^i / \partial w^i$		$u^j = \partial C^j(w^j,r^j)y^j / \partial w^j$
-supply:	$s^i = S^i(w^i \mid \alpha^i)$		$s^j = S^j(w^j \mid \alpha^j)$
-excess demand:	$u^i = m^i + s^i$		$u^j = m^j + s^j$
-commodity clearing:		$m^i + m^j = 0$	
-price linkage:		$w^i = w^j$	

Initial interest lies in signing the qualitative impact of changes in the set of exogenous variables $(\delta^k, \rho^k, \upsilon^k)$ $k \epsilon \{i,j\}$ on each of the endogenous variables. The approach pursued here is to express each variable in these two groups in proportional-change terms (i.e., $\tilde{a} \equiv \Delta a/a$) and solve the resulting linear equation system for each exogenous change. This procedure, is convenient for several reasons. First, it enables the comparative-static effects to be expressed in elasticity terms, with consequent advantages for interpreting the results. Second, the measures are unitless, so that it matters not from where they are evaluated in the initial equilibrium, providing one exists. Third, particular effects can be expressed in share terms (e.g., cost shares and trade shares). By selecting the endpoints of these shares the model is able to parameterize various equilibria and contrast results across alternative trade regimes. As we shall soon see, these share terms play a crucial role in the analytics that follow. Table 2 presents the model in displacement terms.

Table 2. Displacements From Equilibrium

Commodity	Home	Trade	Foreign
Food Product			
-price linkage:		$\tilde{p}^i = \tilde{p} = \tilde{p}^j$	
-commodity clearing:		$\tilde{x}^i = \tilde{x} = \tilde{x}^j$	
-excess supply:	$\tilde{y}^i = \theta^i \tilde{x}^i + (1-\theta^i)\tilde{z}^i$		$\tilde{y}^j = \theta^j \tilde{x}^j + (1-\theta^j)\tilde{z}^j$
-demand:	$\tilde{z}^i = \eta^i \tilde{p}^i + \mu^i \tilde{\delta}^i$		$\tilde{z}^j = \eta^j \tilde{p}^j + \mu^j \tilde{\delta}^j$
-supply:	$\tilde{p}^i = \omega^i \tilde{w}^i + (1-\omega^i)\tilde{r}^i$		$\tilde{p}^j = \omega^j \tilde{w}^j + (1-\omega^j)\tilde{r}^j$
Marketing Input			
-derived demand:	$\tilde{v}^i = \sigma^i \omega^i (\tilde{w}^i - \tilde{r}^i) + \tilde{y}^i$		$\tilde{v}^j = \sigma^j \omega^j (\tilde{w}^j - \tilde{r}^j) + \tilde{y}^j$
-supply:	$\tilde{r}^i = \tilde{\rho}^i$		$\tilde{r}^j = \tilde{\rho}^j$
Farm Input			
-derived demand:	$\tilde{u}^i = -\sigma^i (1-\omega^i)(\tilde{w}^i - \tilde{r}^i) + \tilde{y}^i$		$\tilde{u}^j = -\sigma^j (1-\omega^j)(\tilde{w}^j - \tilde{r}^j) + \tilde{y}^j$
-supply:	$\tilde{s}^i = \varepsilon^i \tilde{w}^i + \beta^i \tilde{\upsilon}^i$		$\tilde{s}^j = \varepsilon^j \tilde{w}^j + \beta^j \tilde{\upsilon}^j$
-excess demand:	$\tilde{u}^i = \alpha^i \tilde{m}^i + (1-\alpha^i)\tilde{s}^i$		$\tilde{u}^j = \alpha^j \tilde{m}^j + (1-\alpha^j)\tilde{s}^j$
-commodity clearing:		$\tilde{m}^i = \tilde{m} = \tilde{m}^j$	
-price linkage:		$\tilde{w}^i = \tilde{w} = \tilde{w}^j$	

The first group of equations specify the price-linkage and commodity-market clearing conditions when there is international trade in the processed product. The proportional changes in $\tilde{x}^i$ and $\tilde{x}^j$ must be identical—both in sign and magnitude. They reflect changes in the volume of trade. The third line of equations specify quantity adjustments in excess supply as a proportion of total domestic supply in the initial equilibrium. In these expressions the parameters θ^k $k \epsilon \{i,j\}$

represent "share" terms. One of these share terms must be negative. This results from the fact that we treat both countries symmetrically, but one must export and the other must import if trade occurs. Hence, $\theta^k \in [0,1]$ if country k is a net exporter, but $\theta^k \in [-\infty, 0]$ if the country is a net importer. Thus, $\theta^k \in [-\infty, 1]$ and $(1-\theta^k) \in [0, +\infty]$, an observation of some importance in the qualitative results that follow.

The second group of equations refer to adjustments in retail demand. The parameters $\eta^k\ k \in \{i,j\}$ and $\mu^k\ k \in \{i,j\}$ denote elasticities of demand for food with respect to price and the demand shift variable, respectively. We assume that the first effect is negative and that the second effect is positive. Hence: $\eta^k \in [-\infty, 0]$ and $\mu^k \in [0, +\infty)$.

Next are presented the implicit supply relations that result from the dual assumptions of constant returns to scale and competitive pricing in the output market. These indicate that the movement in the product price in either country is a convex combination of the respective movements in the farm and nonfarm-input prices. The parameters $\omega^k\ k \in \{i,j\}$ are defined over the unit interval and represent the cost shares of the farm-commodity input used in production of the retail product. The fact that the combined effects of each of the movements in the input prices must sum to one is a result of the linear homogeneity restriction across the unit cost functions in either processing sector. This restriction merely restates the intuition that exogenous changes that affect all prices equivalently will not alter the mix of inputs or outputs.

Since the cost function is linearly homogeneous, the derived demands for each factor of production are zero-degree homogeneous in factor prices. The fifth line of equations specifies the adjustments that occur in demand for the non-farm input in response to changes in the prices of the two ..tors used in food production. Since the cost function is separable in input prices and the level of output, output adjustments do not affect the optimal mix of factors. This mix may alter whenever an exogenous event causes output or input prices to adjust. The degree to which the mix adjusts is conditioned by the parameters $\sigma^k\ k \in \{i,j\}$ which define elasticities of substitution between the two factors. These parameters are positive valued, and my differ between countries. Whenever the factor-price ratio adjusts, the demand for the nonfarm input will rise in proportion to the value of the relevant share, modified by the value of the substitution parameter. The interesting benchmark case, which is frequently invoked for computational simplicity, is $\sigma^k = 0$. This is the fixed-proportions technology proposed by Leontief. It is commonly used in food-marketing studies (e.g., Moschini and Meilke), even though it may not equate well with the technological possibilities actually available. The issue has become a contentious one (Freebairn *et al.*, Alston and Scobie). Hence, for the moment we leave these parameters unconstrained.

The group of equations that follow, refer to demand and supply conditions in the farm-commodity market. The derived demand for the farm input exhibits a similar structure to that of the nonfarm input: Demand for the input adjusts whenever there are adjustments in the scale of operations or the ratio of factor prices adjusts. For any given change in the relevant factor-price ratio, the change in the quantity demanded in processing is largest, the greater the substitution elasticity and the smaller the cost share. The relationship between the change in output and the derived demand for the factor is unitary, in view of the assumption of constant returns to scale in food production. Hence, when fixed proportions are appropriate, the derived demand for the input moves in exact proportion with the proportional change in supply and occurs independently of any change in the relative factor-price ratio. It may seem somewhat counter-intuitive that the adjustment in the factor is inversely related to the share of payments accruing to that input. If the cost share is large and the elasticity of substitution is non-negligible, declining marginal rates of substitution between the two factors dictate that adjustments along any given isoquant, consequent upon a change in the factor-price ratio, will be large. Below the demand equation, the displaced supply function assumes an upward sloping relationship between quantity and price, $\varepsilon^k \in [0, +\infty)$ $k \in \{i,j\}$. Similarly, we will assume that changes in the supply-shift variable result in expansions in output, $\beta^k \in [0, +\infty)$ $k \in \{i,j\}$.

Finally, the remaining equations at the bottom of table 2 refer to the excess demand and trade equilibrium conditions for the farm commodity. In the third last line of equations, the parameters α^k $k \in \{i,j\}$ are the primary-product analogs of the share terms that appear in the processed-product market. The factor-market parameters define proportions of domestic quantities, but in this case it is the total quantity of the primary product that is demanded domestically. Hence, when the country in question imports the primary product the "share" term α^k is positive; when it exports, α^k will be negative. Below the excess demand equations are the displaced versions of the quantity-clearing condition and the international price-linkage equation. Table 3 summarizes the parameters appearing in table 2.

Table 3. Parameter Definitions, Descriptions, and Domains

Parameter	Description	Domain
$\theta^k \equiv x^k/y^k$	Share of exports in domestic production of the retail product	$(-\infty, +1]$
$\eta^k \equiv (\partial D^k/\partial p^k)(p^k/\partial z^k)$	Elasticity of demand for food	$(-\infty, 0]$
$\omega^k \equiv w^k u^k / C^k(\cdot) y^k$	Cost share of farm inputs in marketing	$(0, +1)$
$\sigma^k \equiv (\partial(u^k/v^k)/\partial(w^k/r^k)) \times ((w^k/r^k)/\partial(u^k/v^k))$	Elasticity of substitution between farm and nonfarm inputs in retail food production	$[0, +\infty)$
$\varepsilon^k \equiv (\partial S^k/\partial w^k)(w^k/\partial s^k)$	Elasticity of supply of the farm commodity	$[0, +\infty)$
$\alpha^k \equiv m^k/u^k$	Share of imports in domestic demand for the farm commodity	$(-\infty, +1]$
$\mu^k \equiv (\partial D^k/\partial \delta^k)(\delta^k/z^k)$	Retail-food demand-shift elasticity	$[0, +\infty)$
$\beta^k \equiv (\partial S^k/\partial \upsilon^k)(\upsilon^k/s^k)$	Farm-commodity supply-shift elasticity	$[0, +\infty)$

Qualitative Results

In this section we discuss the qualitative findings of the three trade regimes: (a) trade in processed products, (b) trade in the primary commodity, and (c) trade in both the processed product and the primary commodity. Focusing attention on the movements in prices and the volumes of trade, table 4 presents quasi-reduced forms corresponding to each regime:

Table 4. Quasi-Reduced Forms Under Alternative Trading Scenarios

Trade In Processed Products

$$\begin{pmatrix} 1 & -\omega^i & & \\ 1 & & -\omega^j & \\ -(1-\theta^i)\eta^i & \varepsilon^i+\sigma^i(1-\omega^i) & & -\theta^i \\ -(1-\theta^j)\eta^j & & \varepsilon^j+\sigma^j(1-\omega^j) & -\theta^j \end{pmatrix} \begin{pmatrix} \tilde{p} \\ \tilde{w}^i \\ \tilde{w}^j \\ \tilde{x} \end{pmatrix} = \begin{pmatrix} & & (1-\omega^i) & & & \\ & & & (1-\omega^j) & & \\ (1-\theta^i)\mu^i & & \sigma^i(1-\omega^i) & & -\beta^i & \\ & (1-\theta^j)\mu^j & & \sigma^j(1-\omega^j) & & -\beta^j \end{pmatrix} \begin{pmatrix} \tilde{\delta}^i \\ \tilde{\delta}^j \\ \tilde{p}^i \\ \tilde{p}^j \\ \tilde{\upsilon}^i \\ \tilde{\upsilon}^j \end{pmatrix}$$

Trade In Primary Products

$$\begin{pmatrix} 1 & & -\omega^i & \\ & 1 & -\omega^j & \\ -\eta^i & & (1-\alpha^i)\varepsilon^i+\sigma^i(1-\omega^i) & \alpha^i \\ & -\eta^j & (1-\alpha^j)\varepsilon^j+\sigma^j(1-\omega^j) & \alpha^j \end{pmatrix} \begin{pmatrix} \tilde{p}^i \\ \tilde{p}^j \\ \tilde{w} \\ \tilde{m} \end{pmatrix} = \begin{pmatrix} & & (1-\omega^i) & & & \\ & & & (1-\omega^j) & & \\ \mu^i & & \sigma^i(1-\omega^i) & & -(1-\alpha^i)\beta^i & \\ & \mu^j & & \sigma^j(1-\omega^j) & & -(1-\alpha^j)\beta^j \end{pmatrix} \begin{pmatrix} \tilde{\delta}^i \\ \tilde{\delta}^j \\ \tilde{p}^i \\ \tilde{p}^j \\ \tilde{\upsilon}^i \\ \tilde{\upsilon}^j \end{pmatrix}$$

Trade In Both Primary And Processed Products

$$\begin{pmatrix} 1 & -\omega^i & & \\ 1 & -\omega^j & & \\ -(1-\theta^i)\eta^i & (1-\alpha^i)\varepsilon^i+\sigma^i(1-\omega^i) & -\theta^i & \alpha^i \\ -(1-\theta^j)\eta^j & (1-\alpha^j)\varepsilon^j+\sigma^j(1-\omega^j) & -\theta^j & \alpha^j \end{pmatrix} \begin{pmatrix} \tilde{p} \\ \tilde{w} \\ \tilde{x} \\ \tilde{m} \end{pmatrix} = \begin{pmatrix} & & (1-\omega^i) & & & \\ & & & (1-\omega^j) & & \\ \mu^i & & \sigma^i(1-\omega^i) & & -(1-\alpha^i)\beta^i & \\ & \mu^j & & \sigma^j(1-\omega^j) & & -(1-\alpha^j)\beta^j \end{pmatrix} \begin{pmatrix} \tilde{\delta}^i \\ \tilde{\delta}^j \\ \tilde{p}^i \\ \tilde{p}^j \\ \tilde{\upsilon}^i \\ \tilde{\upsilon}^j \end{pmatrix}$$

Trade in Processed Products

The comparative-static results from this model are depicted in table 5.

Table 5. Summary of Effects: Trade in Processed Products

<u>Shifts in Food-Product Demand</u>

$$\left.\begin{aligned}
\tilde{p} &= \tilde{\delta}^h \frac{(1-\theta^h)\,\mu^h\,\theta^g\,\omega^h\,\omega^g}{\Delta}\\
\tilde{w}^g &= \tilde{\delta}^h \frac{(1-\theta^h)\,\mu^h\,\theta^g\,\omega^h}{\Delta}\\
\tilde{w}^h &= \tilde{\delta}^h \frac{(1-\theta^h)\,\mu^h\,\theta^g\,\omega^g}{\Delta}\\
\tilde{x} &= \tilde{\delta}^h \frac{(1-\theta^h)\,\mu^h\,\omega^h\left[\varepsilon^g+\sigma^g(1-\omega^g)-(1-\theta^g)\eta^g\omega^g\right]}{\Delta}
\end{aligned}\right\}\ \{g,h\}\in\{i,j\}$$

<u>Shifts in Farm-Commodity Supply</u>

$$\left.\begin{aligned}
\tilde{p} &= \tilde{\upsilon}^g \frac{\beta^g\,\theta^h\,\omega^h\,\omega^g}{\Delta}\\
\tilde{w}^g &= \tilde{\upsilon}^g \frac{\beta^g\,\theta^h\,\omega^h}{\Delta}\\
\tilde{w}^h &= \tilde{\upsilon}^g \frac{\beta^g\,\theta^h\,\omega^g}{\Delta}\\
\tilde{x} &= \tilde{\upsilon}^g \frac{\beta^g\,\omega^g\left[\varepsilon^h+\sigma^h(1-\omega^h)-(1-\theta^h)\eta^h\omega^h\right]}{\Delta}
\end{aligned}\right\}\ \{g,h\}\in\{i,j\}$$

<u>Shifts in Marketing-Services Supply</u>

$$\left.\begin{aligned}
\tilde{p} &= \tilde{\rho}^h \frac{(1-\omega^h)(\varepsilon^h+\sigma^h)\,\theta^g\,\omega^g}{\Delta}\\
\tilde{w}^g &= \tilde{\rho}^h \frac{(1-\omega^h)(\varepsilon^h+\sigma^h)\,\theta^g}{\Delta}\\
\tilde{w}^h &= \tilde{\rho}^h \frac{(1-\omega^h)\left\{\left[\varepsilon^g+\sigma^g(1-\omega^g)-(1-\theta^g)\eta^g\omega^g\right]\theta^h+\theta^g\left[(1-\theta^h)\eta^h+\sigma^h\right]\omega^g\right\}}{\Delta}\\
\tilde{x} &= \tilde{\rho}^h \frac{(1-\omega^h)(\varepsilon^h+\sigma^h)\left[\varepsilon^g+\sigma^g(1-\omega^g)-(1-\theta^g)\eta^g\omega^g\right]}{\Delta}
\end{aligned}\right\}\ \{g,h\}\in\{i,j\}$$

where: $\Delta \equiv \theta^g\omega^g\left[\varepsilon^h+\sigma^h(1-\omega^h)-(1-\theta^h)\eta^h\omega^h\right]-\theta^h\omega^h\left[\varepsilon^g+\sigma^g(1-\omega^g)-(1-\theta^g)\eta^g\omega^g\right].$

Since we treat both countries symmetrically, we can depict the results in terms of the general superscripts $\{g,h\}\in\{i,j\}$. In general, the signs of the effects depend on the origin of the change and whether the country exports or imports the commodity in question. In the discussion that follows, we refer to the country from which the change emanates as the "home" country. Note that the denominator in each of the comparative-static expressions has the same sign as the parameter θ^g. Hence it is positive if country g is an exporter, but negative if country g is an importer. Since the numerator of the first three expressions has the same sign as the denominator, the first three effects are unambiguously positive. Thus, *ceteris paribus*, adjustments that cause demands to shift out ($\tilde{\delta}^h>0$) cause prices to rise, irrespective of whence the adjustment emanates. The fourth effect, on the other hand, is dependent on the origin of change: it is negative if the change originates in the exporting country, but positive if it stems from adjustments in the importing country. These responses are intuitive ones that we would expect to observe in real equilibria. The process of adjustment is as follows: Expansions in demand call forth disequilibria in quantities traded at the original world price. If the change emanates from the exporting region, there is an immediate reduction in the quantity exported. The reduction in exports causes the world price to rise. While exports fall, domestic production in both countries expands in response to the increase in price. Derived demand for both factors of production expand along their respective supply schedules. The price of the farm commodity increases. Accordingly, the unit cost of production is raised until its value is once again equated to the world price of the product. The adjustment pattern is similar if the change emanates from the importing region. However, in this case, imports rise. The expansion in demand is met partly from this source and partly from expansion in domestic supply. The price of the farm commodity and the unit cost of production in processing both rise.

Increases in domestic production of the farm commodity ($\tilde{\upsilon}^g > 0$) provide a nice contrast to the previous patterns: The world price of the processed product, the domestic price of the farm commodity, and the price in the foreign farm sector all decline. The volume of trade expands if the home country exports the processed product and contracts if it imports. These adjustment patterns are rationalized as follows: Expansions in domestic production lower the price of the farm commodity along the original derived demand. Domestic production of the processed product expands and there is a consequent reduction in the price of output. Domestic demand increases. If the product is originally in excess supply then the expansion in demand is less than the full expansion in supply; exports increase If the good is originally in excess demand then demand expands less than supply; imports rise.

Adjustments in the price of marketing services is the only case in which ambiguity may arise. When the prices of these services increase ($\tilde{\rho}^h > 0$) it may be possible for the foreign and domestic farm prices to move in opposite directions. The price of the processed product increases, regardless of the origin of the change, but the direction of change in the volume of trade depends on the origin of the initial shift.

When the home country imports the processed product, the following adjustments occur: The factor-price increase causes unit costs to rise and, consequently, production to contract as imports become more attractive. The volume of trade expands.

Demand contracts in the foreign economy, while exports increase and production expands. There is a favorable shift outwards in the derived demand for the farm commodity. The price of the farm commodity rises unambiguously. Domestically, the situation is complicated by two offsetting effects. The first is an unfavorable movement in domestic production of the traded good. If substitution possibilities are nonexistent, the contraction in output in this sector shifts inward the derived demand for the primary product. Its price must fall. However, where substitution is possible, the rise in the price of the nonfarm input shifts factor intensity toward use of the farm commodity. If substitution possibilities are great enough, the derived demand for the factor may actually expand, with consequent increase in the domestic farm price. The extent to which this is possible is indicated by the numerator in the expression depicting the movement in the domestic farm price. In autarky ($\theta^h = 0$) this numerator assumes the same sign as the term $(\eta^h+\sigma^h)$, which appears in several of the expressions derived by Gardner. The first element—the food demand elasticity—is negative. It represents the contraction effect; the more elastic demand, the greater the contraction in output for the given price change. The second term—the substitution effect—is positive. In the trade equilibrium considered here, this term also plays a role, but it is modified substantially by the importance of trade in the domestic economy. This effect is depicted through the value of the share term θ^h. Recall that if country h imports the food product then this "share" term is actually negative. From the numerator we can conclude that, *ceteris paribus*, the greater the importance of trade the more likely it is that the domestic farm price will decline. The reason for this is simple: Contractions in domestic production are exacerbated by the extent to which consumption can be met from foreign sources. When the change emanates from the exporting region the situation is similar: The greater the importance of trade the less likely it is that the farm price will rise. Cost increases in the exporting region lead to reductions in exports and consequent reductions in domestic production. The greater the importance of trade, the more likely it is that derived demand for the farm commodity will contract.

Trade in Primary Products

Results pertaining to the regime in which the primary product is traded are presented in table 6. In this case, the denominator in each of the comparative-static expressions has the same sign as the parameter α^h. Hence it is positive if country h is an importer, but negative if it exports. In comparison with the previous case, the overall pattern of qualitative effects is similar between the two regimes: Shifts in food demand and in the supply of the farm commodity lead to unambiguous adjustments in farm and retail prices and in the volume of trade; ambiguous effects arise when the marketing-service price adjusts.

Expansions in domestic demand ($\tilde{\delta}^g > 0$) cause the domestic price of the processed product to rise, inflate the international price of the primary product, and cause the price of the processed product in the foreign economy to increase. If the country in which the initial change occurs is an importer the volume of trade expands, *vice versa* if the country exports.

Table 6. Summary of Effects: Primary Products Trade

Shifts in Food-Product Demand

$$\left.\begin{aligned}
\tilde{p}^g &= \tilde{\delta}^g \, \frac{\mu^g \alpha^h \omega^g}{\Psi} \\
\tilde{p}^h &= \tilde{\delta}^g \, \frac{\mu^g \alpha^h \omega^h}{\Psi} \\
\tilde{w} &= \tilde{\delta}^g \, \frac{\mu^g \alpha^h}{\Psi} \\
\tilde{m} &= \tilde{\delta}^g \, \frac{\mu^g \left[\eta^h\omega^h - \sigma^h(1-\omega^h) - (1-\alpha^h)\varepsilon^h\right]}{\Psi}
\end{aligned}\right\} \{g,h\} \in \{i,j\}$$

Shifts in Farm-Commodity Supply

$$\left.\begin{aligned}
\tilde{p}^g &= \tilde{\upsilon}^h \, \frac{(1-\alpha^h)\,\beta^h \alpha^g \omega^g}{\Psi} \\
\tilde{p}^h &= \tilde{\upsilon}^h \, \frac{(1-\alpha^h)\,\beta^h \alpha^g \omega^h}{\Psi} \\
\tilde{w} &= \tilde{\upsilon}^h \, \frac{(1-\alpha^h)\,\beta^h \alpha^g}{\Psi} \\
\tilde{m} &= \tilde{\upsilon}^h \, \frac{(1-\alpha^h)\,\beta^h \left[\eta^g\omega^g - \sigma^g(1-\omega^g) - (1-\alpha^g)\varepsilon^g\right]}{\Psi}
\end{aligned}\right\} \{g,h\} \in \{i,j\}$$

Shifts in Marketing-Services Supply

$$\left.\begin{aligned}
\tilde{p}^g &= \tilde{\rho}^g \, \frac{(1-\omega^g)\left\{\left[(1-\alpha^g)\varepsilon^g + \sigma^g\right]\alpha^h - \alpha^g\left[(1-\alpha^h)\varepsilon^h + \sigma^h(1-\omega^h) - \eta^h\omega^h\right]\right\}}{\Psi} \\
\tilde{p}^h &= \tilde{\rho}^g \, \frac{(1-\omega^g)(\eta^g+\sigma^g)\,\alpha^h \omega^h}{\Psi} \\
\tilde{w} &= \tilde{\rho}^g \, \frac{(1-\omega^g)(\eta^g+\sigma^g)\,\alpha^h}{\Psi} \\
\tilde{m} &= \tilde{\rho}^g \, \frac{(1-\omega^g)(\eta^g+\sigma^g)\left[\eta^h\omega^h - \sigma^h(1-\omega^h) - (1-\alpha^h)\varepsilon^h\right]}{\Psi}
\end{aligned}\right\} \{g,h\} \in \{i,j\}$$

where: $\Psi = \alpha^h\left[(1-\alpha^g)\varepsilon^g + \sigma^g(1-\omega^g) - \eta^g\omega^g\right] - \alpha^g\left[(1-\alpha^h)\varepsilon^h + \sigma^h(1-\omega^h) - \eta^h\omega^h\right]$

Expansions in domestic demand cause derived demand for both factors of production to rise. The price of the farm commodity increases along the domestic supply schedule Processing costs and the price of the non traded good also rise. The rise in the farm commodity price—common between countries—stimulates production in the farm sectors of both economies. If the country in which the initial change occurs is deficient in supply, the volume of trade expands; if the country is initially in excess demand, trade contracts. In the foreign country, the increase in the farm price stems associated increases in unit costs of production and in the price of the processed product, regardless of its trading status.

When farm commodity supply moves outward ($\tilde{\upsilon}^h > 0$) the following sequence of events occur: The farm price falls. Unit costs of food production fall in both countries. Processed product prices decline and demand is stimulated. Domestic production of the food product expands. This contracts trade if the home country imports but expands if it exports.

The effects of increases in service costs ($\tilde{p}^g > 0$) are somewhat more complicated. Costs of processing in the home economy rise and there is an unambiguous rise in the domestic price of the processed product. This, however, is the only determinable effect. The price increase chokes-off domestic demand and causes production to contract. This dampens demand for the primary product. However, if substitution possibilities exist, derived demand may actually expand. Whether it will do so, depends crucially on the elasticities of demand for food and substitution in processing. The direction of change in demand has the same sign as the term ($\eta^g+\sigma^g$), which appeared in the previous experiments. If demand is very elastic, the decline in production stemming from the price change in processing will be large. Consequently, derived demand will contract and the price of the farm commodity will decline. This is unambiguously the case if technology exhibits fixed-proportions, but may not be so when it is possible to substitute away from the service input—now more expensive—toward use of the farm commodity. A decline in the farm price stimulates the volume of trade if the country is a net importer, *vice versa* if it exports. Unit costs of processing fall in the foreign economy and there is a consequent adjustment in the price of the food product. The converse is the case if substitution possibilities are great enough to effect price increases in the home country.

Trade in Both Primary and Processed Products

When trade possibilities are realized at both levels of the marketing system more complex adjustment patterns emerge. Table 7 summarizes the formulae that pertain to this setting. The complexities of this regime stem primarily from the symbol Ξ, representing the denominator in each of the comparative-static effects. In assessing the signs of these expressions, note that the denominators can be defined in several alternative ways. These are depicted through the equalities appearing at the bottom of table 7. The denominator is positive if the two countries import one of the commodities and export the other. That is, if the pattern of trade is "circular." If trade occurs in only one direction then the denominator is negative. Chambers restricted attention to the circular case. Empirically, however, one can find examples of both trade patterns. Hence, in the ensuing discussion, we retain this more general interpretation.

Table 7. Summary of Effects: Trade in Both Primary and Processed Products

<u>Shifts in Food-Product Demand</u>

$$\left.\begin{aligned}
\tilde{p} &= \tilde{\delta}^h \frac{0}{\Xi} \\
\tilde{w} &= \tilde{\delta}^h \frac{0}{\Xi} \\
\tilde{x} &= \tilde{\delta}^h \frac{(1-\theta^h)\,\mu^h\,(\omega^h-\omega^g)\,\alpha^g}{\Xi} \\
\tilde{m} &= \tilde{\delta}^h \frac{(1-\theta^h)\,\mu^h\,(\omega^h-\omega^g)\,\theta^g}{\Xi}
\end{aligned}\right\}\ \{g,h\} \in \{i,j\}$$

<u>Shifts in Farm-Commodity Supply</u>

$$\left.\begin{aligned}
\tilde{p} &= \tilde{\upsilon}^g \frac{0}{\Xi} \\
\tilde{w} &= \tilde{\upsilon}^g \frac{0}{\Xi} \\
\tilde{x} &= \tilde{\upsilon}^g \frac{(1-\alpha^g)\,\beta^g\,(\omega^h-\omega^g)\,\alpha^h}{\Xi} \\
\tilde{m} &= \tilde{\upsilon}^g \frac{(1-\alpha^g)\,\beta^g\,(\omega^h-\omega^g)\,\theta^h}{\Xi}
\end{aligned}\right\}\ \{g,h\} \in \{i,j\}$$

<u>Shifts in Marketing-Services Supply</u>

$$\left.\begin{aligned}
\tilde{p} &= \tilde{\rho}^h \frac{(1-\omega^h)\,(\alpha^g\theta^h-\theta^g\alpha^h)\,\omega^g}{\Xi} \\
\tilde{w} &= \tilde{\rho}^h \frac{(1-\omega^h)\,(\alpha^g\theta^h-\theta^g\alpha^h)}{\Xi} \\
\tilde{x} &= \tilde{\rho}^h \frac{(1-\omega^h)\,(\omega^h-\omega^g)\,\sigma^h\,\alpha^g}{\Xi} \\
\tilde{m} &= \tilde{\rho}^h \frac{(1-\omega^h)\,(\omega^h-\omega^g)\,\sigma^h\,\theta^g}{\Xi}
\end{aligned}\right\}\ \{g,h\} \in \{i,j\}$$

where $\Xi \equiv (\omega^g-\omega^h)(\alpha^g\theta^h-\theta^g\alpha^h) \equiv (\omega^g-\omega^h)^2\,\alpha^g\,\theta^g\,\omega^g\,\lambda \equiv (\omega^g-\omega^h)^2\,\alpha^g\,\theta^g\,\omega^h\,\tau$, where $\lambda \equiv u^g/u^h$ and $\tau \equiv y^g/y^h$

The first anomaly encountered is that farm and retail prices are insensitive to movements in demand and supply. This result is dependent on three key assumptions: pricing behavior in the output market, the structure of production in food manufacturing, and the elasticity of supply of marketing services to the processing sector. We have assumed that pricing is competitive and that technology exhibits constant returns to scale. These assumptions combine to yield implicit supply schedules that are independent of output quantities and are defined over four arguments: the common price of the processed product, the common price of the farm commodity, and the country-specific prices of marketing services. However, when the latter are exogenous to processing, the supply schedules combine to form a block-recursive system in farm and retail prices. When the prices of marketing services adjust farm and retail prices adjust accordingly, but they are insensitive to movements in either demand or supply.

The intuition for these findings stems from the fact that unit costs of production do not adjust as a result of demand and supply shifts. In the previous regimes, supply and demand shifts called forth movements along domestic supply and demand curves—a direct result of an institutional barrier to trade at one level of the marketing system. In the current regime, all domestic requirements can be met from foreign sources, at the world price that prevails prior to the change. As a result, adjustments in excess demands and supplies are met entirely from adjustments in the volume of trade at both levels of the system.

Consider the effects of a demand shift in the home country ($\tilde{\delta}^h > 0$) with specific reference to table 2. We have already established that farm and retail prices remain constant. It follows that domestic demand for the retail product expands by the full amount of the initial shift, while domestic supply of the primary product remains unchanged. Hence, home country adjustments in derived demand are met entirely through adjustments in the volume of primary-product trade. In the foreign economy similar responses are present: The demand shift in the home economy has no affect on foreign demand. Hence, foreign supply adjusts solely in relation to movements in the volume of trade. Derived demand adjusts in proportion to adjustments in supply in processing. With price effects absent, foreign supply of the farm commodity is stationary, hence the entire change in derived demand is met from adjustments abroad. The directions of movements in trade volumes depend on three factors: the origin of change, the pattern of trade, and relative factor intensities in processing. If the home country exports the processed product, food trade expands if factor intensity is greater in the home country. That is, if the term (ω^h-ω^g) is positive. Trade contracts if the home country imports the food product. Trade in primary products adjusts in similar fashion. When factor intensity is greater in the home country, trade expands if the country exports and contracts if it imports.

Like shifts in food demand, shifts in the supply of the primary product ($\tilde{u}^g > 0$) are absorbed by quantity adjustments in the volume of trade. Since farm and retail prices remain constant, domestic and foreign demands for the food product remain unchanged. Home country supply of the primary product expands by the full amount of the initial adjustment. Domestic derived demand and the volume of primary-product trade both adjust. Domestic supply of the food product moves in exact proportion with the adjustment in derived demand, but all of this adjustment is transmitted to the foreign country *via* adjustments in the volume of food trade. Since foreign demand remains unchanged, all of the adjustment in trade is absorbed by changes in domestic supply which, in turn, effect adjustments in derived demand for the farm commodity. Once, again, these are transmitted abroad *via* adjustments in primary-product trade. In comparison with demand shifts, the supply shift has an opposite affect on the directions of change in the volumes of trade: If the home country exports the processed product, food trade contracts if factor intensity is greater in the home country. It expands if the home country imports the food product. When factor intensity is greater in the home country, primary-product trade contracts if the country exports and expands if it imports.

Shifts in marketing-services supply $(\tilde{p}^h > 0)$ also provide a nice contrast to the results of the previous regimes. All of the patterns of change depend on the relative degrees of factor intensity between the two countries. When service prices increase farm and retail prices rise when the home country has lower factor intensity, but they decline when its factor intensity is greater. When the home country exports the processed product, trade volume expands when its factor intensity is greater and contracts when it is lesser; *vice versa* when it imports the final good. When it imports the primary product, trade volume in this commodity rises if home-country factor intensity is greater and contracts when it is not; *vice versa* when it exports the primary product.

Transportation Costs, The Pattern of Trade, and Elasticities of Price Transmission

We have until now, left the question of the pattern of trade unanswered by neglecting the issue of transportation costs. These costs play an insignificant role in signing the qualitative effects investigated thus far. They are important, however, in evaluating the quantitative magnitudes of each change.[1] The significance of transportation costs in explaining trade patterns is well known following the seminal literature on single and multi-commodity models of spatial equilibrium (Takayama and Judge). At the present level of generality, it is not possible to say which country exports which of the commodities and which will import. A country may choose to export the processed product and import the primary product, import the food product and export the primary product, import one or both commodities, or export one or both commodities.

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[1] Incorporating transport costs is important for one other reason: When neglected, the matrix of comparative static effects in the third trade regime is singular. This follows from the fact that the cost shares must be the same in each country when transport is free. To observe this, note the following equality $C^i(w,r^i) - C^j(w,r^j) = 0$. Differentiating, holding the prices of the nonfarm inputs constant, we obtain: $(\omega^i - \omega^j)\,\tilde{w} = 0$. Since this must hold for all non-zero changes in prices, it follows that $\omega^i = \omega^j$. Assuming, however, that these cost shares differ—which is the case when transportation costs are considered—we obtain the correct qualitative results from those presented in table 7.

Transportation costs play a significant role in moderating the extent to which changes in the domestic farm price are passed on to the domestic retail sector, or to the farm and retail sectors of the foreign country. Understanding these "pass-through" effects is important in view of their significance to negotiations about trade policy. The transmission elasticity between any two prices, is simply the ratio of the relative price changes occurring as a result of a perturbation from initial equilibrium. In the notation of this paper, we depict this measure as follows:

$$(21) \qquad E(o^g{:}o^h|v^k) \equiv \frac{\tilde{o}^g / \tilde{v}^k}{\tilde{o}^h / \tilde{v}^k} \qquad \left\{ \begin{array}{ll} \{o^g,o^h\} \in \{w^k,p^k\} \\ \{v^k\} & \in \{\delta^k,\upsilon^k,\rho^k\} \end{array} \right\} \qquad \{g,h,k\} \in \{i,j\}\ g \neq h.$$

This expression is closely related to the farm-retail price ratio[2] However, use of (21) is more convenient because the terms Δ, Ψ, and Ξ, which appear as denominators in tables 5-7, cancel as a result of normalization. In the ensuing discussion we adopt the relative movement in the farm price of country i as the numeraire.

To incorporate the effect of transportation, let τ^{cij} $c \in \{x,m\}$ denote the cost of shipping one unit of commodity c from country i to country j. We will assume that the cost is symmetric (i.e., $\tau^{cij} = \tau^{cji} \equiv \tau^c$ $c \in \{x,m\}$), but permit it to differ across product forms (i.e., $\tau^x \neq \tau^m$). The pattern of trade can now be explained using these definitions: Whenever, in autarky, equilibrium quantities are such that the difference in farm prices exceeds τ^m, there will be trade in the food product alone. Whenever quantities are such that the difference in retail prices exceeds τ^x, there will be trade only in the farm commodity. Trade in both farm and retail products occurs whenever quantities select prices that differ by less than τ^x and τ^m, simultaneously. Of course, international arbitrage causes price differences to recede until they reach the amount of the cost difference. That is, until, the equalities $(p^j - p^i) = \tau^x$ and $(w^j - w^i) = \tau^m$ prevail When both products are traded, the pattern of product flow is unidirectional if both elements of (τ^x,τ^m) assume the same sign; the pattern is bi-directional if one element is positive and the other is negative.

The observations above are conventional ones, but their examination leads to several implications within our framework. The first regards cost advantages in food processing: For trade to occur in processed products, the exporting country must have a unit cost advantage at least as great as τ^x in the pre-trade equilibrium. The second regards the specification of the price linkage equations. Incorporating transportation costs, the displaced versions of the price linkage equations that now enter table 2 are:

$$(22) \qquad \lambda^x\, \tilde{p}^i \quad + \quad (1-\lambda^x)\, \tilde{\tau}^x \quad = \quad \tilde{p}^j,$$

---

[2] In particular, defining movements in the ratio in the usual manner. $R(o^g\, o^h|v^k) \equiv \left[\, \tilde{o}^g / \tilde{v}^k \,\right] - \left[\, \tilde{o}^h / \tilde{v}^k \,\right]$, it follows that $R(o^g\, o^h|v^k) = \left[\, E(o^g\, o^h|v^k) - 1 \,\right] \tilde{o}^h$ Therefore the ratio predicts a movement of zero whenever the transmission elasticity predicts unitary elasticity

(23) $$\lambda^m \tilde{w}^i + (1-\lambda^m)\tilde{\tau}^m = \tilde{w}^j.$$

In these expressions, the parameters $\lambda^c \; c \in \{x,m\}$ represent the ratio of the price of the product in country i to that in country j. When country i exports the good in question the parameter is defined over the positive unit interval; it exceeds one when country i imports the good.[3] Evaluating the elasticities of price transmission using these price-linkage specifications, we obtain the results presented in table 8.

Table 8. Elasticities of Price Transmission

Transmission Elasticity	Retail-Product Demand Shifts	Farm-Commodity Supply Shifts	Marketing-Service Price Shifts	
	$\delta^h \; h \in \{i,j\}$	$\upsilon^g \; g \in \{i,j\}$	ρ^i	ρ^j
		Trade in Processed Products		
$E(p^i{\cdot}w^i\mid\cdot)$	ω^i	ω^i	$\frac{(\varepsilon^i+\sigma^i)\,\theta^j\,\omega^j}{\Gamma}$	ω^i
$E(p^j{\cdot}w^i\mid\cdot)$	$\omega^i\lambda^x$	$\omega^i\lambda^x$	$\frac{(\varepsilon^i+\sigma^i)\,\theta^j\,\omega^j\,\lambda^x}{\Gamma}$	$\omega^i\lambda^x$
$E(w^j{\cdot}w^i\mid\cdot)$	$\frac{\omega^i\lambda^x}{\omega^j}$	$\frac{\omega^i\lambda^x}{\omega^j}$	$\frac{(\varepsilon^i+\sigma^i)\,\theta^j\,\lambda^x}{\Gamma}$	$\frac{\Delta}{(\varepsilon^j+\sigma^j)\,\theta^i}$
		Trade in Primary Products		
$E(p^i{\cdot}w^i\mid\cdot)$	ω^i	ω^i	$\frac{\Pi}{(\eta^i+\sigma^i)\,\alpha^j}$	ω^i
$E(p^j{\cdot}w^i\mid\cdot)$	$\omega^j\lambda^m$	$\omega^j\lambda^m$	$\omega^j\lambda^m$	$\frac{\Sigma}{(\eta^j+\sigma^j)\,\alpha^i}$
$E(w^j{\cdot}w^i\mid\cdot)$	λ^m	λ^m	λ^m	λ^m
		Trade in Primary and Processed Products		
$E(p^i{\cdot}w^i\mid\cdot)$	$\frac{0}{0}$	$\frac{0}{0}$	$\omega^j\lambda^m$	ω^i
$E(p^j{\cdot}w^i\mid\cdot)$	$\frac{0}{0}$	$\frac{0}{0}$	$\omega^j\lambda^x\lambda^m$	$\omega^j\lambda^x$
$E(w^j{\cdot}w^i\mid\cdot)$	$\frac{0}{0}$	$\frac{0}{0}$	λ^m	λ^m

$\Gamma \equiv \left[\varepsilon^j+\sigma^j(1-\omega^j)-(1-\theta^j)\eta^j\omega^j\right]\theta^i\lambda^x + \left[(1-\theta^i)\eta^i+\sigma^i\right]\theta^j\omega^j$; $\quad \Delta \equiv \left[\varepsilon^i+\sigma^i(1-\omega^i)-(1-\theta^i)\eta^i\omega^i\right]\theta^j + \left[(1-\theta^j)\eta^j+\sigma^j\right]\theta^i\omega^i\lambda^x$;

$\Pi \equiv \left[(1-\alpha^i)\varepsilon^i+\sigma^i\right]\alpha^j - \left[(1-\alpha^j)\varepsilon^j+\sigma^j(1-\omega^j)-\eta^j\omega^j\right]\alpha^i\omega^i\lambda^m$; $\quad \Sigma \equiv \left[(1-\alpha^j)\varepsilon^j+\sigma^j\right]\alpha^i\lambda^m - \left[(1-\alpha^i)\varepsilon^i+\sigma^i(1-\omega^i)-\eta^i\omega^i\right]\alpha^j$.

[3] A third observation follows from the price linkage equations. It concerns feasible bounds on the movements in prices over which the modeling framework is valid. In autarky we have: $(p^j-p^i) < \tau^x$ and $(w^j-w^i) < \tau^m$. We must avoid discontinuities of the type that exist in transition between each of the three regimes. Hence, the relative movements in prices at either level of the marketing channel cannot be so large that they cause trade to occur, when this is not the case in the initial equilibrium.

Several observations are noteworthy. The first is that the elasticities are dependent on the trade regime that generated them. We consider each of the three regimes in turn, beginning with processed product trade. The first feature among the entries is the symmetric pattern in the signs and values of the elasticities when retail demand or farm supply shift. These elasticities are independent of both the country of origin and of the level of the marketing channel from which the initial change occurred. However, they depend on the direction of product flow. For example, consider an increase in demand in the home country that generates a one percent increase in the domestic farm price. The transmission elasticity between domestic farm and retail prices is always inelastic. It is precisely the value of the cost share in processing which, by definition, can never exceed one. Abroad, the response is affected by the transport parameter λ^x, which is less than one if country i exports, but exceeds one when it imports. In the former case, the transmission elasticity is inelastic, and will be smaller in magnitude than the domestic one. When country i imports the good, the cross-country effect exceeds the domestic effect, with the possibility that an elastic response may arise—that is, the proportional increase in the foreign retail price may be larger than the increase in the domestic farm price. The elasticity of transmission between domestic farm prices depend on the relative values of the cost shares, the direction of flow of product, and the significance of transportation costs.
If country i imports the product, the transmission elasticity will be elastic whenever the foreign cost share exceeds the domestic cost share. If country i exports the good, the effect is inelastic whenever the domestic cost share exceeds the foreign share. Note that these patterns, which are assumed to be generated by a demand shift, are the same as those that emerge if an inward movement in supply causes the domestic price of the farm commodity to increase by one percent. These effects will differ, however, when marketing-service changes cause farm and retail prices to adjust. In this case, the transmission elasticity depends on the country of origin in which the initial change occurs. In general, the signs of the elasticities defined over Γ and Λ are ambiguous.

The pattern that arises when the farm product is traded are similar to the former case. The elasticities are positive and independent of country of origin when either demand or supply shift; some are ambiguous when marketing-service prices change and, in general, depend on the country of origin of the initial change.

The entries in the third regime, in which both commodities are traded, reflect two features that are absent from the other trade scenarios. The first is the insensitivity of farm and retail prices to demand and supply adjustments. The second is the fact that service-price changes lead to unambiguous effects. In this case elastic effects may be apparent for the elasticities between domestic farm and retail prices, between the domestic farm price and the foreign retail price, and between the domestic and foreign farm prices. The precise effects depend on the values of the costs shares and on the origin of change. The exception is the domestic farm-retail elasticity for which shifts in the foreign service price lead unambiguously to inelastic responses.

Concluding Comments

Marketing activities in international trade are governed by forces similar to those in a domestic economy modeled in isolation from world markets. This paper has assessed the qualitative implications of three forces: shifts in the demand for food products, shifts in the supply of farm commodities, and shifts in the price of marketing services. These comprise the typical effects considered by previous authors. They focus attention away from the implications of farm and trade policies and toward learning about the interrelationships that exist between marketing and the trade environment for farm and processed products.

The qualitative properties of the models considered here are similar in structure to those derived in autarky. However, comparative statics in autarkic and non-autarkic regimes may differ in important ways. Contrasting the results across the three regimes, trade is seen to have a significant impact on marketing, but marketing also has a significant impact on trade. The exercise identifies the cost shares of farm inputs in marketing as parameters of key significance. First, they indicate situations in which it may be permissible to neglect marketing activities altogether. Second, they moderate the extent to which movements in domestic farm prices are passed on to other farm and retail prices in the international marketing system. Investigating these effects, we relaxed one of our initial assumptions: Transportation costs were shown to have a significant impact on the transmission elasticities between farm and retail prices. Relaxing additional assumptions—particularly the fourth assumption—additional realism may be introduced and, so, contribute to our understanding of marketing sector linkages in agricultural products trade. In this vein, work continues with extensions of the present framework.

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