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The location of marginal production for value-added and intermediate goods: optimal policies and trade volumes

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The location of marginal production for value-added and intermediate goods: Optimal policies and trade volumes

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CHAPTER I

INTRODUCTION

Over the last two decades trade in high-value (or value-added) agricultural products (HVPs) has been the fastest growing component of world agricultural trade.[1] In 1990 high-value products accounted for approximately 75 percent of world agricultural exports (GAO, 1993b). Some authors attribute the relatively rapid growth of HVP trade to increases in the income of a number of middle-income developing countries (Lee, Henneberry, & Pyles, 1991; Lee & Robinson, 1994). Their reasoning stems from the fact that income elasticities for value-added and meat products are higher than those for food grains, and, as income increases, expenditures on HVPs tend to rise with the change in the dietary composition of food products . Consequently, it is believed that as more countries develop and their incomes rise, one may expect agricultural trade to continue to shift in the direction of HVPs and away from bulk commodities.

While it may be true that high-value agricultural products command a greater share of food expenditures as income rises, it follows that HVP trade will increase as income rises only to the extent that domestic production is unable to meet the rising demand for HVPs. In the case of meat products, Mergos (1989) has suggested that economic development is associated with the adoption of more-feed-grain intensive methods of meat production. Thus it is possible that rising a demand for meat

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[1]High-value products are differentiated from bulk commodities (primarily food and feed grains such as wheat, corn and soybeans) by the level of processing or services added to the product or its per-unit value and bulkiness. HVPs are often separated into the following three categories:

1. Unprocessed products: eggs, fruit, nuts and fresh vegetables;
2. Semi-processed products: fresh, chilled and frozen meat, wheat flour, animal feed, oilseed cake and meal and vegetable oil;
3. Highly processed products: prepared and preserved meats, milk, butter, cheese, cereal preparations, dried fruits, preserved or prepared vegetables, chocolate, beverages and cigarettes (Elleson, 1990).

products primarily met by an expansion of domestic production could increase imports of feed grains more than imports of meat. This observation demonstrates the importance of the production linkages between bulk and value-added goods in assessing the trade response to price and income changes in either market.

In addition to the growing volume of HVP trade, exports of high-value products have been favored by politicians and government analysts for their potential to increase employment and national income by processing agricultural products prior to export (GAO, 1993b). It is believed that processing bulk commodities (or intermediate products) prior to export provides a foreign market for the goods and services involved in the production of the value-added good. Moreover, the income generated by employing additional productive resources in value-added industries is multiplied through the economy, providing an additional source of tax revenues (Schluter & Edmondson, 1989). It must be noted that such an argument in favor of promoting value-added exports is critically dependent upon the assumption that there are unemployed productive resources to be costlessly engaged in the production of value-added goods. Nevertheless, seeking to increase the domestic production of HVPs, policy makers in both exporting and importing countries have appealed to similar arguments as a logical foundation for establishing export promotion programs and import restrictions for value-added agricultural products.

Regardless of the reasoning behind the policy, it is important to ask how effective price policies, such as exports subsidies and import tariffs, are at increasing the domestic production of value-added goods. We must also recognize that variations in production of value-added goods send ripples into intermediate good markets that prompt price and output adjustments. This fact gives rise to the notion that trade policies for value-added goods become trade policies for their underlying intermediate inputs through the linkages that connect these markets. Following this line of reasoning, one can view trade in value-added goods as a substitute for trade in bulk commodities. Consequently, an opportunity cost of promoting exports of HVPs may be a decline in bulk commodity exports.

The goal of this study is to address, at a general level, some of the issues raised by promotion of HVP exports by considering the effects of various exogenous price shocks on the location of marginal production for value-added goods. The accomplishment of this objective is aided by establishing and achieving three operational objectives.

First, the exact nature of the channels through which value-added and intermediate product markets influence one another is investigated. To identify the important production linkages between value-added and intermediate goods, a three-good, three-factor trade model is constructed and analyzed in detail. It is also our desire to uncover any intrinsic properties of trade in value-added goods that may make export subsidies for these products a desirable policy.

Second, optimal trade policies are analyzed for a world with two and three trading countries using the trade model developed in chapter II. Initially, policy makers are assumed to maximize national welfare, allowing one to determine if current arguments for export subsidies are valid when intermediate goods are present. As an alternative, the optimal commercial policy is derived for a country whose policy makers seek to maximize the total value-added in the high-value agricultural industry. The analysis of optimal policies endeavors to widen the scope of the export subsidy literature by incorporating intermediate goods and by providing an alternative objective for policy makers that is more consistent with the informal debate over HVP export promotion.

Third, relevance of the theoretical results is established by applying a partial equilibrium version of the analytical trade model to U.S. meat and feed-grain trade data. Export subsidies and other exogenous price shocks are simulated to determine the response of prices, outputs, and trade volumes. As described above, export promotion of value-added products is ultimately a policy designed to increase the marginal production of value-added goods in the exporting country. Consequently, a primary focus of the empirical application is quantify the production response of value-added industries in both the exporting and importing countries to price shocks through a variety of channels. It is also of interest to determine how strongly and in what manner price shocks in the value-added industries spill over into the intermediate product markets.

The remainder of this thesis is organized to meet the above objectives. The general equilibrium model of trade in value-added and intermediate goods is developed in chapter II. Chapter III is devoted to a theoretical analysis of price and trade volume changes in response to exogenous price variations. Optimal trade policies are analyzed in chapter IV, and the structure of the empirical model is detailed chapter V. Chapters VI, VII, and VIII present the results from simulating subsidies for broiler exports, real exchange rate fluctuations, and reductions in the cost of transporting meat products. Finally, chapter IX provides a summary of the conclusions from this study and suggestions for future research.

CHAPTER II

A MODEL OF TRADE IN VALUE-ADDED AND INTERMEDIATE GOODS

The object of this modeling exercise is to properly capture the production linkages that exist between intermediate and value-added goods in a framework that is fitting for the analysis of commercial policies. The international trade literature contains a great variety of models incorporating intermediate goods; nevertheless, the vast majority of these models may be placed into one of the following broad categories: inter-industry flows, pure intermediate goods, and multi-stage production models.

Literature Review

Inter-industry flows models are characterized by the fact that all, or some subset, of the goods produced in the world may be both consumed and used as inputs in the production of other goods. Thus, these products serve as both intermediate and final goods. Vanek (1963) introduced the inter-industry flows model to bridge the gap between traditional theoretic trade models and the input-output models often used in empirical work. Vanek's contribution was in establishing the validity of the factor-price equalization, Stolper-Samuelson, Rybczynski, and Heckscher-Ohlin theorems in an input-output framework. His work was augmented by McKinnon (1966), Melvin (1969), Warne (1971), Casas (1972), Chang and Mayer (1973), Schweinberger (1975a), and Woodland (1977). These authors investigated issues concerning the gains from trade, technological change, joint products, and the properties of the fixed and variable-intermediate-input-coefficient versions of the inter-industry flows model.

A special case of the inter-industry flows model is the pure intermediate good model. A pure intermediate product is a good that is produced solely to serve as an input in the production of a final good. Pure intermediate products, therefore, are not consumed directly. Batra and Casas (1973), Schweinberger (1975b), Hazari, Sgro and Suh (1981), and Batra and Naqvi (1989) established properties for the pure intermediate good model similar to those of the inter-industry flows model.

Multi-stage production models have emanated from the desire to explain trade patterns in multi-stage production processes. These models differ from the inter-industry flows and pure intermediate good models in that production of the final good is viewed as consisting of a continuum of intermediate stages. Thus, the objective is to explain why countries export and import products at a particular stage of production. Dixit and Grossman (1982), Sanyal (1983), and Sarkar (1985) have explored how the marginal stage of domestic production is influenced by commercial policies, growth, and differing rates of time preference.

Because most primary agricultural products, such as food and feed grains, must undergo a certain amount of further processing before they may be consumed by humans, the pure intermediate good model is a more appropriate framework for analyzing trade in high-value agricultural products than the inter-industry flows model. Although we are interested in how policies affect output at various stages in the production process, it is not the objective of this study to determine whether production of a particular stage will cease as a result of commercial policies. In fact, throughout the analysis we want to maintain that countries remain incompletely specialized in the production of all goods. Consequently, the multi-stage production framework is also inappropriate for the questions at hand. Therefore, the pure intermediate good model is the chosen framework in this study for the analysis of high-value and bulk commodity agricultural trade.

The Production Sector

In this economy three goods—manufactures, meat, and feed grain—are produced from fixed supplies of capital, labor, and land in a constant-returns-to-scale technology. In addition to primary factors, feed grain serves as an intermediate input in the production of both manufactures and meat. Feed grain is a pure intermediate good, and, as such, it does not enter the utility function of the representative consumer. Production is assumed to be free from any distortions or externalities in the factor and goods markets. Finally, all three goods may be traded, but primary factors are not allowed to flow across national boundaries.

Producers seek to maximize profits by choosing the net output levels for each good, given a vector of output prices $\boldsymbol{p}$ and a vector of factor endowments $\boldsymbol{v}$, that maximize the value of total production. This optimization problem can be formally summarized in the maximum value or revenue function, which may be written as $R(\boldsymbol{p},\boldsymbol{v}) = \max_{\boldsymbol{x}}\{\boldsymbol{px} | (\boldsymbol{x},\boldsymbol{v}) \text{ feasible }\} = \boldsymbol{px}(\boldsymbol{p},\boldsymbol{v})$. The properties of the revenue function are well documented (Woodland, 1980; Dixit & Norman, 1980, ch. 2), and they are stated for future reference without proof. The revenue function is (i) defined and non-negative for all $\boldsymbol{p} > 0$ and $\boldsymbol{v} \geq 0$, (ii) convex and homogeneous of degree one in $\boldsymbol{p}$ for fixed $\boldsymbol{v}$, and (iii) concave and homogeneous of degree one in $\boldsymbol{v}$ for fixed $\boldsymbol{p}$. By the envelope theorem, the first derivative of the revenue function with respect to prices is the vector of net outputs. Similarly, the first derivative of the revenue function with respect to endowments is the equilibrium value of the marginal product for each factor, which is the vector of factor prices.

An equivalent expression of the revenue function highlights the fact that in equilibrium the total value of factor endowments is minimized. Formally this entails choosing factor prices to minimize the unit cost of production in each industry, subject to the constraint that unit costs are at least as great as output prices. The problem is written $R(\boldsymbol{p},\boldsymbol{v}) = \min_{\omega}\{\omega\boldsymbol{v} | c^i(\omega) \geq p_i \text{ for all } i = 1,2,3\}$, where ω is the vector of factor prices and $c^i(\omega)$ is the unit cost function in the i^{th} industry. The unit cost function satisfies the usual properties of a cost function—(i)non-decreasing in ω, (ii) concave in ω, and(iii) homogeneous of degree one in ω—and by Shepard's lemma the derivative with respect to factor prices yields the vector of inputs required to produce one unit of output. These unit input requirements (or input coefficients) are functions of factor prices, which are themselves functions of the exogenous output prices.

Given the general nature of production outlined above, the specific structure of the production model is defined in the equations below. This more detailed production model provides us with expressions for the linkages between output and price changes in terms of parameters which may be estimated or obtained from existing data sources. In general, notation will be defined below as needed, but the basic set of variables are defined as follows.

$X_1(\mathbf{p},\mathbf{v})$ = gross output in manufactures.

$X_2(\mathbf{p},\mathbf{v})$ = gross output of meat.

$X_3(\mathbf{p},\mathbf{v})$ = gross output of feed grain.

K_i = capital input into the production of good i.

L_i = labor input into the production of good i.

T_i = land input into the production of good i.

w = price of labor.

r = price of capital.

g = price of land.

p_i = output price of good i.

$c_{ij} = \frac{\partial c^j(\omega)}{\omega_i}$ is the input coefficient of the i^{th} factor into the production of one unit of the j^{th} good, for example $c_{L1} = \frac{L_1}{X_1}$.

As stated above, it is assumed that there are no externalities or distortions in the production process; moreover, it is assumed that producers participate in competitive factor and output markets. Consequently, factor endowments will be fully employed in equilibrium. This condition is contained in equations (2.1)-(2.3).[1]

(2.1) $L = X_1c_{L1} + X_2c_{L2} + X_3c_{L3}$

(2.2) $K = X_1c_{K1} + X_2c_{K2} + X_3c_{K3}$

(2.3) $T = X_1c_{T1} + X_2c_{T2} + X_3c_{T3}$

Each full employment equation simply states that the sum of factor inputs (expressed as the product of output and unit input coefficients) used in each industry must equal the endowment of each factor.

At the firm level, competitive behavior implies that marginal production costs are equated to the exogenous output prices in equilibrium. This condition is contained in equations (2.4)-(2.6).[2] In equations (2.4) and (2.5), c_{32} and c_{31} are

(2.4) $p_1 = wc_{L1} + rc_{K1} + gc_{T1} + c_{31}p_3$

(2.5) $p_2 = wc_{L2} + rc_{K2} + gc_{T2} + c_{32}p_3$

(2.6) $p_3 = wc_{L3} + rc_{K3} + gc_{T3}$

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[1]In an effort to reduce notation, the arguments of variables will be omitted except where they are needed for clarity of discussion.

[2]Equations (2.4)-(2.6) may be derived by applying Euler's derivative property of homogeneous functions to the unit cost function for each good. By linear homogeneity of the unit cost function in factor prices, $\frac{\partial c^i(w,r,g)}{\partial w}w + \frac{\partial c^i(w,r,g)}{\partial r}r + \frac{\partial c^i(w,r,g)}{\partial g}g = c^i(w,r,g) = p_i$. Recalling that marginal costs equal unit costs for linear homogeneous production functions, one can readily arrive at equations (2.4)-(2.6) from the expression above.

the input coefficients for the amount of feed grain used to produce one unit of meat and manufactures respectively. A general specification of the model allows this coefficient to be variable and, hence, a function of factor and grain prices.

The exogeneity of final good prices in the free trade equilibrium permits one to solve for factor prices and outputs levels as functions of factor intensities, input coefficients and final good prices. Before solving for factor prices and outputs, it is beneficial to define direct factor intensities and direct cost shares as follows.

(2.7) $$\gamma_{ij}^{h}=\frac{c_{ih}}{c_{jh}} \quad \text{for } i=T,K;\ j=L,T \text{ and } h=1,2,3$$

(2.8) $$\theta_{Li}=\frac{wc_{Li}}{p_i};\ \theta_{Ki}=\frac{rc_{Ki}}{p_i};\ \theta_{Ti}=\frac{gc_{Ti}}{p_i};\ \theta_{3j}=\frac{p_3c_{3j}}{p_j} \quad \text{for } i=1,2,3 \text{ and } j=1,2$$

Each γ_{ij}^{h} is the ratio of inputs of factor i to factor j in the h^{th} industry. It is apparent that factor intensities depend upon factor prices and, therefore, will change as output prices change. In value-added industries it is useful, at times, to consider the ratio of gross factor inputs. Gross factor intensities include the indirect factor inputs embodied in the intermediate product as well as the direct factor inputs. Gross factor intensities are denoted by the tilde and are defined as follows, $\tilde{\gamma}_{ij}^{h}=\frac{c_{ih}+c_{3h}c_{i3}}{c_{jh}+c_{3h}c_{j3}}$ for i = K, T; j = L, T; and h = 1,2.

Likewise, θ_{ij} is the share of production costs in the j^{th} industry that are attributed to the i^{th} factor. Using the pricing equations (2.4)-(2.6), one may readily infer that $\sum_i \theta_{ij}=1$ for all industries. This fact is useful below in solving for factor prices. It is also convenient to consider gross cost shares. These are also denoted with a tilde and defined as $\tilde{\theta}_{ih}=\theta_{ih}+\theta_{3h}\theta_{i3}$ for $i=K,L,T$ and $h=1,2$.

Normalizing by the price of manufactures, equations (2.4)-(2.6)may be solved simultaneously for the following factor prices. In order for factor prices to be positive,

(2.9) $$w=\frac{1}{\Delta}\left[\frac{c_{T2}p_3}{g}\left(\gamma_{KT}^2-\gamma_{KT}^3\right)\left(\theta_{T3}-\tilde{\theta}_{T1}\right)+\frac{c_{T1}p_2p_3}{g}\left(\gamma_{KT}^3-\gamma_{KT}^1\right)\left(\theta_{T3}-\tilde{\theta}_{T2}\right)\right]$$

(2.10) $$r=\frac{1}{\Delta}\left[\frac{c_{L3}p_2}{w}\left(\gamma_{TL}^3-\gamma_{TL}^1\right)\left((1-\theta_{32})\theta_{L1}-(1-\theta_{31})\theta_{L2}\right)+\frac{c_{L2}p_3}{w}\left(\gamma_{TL}^1-\gamma_{TL}^2\right)\left(\tilde{\theta}_{L1}-\theta_{L3}\right)\right]$$

(2.11) $$g=\frac{1}{\Delta}\left[\frac{c_{L2}p_3}{w}\left(\gamma_{KL}^2-\gamma_{KL}^3\right)\left(\tilde{\theta}_{L1}-\theta_{L3}\right)+\frac{c_{L1}p_2p_3}{w}\left(\gamma_{KL}^3-\gamma_{KL}^1\right)\left(\tilde{\theta}_{L2}-\theta_{L3}\right)\right]$$

(2.12) $$\Delta=c_{L1}c_{L2}c_{L3}\left[\left(\gamma_{TL}^3-\gamma_{TL}^1\right)\left(\gamma_{KL}^2-\gamma_{KL}^3\right)+\left(\gamma_{TL}^3-\gamma_{TL}^2\right)\left(\gamma_{KL}^3-\gamma_{KL}^1\right)\right]$$

equations (2.9)-(2.12) imply the following non-unique sufficient conditions.

$$\gamma_{TL}^3 \gtrless \gamma_{TL}^1 \gtrless \gamma_{TL}^2,\quad \gamma_{KT}^2 \gtrless \gamma_{KT}^3 \gtrless \gamma_{KT}^1,\quad \gamma_{KL}^2 \gtrless \gamma_{KL}^3 \gtrless \gamma_{KL}^1$$

and

$$\tilde{\theta}_{L2} \gtrless \theta_{L3},\quad \theta_{T3} \gtrless \tilde{\theta}_{T2},\quad \tilde{\theta}_{L1} \gtrless \tilde{\theta}_{L2},\quad \theta_{T3} \gtrless \tilde{\theta}_{T1},\quad \tilde{\theta}_{L1} \gtrless \theta_{L3}$$

The conditions for relative factor intensities and cost shares are not unique in the sense that intensities may be rearranged as long as it is done in a manner that maintains the equivalence of net and gross factor intensities. Batra and Casas (1973) have shown that a sufficient condition for any given ordering is that either i) the relative factor intensity of the intermediate good is bounded by the factor intensities of the value-added goods or ii) the commodity whose relative factor intensity lies between the factor intensities of the intermediate good and the other value-added good must be at least as intensive in the use of the intermediate good as the other value-added good.

Following Jones (1965), it is beneficial to recast equations (2.1)-(2.6) in rate-of-change notation in order to perform comparative static exercises. Totally differentiating (2.1)-(2.3) and dividing through by factor endowments yields the following equations depicting the rate of output change.

$$\hat{X}_1\lambda_{L1} + \hat{X}_2\lambda_{L2} + \hat{X}_3\lambda_{L3} = \hat{L} - (\lambda_{L1}\hat{c}_{L1} + \lambda_{L2}\hat{c}_{L2} + \lambda_{L3}\hat{c}_{L3}) \quad (2.13)$$

$$\hat{X}_1\lambda_{K1} + \hat{X}_2\lambda_{K2} + \hat{X}_3\lambda_{K3} = \hat{K} - (\lambda_{K1}\hat{c}_{K1} + \lambda_{K2}\hat{c}_{K2} + \lambda_{K3}\hat{c}_{K3}) \quad (2.14)$$

$$\hat{X}_1\lambda_{T1} + \hat{X}_2\lambda_{T2} + \hat{X}_3\lambda_{T3} = \hat{T} - (\lambda_{T1}\hat{c}_{T1} + \lambda_{T2}\hat{c}_{T2} + \lambda_{T3}\hat{c}_{T3}) \quad (2.15)$$

The circumflex above a variable denotes the derivative of the natural logarithm (i.e., dx/x). The share of the i^{th} factor used in the production of the j^{th} good is represented by λ_{ij}. For example $\lambda_{L1} \equiv L_1/L$. Since $\sum_j \lambda_{ij} = 1$ by definition , equations (2.13)-(2.15) state that the percentage change in total factor usage is the sum of changes in factor inputs used in each industry weighted by the respective share of that factor consumed in that industry.

Totally differentiating equations (2.4)-(2.6) and dividing through by factor prices provides one with expressions for final good prices changes as a function of factor price changes. Analogous to the factor endowment/output equations above, each of the pricing equations below illustrates that the percentage change in output prices is distributed to input markets as a weighted average of factor price changes.

$$\theta_{L1}\hat{w} + \theta_{K1}\hat{r} + \theta_{T1}\hat{g} = -\theta_{31}\hat{p}_3 \quad (2.16)$$

$$\theta_{L2}\hat{w} + \theta_{K2}\hat{r} + \theta_{T2}\hat{g} = \hat{p}_2 - \theta_{32}\hat{p}_3 \quad (2.17)$$

$$\theta_{L3}\hat{w} + \theta_{K3}\hat{r} + \theta_{T3}\hat{g} = \hat{p}_3 \quad (2.18)$$

It is also interesting to note that equation (2.17) can be interpreted as the change in the value added in meat production. Dividing both sides of equation (2.17) by $(1-\theta_{32})$ and interpreting the price changes as resulting from the imposition of tariffs yields an expression similar to the standard effective protection formula developed in Corden (1966).

$$\frac{\hat{p}_2 - \theta_{32}\hat{p}_3}{(1-\theta_{32})} = \frac{\theta_{L2}\hat{w} + \theta_{K2}\hat{r} + \theta_{T2}\hat{g}}{(1-\theta_{32})}, \text{ where } \frac{1}{(1-\theta_{32})}\sum_i \theta_{i2} = 1 \text{ for } i = K, L, T.$$

In order to examine the supply response to commodity price changes, it is necessary to find explicit statements for the input coefficient rates of change as functions of output price changes.[3] Substituting the results into equations (2.13)-(2.15) leads to a system of equations that may be used to solve for output changes as a function of output price changes. The determinant, $1/|\theta|$, refers to the determinant of the matrix of cost shares that can be derived from the left-hand side of equations (2.16)-(2.18). The elements of the coefficient matrix on the right-hand side of equation (2.19) are defined in (2.20). Each of the ψ elements contains the impact

$$\begin{bmatrix} \lambda_{L1} & \lambda_{L2} & \lambda_{L3} \\ \lambda_{K1} & \lambda_{K2} & \lambda_{K3} \\ \lambda_{T1} & \lambda_{T2} & \lambda_{T3} \end{bmatrix} \begin{bmatrix} \hat{X}_1 \\ \hat{X}_2 \\ \hat{X}_3 \end{bmatrix} = \begin{bmatrix} \hat{L} \\ \hat{K} \\ \hat{T} \end{bmatrix} + \frac{1}{|\theta|} \begin{bmatrix} (-\psi_{L2}+\phi_{L2}) & (-\psi_{L3}-\phi_{L3}) \\ (\psi_{K2}+\phi_{K2}) & (\psi_{K3}-\phi_{K3}) \\ (-\psi_{T2}-\phi_{T2}) & (-\psi_{T3}+\phi_{T3}) \end{bmatrix} \begin{bmatrix} \hat{p}_2 \\ \hat{p}_3 \end{bmatrix}. \tag{2.19}$$

$$\begin{aligned}
\psi_{i2} &\equiv \left(\sum_{h=1}^{3} \lambda_{ih}\theta_{Kh}\sigma_{KL}^{h} + \sum_{h=1}^{2} \lambda_{ih}\theta_{K1}\theta_{3h}\sigma_{3L}^{h} \right)(\theta_{T3}-\theta_{T1}) \quad \text{for } i=T,L \\
\psi_{K2} &\equiv \left(\sum_{h=1}^{3} \lambda_{Kh}(1-\theta_{Kh})\sigma_{KL}^{h} - \sum_{h=1}^{2} \lambda_{Kh}\theta_{K1}\theta_{3h}\sigma_{3L}^{h} \right)(\theta_{T3}-\theta_{T1}) \\
\phi_{i2} &\equiv \left(\sum_{h=1}^{3} \lambda_{ih}\theta_{Th}\sigma_{TL}^{h} + \sum_{h=1}^{2} \lambda_{ih}\theta_{T1}\theta_{3h}\sigma_{3L}^{h} \right)(\theta_{K3}-\theta_{K1}) \quad \text{for } i=K,L \\
\phi_{T2} &\equiv \left(\sum_{h=1}^{3} \lambda_{Th}(1-\theta_{Th})\sigma_{TL}^{h} - \sum_{h=1}^{2} \lambda_{Th}\theta_{T1}\theta_{3h}\sigma_{3L}^{h} \right)(\theta_{K3}-\theta_{K1}) \\
\psi_{i3} &\equiv \left(\sum_{h=1}^{3} \lambda_{ih}\theta_{Kh}\sigma_{KL}^{h} + \sum_{h=1}^{2} \lambda_{ih}\theta_{K3}\theta_{3h}\sigma_{3L}^{h} \right)(\theta_{T1}-\tilde{\theta}_{T2}) \quad \text{for } i=T,L \\
\psi_{K3} &\equiv \left(\sum_{h=1}^{3} \lambda_{Kh}(1-\theta_{Kh})\sigma_{KL}^{h} - \sum_{h=1}^{2} \lambda_{Kh}\theta_{K3}\theta_{3h}\sigma_{3L}^{h} \right)(\theta_{T1}-\tilde{\theta}_{T2}) \\
\phi_{i3} &\equiv \left(\sum_{h=1}^{3} \lambda_{ih}\theta_{Th}\sigma_{TL}^{h} + \sum_{h=1}^{2} \lambda_{ih}\theta_{T3}\theta_{3h}\sigma_{3L}^{h} \right)(\tilde{\theta}_{K2}-\theta_{K1}) \quad \text{for } i=K,L \\
\phi_{T3} &\equiv \left(\sum_{h=1}^{3} \lambda_{Th}(1-\theta_{Th})\sigma_{TL}^{h} - \sum_{h=1}^{2} \lambda_{Th}\theta_{T3}\theta_{3h}\sigma_{3L}^{h} \right)(\tilde{\theta}_{K2}-\theta_{K1})
\end{aligned} \tag{2.20}$$

[3]A detailed description of process used to solve for the input coefficients is presented in Appendix I.

of the price change on the gross relative intensity of capital and labor in the first set of parentheses on the right-hand side.[4] The adjustments in gross capital-labor intensities is weighted by a component of the θ matrix representing land cost share differences. Similarly each ϕ element contains the impact of the price changes on the gross relative intensity of land to labor weighted by a component of the θ matrix representing capital cost share differences. Therefore, any price change is weighted by both the gross land/labor and gross capital/labor substitution effects to arrive at the corresponding adjustment in factor usage. It is important to note that, when all factors are substitutes and when the intermediate input substitution effects are not too large, the ψ_{ij} and ϕ_{ij} are positive for all $i = T,K,L$ and $j = 2,3$.

Holding factor endowments constant (i.e., setting $\hat{L} = \hat{K} = \hat{T} = 0$), one can solve the system in (2.19) for gross output changes as a function of relative output price changes. Interpreting equations (2.21)-(2.23) in their logarithmic form, we find that ε_{ii} and ε_{ij} are respectively own and cross-price supply elasticities. The π_{ij} are positive elements of the determinant of the factor-share matrix, λ, and, as stated above, the ψ and ϕ terms are also positive. Despite this knowledge, it is not possible to unambiguously sign the own and cross-price elasticities from equations (2.21)-(2.23). Nevertheless, only one of the six terms in the expanded expressions for ε_{12}, ε_{13}, ε_{22} and ε_{32} is of a different sign from the other terms. Similarly, only two of the terms in the expressions for ε_{23} and ε_{33} differ in sign from the remaining four terms. Consequently, the elasticities may be approximately signed with the usual positive own-price effect and negative cross price effect.

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[4]The changes in gross relative factor intensities are chiefly comprised of input substitution elasticities defined as follows.

$$\sigma^{j}_{KL} \equiv \frac{\hat{c}_{Ki} - \hat{c}_{Li}}{\hat{w} - \hat{r}}; \quad \sigma^{j}_{TL} \equiv \frac{\hat{c}_{Ti} - \hat{c}_{Li}}{\hat{w} - \hat{g}}; \quad \sigma^{j}_{3L} \equiv \frac{\hat{c}_{32} - \hat{c}_{L2}}{\hat{w} - \hat{p}_3} \quad \text{for } i = 1,2,3 \quad j = 1,2$$

(2.21)
$$\hat{X}_1 = \frac{1}{|\lambda||\theta|}\begin{bmatrix}\left(\pi_{11}\left(-\psi_{L2}+\phi_{L2}\right)-\pi_{12}\left(\psi_{K2}+\phi_{K2}\right)+\pi_{13}\left(-\psi_{T2}-\phi_{T2}\right)\right)\hat{p}_2 + \\ \left(\pi_{11}\left(-\psi_{L3}-\phi_{L3}\right)-\pi_{12}\left(\psi_{K3}-\phi_{K3}\right)+\pi_{13}\left(-\psi_{T3}+\phi_{T3}\right)+\right)\hat{p}_3\end{bmatrix}$$
$$= \varepsilon_{12}\hat{p}_2 + \varepsilon_{13}\hat{p}_3$$

(2.22)
$$\hat{X}_2 = \frac{1}{|\lambda||\theta|}\begin{bmatrix}\left(\pi_{21}\left(-\psi_{L2}+\phi_{L2}\right)+\pi_{22}\left(\psi_{K2}+\phi_{K2}\right)-\pi_{23}\left(-\psi_{T2}-\phi_{T2}\right)\right)\hat{p}_2 + \\ \left(\pi_{21}\left(-\psi_{L3}-\phi_{L3}\right)+\pi_{22}\left(\psi_{K3}-\phi_{K3}\right)-\pi_{23}\left(-\psi_{T3}+\phi_{T3}\right)+\right)\hat{p}_3\end{bmatrix}$$
$$= \varepsilon_{22}\hat{p}_2 + \varepsilon_{23}\hat{p}_3$$

(2.23)
$$\hat{X}_3 = \frac{1}{|\lambda||\theta|}\begin{bmatrix}\left(-\pi_{31}\left(-\psi_{L2}+\phi_{L2}\right)-\pi_{32}\left(\psi_{K2}+\phi_{K2}\right)+\pi_{33}\left(-\psi_{T2}-\phi_{T2}\right)\right)\hat{p}_2 + \\ \left(-\pi_{31}\left(-\psi_{L3}-\phi_{L3}\right)-\pi_{32}\left(\psi_{K3}-\phi_{K3}\right)+\pi_{33}\left(-\psi_{T3}+\phi_{T3}\right)+\right)\hat{p}_3\end{bmatrix}$$
$$= \varepsilon_{32}\hat{p}_2 + \varepsilon_{33}\hat{p}_3$$

(2.24)
$$|\lambda| = \frac{\lambda_{T2}\lambda_{L1}\lambda_{L3}}{\gamma_{KT}\gamma_{TL}}\left(\gamma_{TL}^3-\gamma_{TL}^1\right)\left(\gamma_{KT}^2-\gamma_{KT}^3\right)+\frac{\lambda_{T1}\lambda_{L2}\lambda_{L3}}{\gamma_{KT}\gamma_{TL}}\left(\gamma_{TL}^3-\gamma_{TL}^2\right)\left(\gamma_{KT}^3-\gamma_{KT}^1\right)\gtrless 0$$

for the conditions implied by (2.9) - (2.12).

It can be shown that the output changes are a weighted average of the factor usage changes at constant output levels since

$$\frac{\pi_{11}-\pi_{12}+\pi_{13}}{|\lambda|} = \frac{\pi_{21}+\pi_{22}-\pi_{23}}{|\lambda|} = \frac{-\pi_{31}-\pi_{32}+\pi_{33}}{|\lambda|} = 1.$$

In other words, relative output price changes with fixed factor endowments induce adjustments in factor intensities in each industry in response to changes in the marginal value product of each factor. As factor intensities change, factors flow between industries until the marginal value product of each factor is equalized across all industries. The changes in output that result from the relative price changes are a weighted average of the factor flows between industries. Albeit this result is not essentially different from a similar trade model without intermediate products, the variable coefficient structure for the intermediate product does add an additional component to the ψ and ϕ terms that may accentuate or dampen the factor flows that would occur with a fixed-coefficient technology or in the absence of an intermediate product.

The Structure Of Demand

Thus far we have focused on the production of output without much consideration of consumption. The demand side of the model may take on a variety of characteristics; nevertheless, we can describe final good consumption in very general terms at the outset and add more structure as needed. Consumers are assumed to maximize their individual utility function subject to a linear budget constraint. We assume further that individual consumer demands resulting from utility maximization can be aggregated into a community utility function that allows us to treat the economy as having a single consumer. Thus, individuals may have identical, quasi-linear or generalized linear preferences; however, the specific preference structure need not be detailed at this point. What is important is that we can represent consumer choices by a community or social utility function that, at least initially, weights all consumers' welfare equally.

Utility maximization is dual to expenditure minimization; inasmuch as, choosing a consumption bundle that minimizes expenditures, while achieving the level of utility attained in the utility maximization problem, results in the same bundle being chosen as the utility maximizing bundle. The expenditure function is the optimal value function resulting from the expenditure minimization problem, and it may be formally defined as $e(\boldsymbol{p},\boldsymbol{u}) \equiv \min_{\boldsymbol{d}}\{\boldsymbol{pd} | U(\boldsymbol{d}) \geq u\}$, where $\boldsymbol{d}$ is the consumption vector, $U(\boldsymbol{d})$ is the direct community utility function and u is the target utility level. As with the revenue function, the properties of the expenditure function are well known (Varian, 1984; Dixit & Norman, 1980), and consequently they are listed here for convenience without proof. The expenditure function (i) is continuous, non-decreasing, concave and homogeneous of degree one in $\boldsymbol{p}$ for fixed u, (ii) is continuous and increasing in utility for fixed $\boldsymbol{p}$, (iii) may be inverted to obtain the indirect utility function, $V(\boldsymbol{p},m)$, with prices and income as arguments, (iv) has a partial derivative with respect to utility that is proportional to the marginal utility of income, and (v) has a partial derivative with respect to prices that yields the vector of optimal compensated final good demands.

Given this general specification of consumer demands it is now possible to close out the model with the balance of payments equation and international equilibrium conditions. The balance of payments condition in (2.25) states that total expenditures for final goods in a country must equal that country's value of net production in equilibrium.

$$(2.25) \qquad X_1(\boldsymbol{p},\boldsymbol{v}) + P_2X_2(\boldsymbol{p},\boldsymbol{v}) + P_3(X_3(\boldsymbol{p},\boldsymbol{v}) - d_3(\boldsymbol{p})) = d_1(p_2,u) + P_2d_2(p_2,u)$$

In the balance of payments equation, $d_3(\boldsymbol{p}) = c_{31}X_1(\boldsymbol{p},\boldsymbol{v}) + c_{32}X_2(\boldsymbol{p},\boldsymbol{v})$ is the derived demand for the intermediate good, and $(X_3\text{-}d_3)$ is net domestic production of the intermediate good. When the intermediate good is traded, this difference may be positive or negative depending upon whether the country is an importer or exporter of the intermediate product. On the right hand side of equation (2.25), $d_i(p_2,u)$ is the compensated demands for good i (i = 1,2,) derived from property (v) of the expenditure function.

Finally, it is assumed that there is a foreign country with an identical technology but differing factor endowments. Therefore the foreign country can be characterized by a set of equations analogous to (2.1)-(2.6) and (2.25). International equilibrium requires that the sum of excess supplies for the global economy be equal to zero in each market. Ignoring transportation costs, free trade implies that the foreign domestic price vector is equal to the home country domestic price vector. These conditions are captured in equations (2.26) and (2.27).[5] The variable $q_i(\boldsymbol{p},u)$ is

[5]It will be the practice throughout this study that foreign variables are denoted with an asterisk when there is only one foreign country.

the compensated excess supply of good i and is defined as $q_i(\boldsymbol{p},u) \equiv X_i(\boldsymbol{p},\boldsymbol{v}) - d_i(\boldsymbol{p},u)$.[6] Furthermore, in the interest of conserving notation, we will define the following derivatives, $q_{ij} \equiv \frac{\partial q_i(\boldsymbol{p},u)}{\partial p_j}$ and $q_{iu} \equiv \frac{\partial q_i(\boldsymbol{p},u)}{\partial u}$ for $i,j = 1,2,3$.

(2.26) $$q_1(\boldsymbol{p},u) + q_1^*(\boldsymbol{p}^*,u^*) = q_2(\boldsymbol{p},u) + q_2^*(\boldsymbol{p}^*,u^*) = q_3(\boldsymbol{p}) + q_3^*(\boldsymbol{p}^*) = 0$$

(2.27) $$\boldsymbol{p} = \boldsymbol{p}^*$$

Following Woodland (1980), the uncompensated excess supply functions may be derived from the compensated excess supplies by substituting the indirect utility function, $V(\boldsymbol{p},m)$, for direct utility. Income for the economy is equal to the gross national product plus tariff revenues (b). Making the appropriate substitution for m gives us the final form of the uncompensated offer curves, $z_i(\boldsymbol{p}, V(p_2, R(\boldsymbol{p},\boldsymbol{v},b))) = z_i(\boldsymbol{p},\boldsymbol{v},b)$ for $i = 1,2$. The compensated and uncompensated excess supplies for the intermediate good are identical since neither excess supply depends upon utility. We will employ the same notational convention as above for the price derivatives of the uncompensated excess supplies.

(2.28) $$z_{ij} = q_{ij} + q_{iu}\left(\frac{\partial V(\boldsymbol{p},m)}{\partial m}\frac{\partial R(\boldsymbol{p},\boldsymbol{v})}{\partial p_j} + \frac{\partial V(\boldsymbol{p},m)}{\partial p_j}\right) = q_{ij} + q_{iu}q_j$$

Normalizing the marginal utility of income to equal one and ignoring tariff revenues for the moment, the relationship between the uncompensated and compensated price derivatives is described in equation (2.28). Thus, as with the standard Slutsky decomposition of substitution and income effects for consumer

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[6]Since we are holding factor endowments constant throughout the analysis, the vector of endowments has been dropped as an argument of excess supply. This convention will also be followed below, and the endowment vector will only be specified as an argument when it is relevant to the discussion.

demands, the uncompensated and compensated price derivatives of excess supply are equal when the income effects (q_{i_u}) are zero.

Conclusions

From the theoretical model we can see that markets for value-added and intermediate goods influence each other through at least three channels. The most obvious connection between bulk commodities and HVPs is the demand relationship for the intermediate good derived from production of the high-value product. Although it is not as easily seen, Equations (2.21)-(2.23) indicate that value-added and intermediate goods are substitutes in production through competition for scarce productive factors when primary factors are fully employed in the economy. Finally, when the production technology of the value-added good allows substitution between primary factors of production and the intermediate good, circumstances in the final goods market that differentially affect primary factor returns and intermediate product prices will cause final good producers to vary their per unit demand for the intermediate product.

Each of these channels may be summarized by one or more elasticities. Intermediate product demand elasticities represent the derived demand connection between final and intermediate product markets. Substitution between two primary factors in the production of either final or intermediate products is captured by the respective input substitution elasticity. Similarly, the substitution between primary factors and intermediate inputs in the production of value-added commodities may also be summarized by an input substitution elasticity. These measures of the two types of input substitution along with cost shares and input usage shares combine to construct own and cross-price supply elasticities. Supply elasticities encompass the latter two connections between bulk commodities and high-value products mentioned above.

Whereas input demand and supply elasticities are functions of substitution elasticities, it is the latter parameters that truly underlie the production connections between value-added and intermediate goods. Their importance is evident in the fact that restrictions must be placed on their relative magnitudes in order to determine the sign of supply and input demand elasticities. Unfortunately, inputs substitution elasticities are difficult to accurately estimate, and empirical researchers are often forced to use estimates of supply and intermediate input demand elasticities that imply substitution elasticities that are inconsistent with each other. As a result, information contained in cross-price elasticities of supply and input demand may, at best, be inaccurate and is often omitted altogether. The empirical model described in chapter V provides one approach for correcting this omission in the present empirical work.

CHAPTER III

COMPARATIVE STATICS

Having specified in the last chapter a complete general equilibrium model of trade in value-added and intermediate goods, it is profitable to employ the model in some comparative static exercises to determine the effect of exogenous price changes on domestic prices and trade levels. This chapter proceeds by first examining the impact of commercial policies implemented by an exporting country, particularly export subsidies. Then the effects of transportation cost reductions are investigated. Finally, the impacts of fluctuations in real exchange rates on prices and trade composition are explored.

Before we can begin the analysis of exogenous price changes, we must be able to assign a positive or negative direction to price derivatives of excess supplies. The first step is to develop expressions for the change in demand resulting from a price change. Since meat demand responds only to the relative price of meat and manufactures, the compensated own-price elasticity of demand, η_{22}, in equation (3.1) captures the necessary information. The intermediate product, however, has a derived demand; hence, changes in both the output levels of the value-added goods and the intermediate input coefficients determine the demand response to a change in commodity prices.

(3.1) $\hat{d}_2 = \eta_{22}\hat{p}_2 \quad \text{where } \eta_{22} < 0.$

(3.2) $\hat{d}_3 = \hat{c}_{31} + \hat{X}_1 + \hat{c}_{32} + \hat{X}_2$

Substituting the appropriate expressions for production and input coefficient changes into equation (3.2) provides us with a relationship between variations in demand and output prices. As with supply elasticities, the demand elasticities for the intermediate good cannot be unambiguously signed; however, they may be

$$(3.3)\qquad \hat{d}_3 = \frac{1}{|\theta|}\left\{\begin{aligned}&\begin{bmatrix}\left(\theta_{K1}\sigma^1_{KL} + \theta_{K2}\sigma^2_{KL} - \theta_{K1}(1-\theta_{31})\sigma^1_{3L} - \theta_{K1}(1-\theta_{32})\sigma^2_{3L}\right)\left(\theta_{T3} - \tilde{\theta}_{T1}\right)\\ +\left(\theta_{T1}(1-\theta_{31})\sigma^1_{3L} + \theta_{T1}(1-\theta_{32})\sigma^2_{3L} - \theta_{T1}\sigma^1_{TL} - \theta_{T2}\sigma^2_{KL}\right)\left(\theta_{K3} - \tilde{\theta}_{K1}\right)\end{bmatrix}\hat{p}_2\\ &\begin{bmatrix}\left(\theta_{K1}\sigma^1_{KL} + \theta_{K2}\sigma^2_{KL} - \theta_{K3}(1-\theta_{31})\sigma^1_{3L} - \theta_{K3}(1-\theta_{32})\sigma^2_{3L}\right)\left(\tilde{\theta}_{T1} - \tilde{\theta}_{T2}\right)\\ +\left(\theta_{T1}\sigma^1_{TL} + \theta_{T2}\sigma^2_{KL} - \theta_{T3}(1-\theta_{31})\sigma^1_{3L} - \theta_{T3}(1-\theta_{32})\sigma^2_{3L}\right)\left(\tilde{\theta}_{K2} - \tilde{\theta}_{K1}\right)\end{bmatrix}\hat{p}_3\end{aligned}\right\}$$

$$+(\varepsilon_{12} + \varepsilon_{22})\hat{p}_2 + (\varepsilon_{13} + \varepsilon_{23})\hat{p}_3$$

$$= (\xi_{32} + \varepsilon_{12} + \varepsilon_{22})\hat{p}_2 + (\xi_{33} + \varepsilon_{13} + \varepsilon_{23})\hat{p}_3 = \eta_{32}\hat{p}_2 + \eta_{33}\hat{p}_3$$

approximately signed by assuming $\sigma^1_{KL} > \sigma^1_{3L} > \sigma^1_{TL}$ and $\sigma^2_{KL} > \sigma^2_{3L} > \sigma^2_{TL}$. These conditions imply that producers of value-added goods substitute inputs of the intermediate product more readily than inputs of land in response to changes in relative factor prices. For example, since production of the intermediate good is relatively intensive in its use of land, an increase in the price of the intermediate good will cause the factor returns to land to rise relative to the returns for other factors of production. The condition above states that value-added producers will have a greater response to the rise in the intermediate good price than to the rise in the price of land, despite the fact that the price of land increases relative to the intermediate input price by the magnification theorem (Jones, 1965). With this ordering of substitution effects, it can be shown that $\xi_{32} > 0$ and $\xi_{33} < 0$. Consequently, unless the cross-price effects in manufactures production dominate, the intermediate input demand elasticity terms may be signed $\eta_{32} > 0$ and $\eta_{33} < 0$.

Using supply and demand elasticities, we can now consider the direction of excess supply price derivatives. Uncompensated own-price derivatives are expressed in terms of elasticities in equations (3.4) and (3.5). Assuming the income effect is small, excess supply for either good varies positively with a change in its own price. Conversely, we see in equations (3.6) and (3.7) that excess supplies vary negatively with changes in other prices. An additional assumption that is crucial

(3.4) $$z_{22} = \varepsilon_{22}\frac{X_2}{p_2} - \eta_{22}\frac{d_2}{p_2} + q_{2u}q_2 > 0$$

(3.5) $$z_{33} = \varepsilon_{33}\frac{X_3}{p_3} - \eta_{33}\frac{d_3}{p_3} > 0$$

(3.6) $$z_{23} = \varepsilon_{23}\frac{X_2}{p_3} + q_{2u}q_3 < 0$$

(3.7) $$z_{32} = \varepsilon_{32}\frac{X_3}{p_2} - \eta_{32}\frac{d_3}{p_2} < 0$$

for the comparative static results below is the following stability condition derived from the quasi-convexity property of the indirect trade utility function (Woodland, 1980). Equation (3.8) simply states that a good's excess supply responds more to a change in the good's own price than to changes in other prices.

(3.8) $$z_{22}z_{33} - z_{23}z_{32} > 0$$

Export Taxes and Subsidies

Employing the above results, we are able to examine the effects of commercial policies implemented by an exporting country. An export tax/subsidy introduces a wedge between the home country's domestic price vector and the foreign country's price vector. The equality between the home and foreign prices in (2.27) is replaced by the relationship in equation (3.9).

(3.9) $$\boldsymbol{p}^{*} = \boldsymbol{sp} = \begin{bmatrix} 1+s_2 & 0 \\ 0 & 1+s_3 \end{bmatrix}\begin{bmatrix} p_2 \\ p_3 \end{bmatrix}$$

The tax rate levied on good *i* is given by $(1+s_i)$ in the $\boldsymbol{s}$ matrix, so an export subsidy is provided for good *i* when s_i is negative.

We begin to solve for domestic price changes as a result of commercial policies by differentiating the equilibrium price relationship in equation (3.9) and the balance of payments and market clearing conditions in equations (2.25) and (2.26).

Assuming the economy is initially at a free trade equilibrium, the resulting system of equations in (3.10) may be solved for the desired price-subsidy derivatives in (3.11).[1]

When the income effects associated with changes in consumers' utility are negligible, the impact of a subsidy for either the HVP or the intermediate good is a rise in the domestic price of the subsidized good. The impact on the price of the unsubsidized good, however, is ambiguous and depends upon the relative magnitudes of the own and cross-price effects in the two countries. In particular,

$$\text{(3.10)} \quad \begin{bmatrix} q_2 & q_3 & -1 \\ q_{22}+\dot{z}_{22} & q_{23}+\dot{z}_{23} & q_{2u} \\ q_{32}+\dot{z}_{32} & q_{33}+\dot{z}_{33} & 0 \end{bmatrix} \begin{bmatrix} dp_2 \\ dp_3 \\ du \end{bmatrix} = \begin{bmatrix} \dot{z}_2 & \dot{z}_3 \\ -\dot{z}_{22} & -\dot{z}_{23} \\ -\dot{z}_{32} & -\dot{z}_{33} \end{bmatrix} \begin{bmatrix} p_2 ds_2 \\ p_3 ds_3 \end{bmatrix}$$

$$\frac{dp_2}{ds_2} = \frac{p_2}{|\Sigma_1|}\left[\left(\dot{z}_{22}\dot{z}_{33} - \dot{z}_{23}\dot{z}_{32}\right) + \left(\dot{z}_{22}z_{33} - z_{23}\dot{z}_{32}\right) + q_{2u}q_2\left(z_{33} + \dot{z}_{33}\right)\right] ? 0$$

$$\frac{dp_2}{ds_3} = \frac{p_3}{|\Sigma_1|}\left[\left(\dot{z}_{23}z_{33} - z_{23}\dot{z}_{33}\right) + q_{2u}q_3\left(z_{33} + \dot{z}_{33}\right)\right] ? 0$$

$$\text{(3.11)} \quad \frac{dp_3}{ds_2} = \frac{p_2}{|\Sigma_1|}\left[\left(\dot{z}_{32}z_{22} - z_{32}\dot{z}_{22}\right) + q_{2u}q_2\left(z_{32} + \dot{z}_{32}\right)\right] ? 0$$

$$\frac{dp_3}{ds_3} = \frac{p_3}{|\Sigma_1|}\left[\left(\dot{z}_{22}\dot{z}_{33} - \dot{z}_{23}\dot{z}_{32}\right) + \left(z_{22}\dot{z}_{33} - \dot{z}_{23}z_{32}\right) + q_{2u}q_3\left(z_{32} + \dot{z}_{32}\right)\right] ? 0$$

$$|\Sigma_1| = -\begin{bmatrix} \left(\dot{z}_{22}\dot{z}_{33} - \dot{z}_{23}\dot{z}_{32}\right) + \left(z_{22}\dot{z}_{33} - \dot{z}_{23}z_{32}\right) + \\ \left(\dot{z}_{22}z_{33} - z_{23}\dot{z}_{32}\right) + \left(z_{22}z_{33} - z_{23}z_{32}\right) \end{bmatrix} < 0$$

one can see from equation (3.12) that an export subsidy for the value-added good is more likely to raise the domestic price for the intermediate good the larger the decline in feed grain excess supply in the home country. Similarly, the larger the

[1]*Derivation of equation (3.10) is more fully explained in Appendix II.*

increase in foreign excess demand for meat and the smaller the response in foreign feed grain markets, the greater the possibility that feed grain prices will rise.

(3.12) $$\frac{\dot{z}_{22}}{\dot{z}_{32}} < \frac{z_{22}}{z_{32}} \Rightarrow \frac{dp_3}{ds_2} < 0$$

(3.13) $$\frac{\dot{z}_{33}}{\dot{z}_{23}} < \frac{z_{33}}{z_{23}} \Rightarrow \frac{dp_2}{ds_3} < 0$$ [2]

Equations (3.12) and (3.13) illustrate a result that is recurrent throughout the comparative statics discussed in this chapter. Specifically, counterintuitive price responses occur in connected markets when there is a large disparity between trading countries in the relative excess supply changes that result from an exogenous price shock. Since these ratios of excess supply derivatives are negative, the perverse price change will more readily occur when the exporting country's excess supply is inelastic in the market experiencing the price shock or when the connected market's response is large. The opposite reactions are needed in the corresponding foreign markets to provide the necessary movements in import demand. It will become apparent below that price levels and costs also play a role in determining the magnitude of price and quantity changes.

We can determine the impact of an export subsidy on the volume of trade by totally differentiating the domestic excess supply schedule as in equation (3.14)

(3.14) $$\frac{dz_i}{ds_j} = z_{i2}\frac{dp_2}{ds_j} + z_{i3}\frac{dp_3}{ds_j},\ i = 2,3;\ j = 2,3.$$

Recognizing that z_{ii} is positive and z_{ij} is negative, we see that an export subsidy will increase (decrease) the excess supply of the subsidized (unsubsidized) good when (3.12) and (3.13) are not satisfied. When perverse cross-price effects do occur, the excess supply response for both the subsidized and unsubsidized goods become

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[2]These conditions are comparable to those derived in Paarlberg (1995).

ambiguous. The greater the cross price effect, the more likely trade volumes will move in counterintuitive directions.

Transportation Costs And Exchange Rates

Transportation costs and exchange rates can be added to the model by modifying the price equilibrium equation (2.27) as shown in (3.15). Transportation costs (T) are the costs incurred in shipping the commodity from the exporting country to the foreign port. The exchange rate (μ) affects all components of the foreign

$$(3.15) \quad \begin{bmatrix} \dot{p}_2 \\ \dot{p}_3 \end{bmatrix} = \begin{bmatrix} p_2 + T_2 & 0 \\ 0 & p_3 + T_3 \end{bmatrix} \mu$$

price proportionally. The equilibrium price relationship may be used in conjunction with the balance of payments and market clearing conditions in equations (2.25) and (2.26) to construct a system of equations for comparative statics.

Differentiating the equilibrium conditions yields the system of differential equations in (3.16) that may be used to solve for price and trade volume changes as the transportation cost or the exchange rate is altered.

$$(3.16) \quad \begin{bmatrix} q_2 & q_3 & -1 \\ q_{22} + \dot{z}_{22}\mu & q_{23} + \dot{z}_{23}\mu & q_{2u} \\ q_{32} + \dot{z}_{32}\mu & q_{33} + \dot{z}_{33}\mu & 0 \end{bmatrix} \begin{bmatrix} dp_2 \\ dp_3 \\ du \end{bmatrix} = \begin{bmatrix} 0 \\ -\dot{z}_{22}(\mu dT_2 + (p_2 + T_2)d\mu) - \dot{z}_{23}(\mu dT_3 + (p_3 + T_3)d\mu) \\ -\dot{z}_{32}(\mu dT_2 + (p_2 + T_2)d\mu) - \dot{z}_{33}(\mu dT_3 + (p_3 + T_3)d\mu) \end{bmatrix}$$

Beginning with transportation costs, the equations in (3.17) indicate that the exporting country's price will rise for a good whose transportation cost declines. The price change, however, is only a fraction of the decrease in transportation costs. Reducing the cost of transporting meat while holding other costs constant causes an ambiguous price response in other markets. Feed grain prices will fall as long as the condition for perverse price effects in (3.12) is not satisfied. Under these circumstances, the reduction in the cost of meat transport causes either a large fall in foreign demands for feed grain or a large decline in home country meat demand. One or more of these changes is sufficient to cause world supply of feed grains to rise faster than world demand, prompting a decline the feed grain price.

$$\frac{dp_2}{d\mathrm{T}_2} = \frac{\mu}{|\Sigma_2|}\left[\left(\dot{z}_{22}\dot{z}_{33} - \dot{z}_{23}\dot{z}_{32}\right)\mu + \left(\dot{z}_{22}z_{33} - z_{23}\dot{z}_{32}\right)\right] < 0$$

$$\frac{dp_2}{d\mathrm{T}_3} = \frac{\mu}{|\Sigma_2|}\left[\left(\dot{z}_{23}z_{33} - z_{23}\dot{z}_{33}\right)\right] ? 0$$

$$\text{(3.17)} \quad \frac{dp_3}{d\mathrm{T}_2} = \frac{\mu}{|\Sigma_2|}\left[\left(\dot{z}_{32}z_{22} - z_{32}\dot{z}_{22}\right)\right] ? 0$$

$$\frac{dp_3}{d\mathrm{T}_3} = \frac{\mu}{|\Sigma_2|}\left[\left(\dot{z}_{22}\dot{z}_{33} - \dot{z}_{23}\dot{z}_{32}\right)\mu + \left(z_{22}\dot{z}_{33} - \dot{z}_{23}z_{32}\right)\right] < 0$$

$$|\Sigma_2| = -\begin{bmatrix} \left(\dot{z}_{22}\dot{z}_{33} - \dot{z}_{23}\dot{z}_{32}\right)\mu^2 + \left(z_{22}\dot{z}_{33} - \dot{z}_{23}z_{32}\right)\mu + \\ \left(\dot{z}_{22}z_{33} - z_{23}\dot{z}_{32}\right)\mu + \left(z_{22}z_{33} - z_{23}z_{32}\right) \end{bmatrix} < 0$$

Making the appropriate modifications to equation (3.14) permits one to assess the impact of transportation cost reductions on trade volumes. As with the export subsidy, trade increases for the good experiencing a decline in its cost of transportation, but trade in other goods falls. It is important to point out that both the price and trade responses discussed above are dependent upon the assumption that transportation costs are added to the home country's domestic price. If, rather, the transportation cost for a good were subtracted from the home country price, a decline in the absolute size of the price wedge constitutes a rise in procurement costs for the importing country. Consequently the price and trade volume changes would switch direction. The importance of the manner in which transportation costs are imputed will become more apparent in the empirical chapters.

Solving the system of equations in (3.16) for price changes with respect to movements in the exchange rate results in the relationships shown in (3.18).

(3.18)
$$\frac{dp_2}{d\mu} = \frac{1}{|\Sigma_2|}\begin{bmatrix}\left(\left(\dot{z}_{22}\dot{z}_{33} - \dot{z}_{23}\dot{z}_{32}\right) + \left(\dot{z}_{22}z_{33} - z_{23}\dot{z}_{32}\right)\right)(p_2 + \mathrm{T}_2) + \\ \left(\dot{z}_{23}z_{33} - z_{23}\dot{z}_{33}\right)(p_3 + \mathrm{T}_3)\end{bmatrix} ?\, 0$$

$$\frac{dp_3}{d\mu} = \frac{1}{|\Sigma_2|}\begin{bmatrix}\left(\left(\dot{z}_{22}\dot{z}_{33} - \dot{z}_{23}\dot{z}_{32}\right) + \left(z_{22}\dot{z}_{33} - \dot{z}_{23}z_{32}\right)\right)(p_3 + \mathrm{T}_3) + \\ \left(z_{22}\dot{z}_{32} - z_{32}\dot{z}_{22}\right)(p_2 + \mathrm{T}_2)\end{bmatrix} ?\, 0$$

Assuming the third term in the brackets on the right hand side of the equations in (3.18) does not dominate the expression, we obtain the intuitive result that a real exchange rate depreciation raises the domestic price of both value-added and intermediate goods. When we take a closer look at the conditions for a domestic price decline, an important difference is revealed in the responses of the two types of goods to exchange fluctuations. As long as the conditions in (3.12) and (3.13) are

(3.19)
$$\frac{(p_2 + \mathrm{T}_2)}{(p_3 + \mathrm{T}_3)} < \frac{\left(\dot{z}_{33}z_{23} - \dot{z}_{23}z_{33}\right)}{\left(\dot{z}_{22}\dot{z}_{33} - \dot{z}_{23}\dot{z}_{32}\right) + \left(\dot{z}_{22}z_{33} - \dot{z}_{32}z_{23}\right)} \Rightarrow \frac{dp_2}{d\mu} > 0$$

$$\frac{(p_3 + \mathrm{T}_3)}{(p_2 + \mathrm{T}_2)} < \frac{\left(\dot{z}_{22}z_{32} - \dot{z}_{32}z_{22}\right)}{\left(\dot{z}_{22}\dot{z}_{33} - \dot{z}_{23}\dot{z}_{32}\right) + \left(\dot{z}_{33}z_{22} - \dot{z}_{23}z_{32}\right)} \Rightarrow \frac{dp_3}{d\mu} > 0$$

not satisfied, both sides of (3.19) are positive; therefore, the inequality will be most likely satisfied for intermediate goods. This is true because the transportation-inclusive price of the value-added good will exceed the intermediate good price, except when the cost of transporting the intermediate good is sufficiently large relative to the cost of transporting the high-value product. Even when intermediate good prices do not decline after an exchange rate depreciation, equation (3.18) shows that a movement in the exchange rate is not likely to affect domestic prices in the same proportion or even the same direction.

Employing equation (3.14), we find that the direction of trade volume movements is ambiguous when prices of final and intermediate goods both rise with a depreciation of the real exchange rate. High-value goods may be more likely to experience an increase in trade if bulk commodities tend to have larger cross-price effects relative to value-added goods. When the intermediate good price decreases as the exchange rate declines, trade in value-added goods unambiguously increases, and exchange of bulk commodities is certain to fall.

Summary And Conclusions

In this chapter the reaction of domestic prices and trade volumes to exogenous price shocks was examined. In general, the quantity traded and price will increase for a good whose exports are subsidized or whose transportation cost declines. Either of these price shocks will cause trade volumes and prices to decline in markets indirectly affected. Nevertheless, perverse price and trade changes may result when excess supply reactions differ greatly among linked goods and trading nations.

A depreciation of a country's real exchange rate will most often cause quantities traded and prices to rise. Value-added and intermediate goods, however, may be differentially affected by fluctuation in currency values, potentially causing a shift in the commodity composition of trade. The relative size of cross-price effects, as well as relative price levels, are important in determining which good will experience the larger price and trade volume change. Empirical results are needed to determine whether or not there is a consistent pattern in the responses of value-added and intermediate goods to exchange rate fluctuations.

CHAPTER IV

OPTIMAL TRADE POLICIES

One goal in modeling this economy is to study the effects of commercial policies employed by exporters and importers on prices, exports and the location of marginal production. It is helpful in understanding the set of beneficial policies for each type of country to examine the optimal commercial policy rule in a variety of settings. We begin our investigation in a two-country setting by examining the price wedge chosen when policy makers seek to maximize national welfare as summarized by the community utility function. The analysis is expanded to consider second-best price discrimination arguments for export subsidies by adding another importing country. Finally, it is assumed that policy makers perceive that it is beneficial to increase local production of value-added goods and, therefore, choose a trade tax/subsidy to maximize the total value added in the high-value agricultural industry.

Utility Maximization: The Two-Country Case

Following Feenstra's (1986) adaptation of Woodland's (1980) method for deriving optimal trade policies, we begin by assuming that the home country exports both meat and feed grains, and it levies an *ad velorem* export tax/subsidy on one or both of the exported goods. Since we have normalized by the price of manufactures, we can consider intervention in only the value-added and intermediate good markets without loss of generality. The relationship between home country and foreign prices is given in equation (3.9) above. In addition to specifying the price wedge, we must augment the balance of payments equation to reflect the tax revenue or subsidy cost. This is accomplished in equation (4.1), which states that the sum value of excess supplies in the home country and tax revenue must equal zero.

$$(4.1) \qquad q_1(\boldsymbol{p},u)+p_2q_2(\boldsymbol{p},u)+p_3q_3(\boldsymbol{p})+(p_2-p_2^*)z_2^*(\boldsymbol{p}^*)+(p_3-p_3^*)z_3^*(\boldsymbol{p}^*)=0$$

The objective for the home country is to maximize utility by choosing the price wedge $(\boldsymbol{p}-\boldsymbol{p}^*)$ subject to the balance of payments constraint. First-order conditions may be found by differentiating (4.1) with respect to utility and home country prices, yielding the expression below. The equation may be greatly simplified by noting that the optimality of the compensated excess supply functions implies that the sum value

$$\begin{aligned}&(q_{1u}+p_2q_{2u})du+(q_{12}+p_2q_{22}+p_3q_{32})dp_2+(q_{13}+p_2q_{23}+p_3q_{33})dp_3\\&+(q_2+z_2^*)dp_2+(q_3+z_3^*)dp_3=0\end{aligned},$$

of excess supplies cannot increase at equilibrium prices. Consequently, the second and third terms on the left hand side are zero. Similarly, by normalizing the marginal utility of income to equal one, it can be shown that the Engle aggregation condition for income elasticities implies $q_{1u}+p_2q_{2u}=-1$. The simplified expression is set equal to zero to provide the following two first-order conditions, which are simply a restatement of the market clearing conditions in (2.26).

$$(4.2) \qquad \begin{aligned}\frac{du}{dp_2}&=(q_2+z_2^*)=0\\ \frac{du}{dp_3}&=(q_3+z_3^*)=0\end{aligned}$$

By differentiating (4.1) with respect to foreign prices and utility and simplifying, we derive two additional optimization conditions. The bar over prices denotes that these are the optimal prices. From the matrix form of the optimal price wedge rule,

$$(3.3) \qquad \left.\begin{aligned}\frac{du}{dp_2^*}&=(\bar{p}_2-\bar{p}_2^*)z_{22}^*+(\bar{p}_3-\bar{p}_3^*)z_{32}^*=z_2^*\\ \frac{du}{dp_3^*}&=(\bar{p}_2-\bar{p}_2^*)z_{23}^*+(\bar{p}_3-\bar{p}_3^*)z_{33}^*=z_3^*\end{aligned}\right\}\Rightarrow(\bar{p}-\bar{p}^*)=z_p^{*-1}z^*$$

it is evident that we have obtained a generalization of the standard optimal tariff result; namely, the optimal tax/subsidy is equal to the inverse price elasticity of the foreign offer curve. The specific solutions for the optimal taxes are

$$(4.4) \qquad \begin{aligned} s_2 &= \frac{1}{p_2}\left[\frac{\dot{z}_3\dot{z}_{32} - \dot{z}_2\dot{z}_{33}}{\dot{z}_{22}\dot{z}_{33} - \dot{z}_{23}\dot{z}_{32}}\right] \\ s_3 &= \frac{1}{p_3}\left[\frac{\dot{z}_2\dot{z}_{23} - \dot{z}_3\dot{z}_{22}}{\dot{z}_{22}\dot{z}_{33} - \dot{z}_{23}\dot{z}_{32}}\right] \end{aligned}.$$

Using the identical optimal policy expression, Feenstra established that a general export subsidy may be an optimal commercial policy provided that the linked goods are sufficiently strong complements in the importing country. Thus, it is of interest to determine if it is ever optimal, based on Feenstra's proposition, to subsidize the value-added good. Assuming the denominator of the bracketed term is positive by the stability conditions (Woodland, 1980), we find that s_2 is negative for $\frac{\dot{z}_{32}}{\dot{z}_{33}} > \left|\frac{\dot{z}_2}{\dot{z}_3}\right|$. We can expand this condition in terms of supply and demand elasticities as in equation (4.5). Using the signs determined in the last chapter for the elasticities, we quickly see that left hand side is negative; hence, the condition for an export subsidy cannot be satisfied. This conclusion is important because it demonstrates that general export subsidies for HVPs cannot be supported as an

$$(4.5) \qquad \frac{\dot{\varepsilon}_{32}X_3 - \dot{\eta}_{32}d_3}{\dot{\varepsilon}_{33}X_3 - \dot{\eta}_{33}d_3} > \frac{|\dot{z}_2|}{|\dot{z}_3|}\frac{\dot{p}_2}{\dot{p}_3}$$

optimal policy by Feenstra's market linkages proposition. The reason for the proposition's failure is that intermediate and value-added goods are trade substitutes at home and abroad in the sense that increasing the price of one good decreases the export supply of the other good. Similar arguments could be made against an export subsidy for the bulk commodity.

Utility Maximization: The Three-Country Case

Abbott, Sharples and Paarlberg (1987) and Dutton (1990) have argued that targeted export subsidies may be welfare-enhancing or even a second-best commercial policy when a monopolizing exporter cannot, for some reason, levy the optimal export tax to price discriminate in importing markets. As Dutton explains, by not discriminating against one of the importing countries, the domestic and foreign rates of transformation differ between the exporting and the non-targeted nation. When the market power of the exporting nation is small in the targeted market relative to its market power in the other importing country and when the volume of exports to the non-targeted country is large, it is more likely that the optimal policy will be an export subsidy.

In order to consider this argument for subsidized exports of high-value agricultural products, the analysis above must be modified to incorporate a second importing country. First, the market equilibrium conditions in (2.26) are adjusted as in (4.6) to accommodate international market clearing for three countries. Second, the balance of payments equation is rewritten to reflect country 1 as the targeted country.[1] Finally, it should be noted that the international price linkage between the home country and country 1 is characterized by equation (3.9), while the home and country 2 exhibit the free trade price relationship in equation (2.27).

$$(4.6) \qquad q_2(\boldsymbol{p},u) + z_2^1(\boldsymbol{p}^1) + z_2^2(\boldsymbol{p}^2) = q_3(\boldsymbol{p},u) + z_3^1(\boldsymbol{p}^1) + z_3^2(\boldsymbol{p}^2) = 0$$

$$(4.7) \qquad q_1(\boldsymbol{p},u) + p_2 q_2(\boldsymbol{p},u) + p_3 q_3(\boldsymbol{p}) + (p_2 - p_2^1) z_2^1(\boldsymbol{p}^1) + (p_3 - p_3^1) z_3^1(\boldsymbol{p}^1) = 0$$

---

[1]Throughout the discussion of the three-country case, the exporting country (home country) variables do not carry a superscript, while the importing country variables are differentiated by the superscripted number.

Differentiating the two market clearing conditions and the balance of payments equation with respect to home country prices, utility, and country 1 prices yields the system of equations in (4.8) that may be solved for the optimal commercial policy. Cramer's rule is employed to find du/dp_2^1 and du/dp_3^1, and we set these first order conditions equal to zero to solve for the optimal price wedges given in equation (4.9).

$$
\begin{bmatrix} (q_2+z_2^1) & (q_3+z_3^1) & -1 \\ (q_{22}+z_{22}^1) & (q_{23}+z_{23}^1) & q_{2u} \\ (q_{32}+z_{32}^1) & (q_{33}+z_{33}^1) & 0 \end{bmatrix} \begin{bmatrix} dp_2 \\ dp_3 \\ du \end{bmatrix} = \begin{bmatrix} \left(z_2^1-(p_2-p_2^1)z_{22}^1-(p_3-p_3^1)z_{32}^1\right) & \left(z_3^1-(p_2-p_2^1)z_{23}^1-(p_3-p_3^1)z_{33}^1\right) \\ -z_{22}^1 & -z_{23}^1 \\ -z_{32}^1 & -z_{33}^1 \end{bmatrix} \begin{bmatrix} dp_2^1 \\ dp_2^2 \end{bmatrix} \tag{4.8}
$$

$$
\begin{aligned}
s_2^1 &= \frac{1}{p_2}\left[\frac{z_3^1 z_{32}^1 - z_2^1 z_{33}^1}{z_{22}^1 z_{33}^1 - z_{23}^1 z_{32}^1}\right] - \frac{1}{p_2}\left[\frac{z_3^2(q_{32}+z_{32}^2) - z_2^2(q_{33}+z_{33}^2)}{(q_{22}+z_{22}^2)(q_{33}+z_{33}^2)-(q_{23}+z_{23}^2)(q_{32}+z_{32}^2)}\right] \\
s_3^1 &= \frac{1}{p_3}\left[\frac{z_2^1 z_{23}^1 - z_3^1 z_{22}^1}{z_{22}^1 z_{33}^1 - z_{23}^1 z_{32}^1}\right] - \frac{1}{p_3}\left[\frac{z_2^2(q_{23}+z_{23}^2) - z_3^2(q_{22}+z_{22}^2)}{(q_{22}+z_{22}^2)(q_{33}+z_{33}^2)-(q_{23}+z_{23}^2)(q_{32}+z_{32}^2)}\right]
\end{aligned} \tag{4.9}
$$

The price wedge is composed of two elements, the first of which is the optimal tariff for the targeted country in the two-country case. The second term is the inverse derivative of the residual excess supply with respect to price multiplied by the excess supply vector for the non-targeted country. This second expression captures the effects the price wedge introduces in the exporting and non-targeted countries through the change in the exporting country's domestic price. Thus, the optimal tariff for exports to the targeted country is reduced by the tariff's impact on the rest of the world. If this secondary impact is large, then the optimal targeted tariff may be a subsidy. Thus, price discrimination arguments for export subsidies remain valid when the subsidized goods are either HVPs or bulk commodities.

Value Added Maximization

As an alternative to the utility maximization approach employed above, the optimal policy shall be derived below for a country whose policy makers seek to maximize the total value-added in the high-value agricultural industry. Such a policy goal may be founded upon the arguments for domestic value-added production presented in chapter I. It was noted in that discussion that the validity of promoting domestic production of value-added goods is critically dependent upon the underlying assumptions about resource availability and foreign production elasticity; nevertheless, value added maximization is imbedded in the sort of policy that is often proposed in informal discussions and government debates.

The optimization problem may be formally stated in the two-country case as

$$\max_{p,\dot{p}} \{X_2\Lambda\} \text{ , where } \Lambda = (p_2 - c_{32}p_3),$$

$$\text{subject to } q_1 + p_2q_2 + p_3q_3 + (p_2 - \dot{p}_2)\dot{z}_2 + (p_3 - \dot{p}_3)\dot{z}_3 = 0$$

$$q_2 + \dot{z}_2 = 0$$

$$q_3 + \dot{z}_3 = 0.$$

Λ is the value added from producing one unit of the high-value product. The constraints are the balance of payments condition and the world market clearing equations for goods 2 and 3. Writing the problem in lagrangian form, totally differentiating, and simplifying results in the first order conditions below.
The μ_i are the lagrange multipliers corresponding to the respective optimization constraints.

The conditions in (4.10) can be used to solve for the lagrange multipliers. Substituting the resulting expressions back into (4.10) and evaluating around the free trade equilibrium, we can manipulate the equations to form the system in (4.11) that may be solved for the value-added maximizing trade policies in (4.12).[2] The bar over the price wedges on the right-hand side of the optimal policy rules denotes that these price wedges are the utility maximizing price wedge from equation (3.3). A can be interpreted as the change in value added as exports of the HVP increase. Similarly, B is the change in value added as exports of the intermediate good increase.

(4.10)
$$
\begin{aligned}
\frac{dL}{dp_2} &= \frac{\partial \Lambda}{\partial p_2} X_2 + \Lambda \frac{\partial X_2}{\partial p_2} + \mu_2 (q_{22} + q_{2u} du) + \mu_3 q_{32} - \mu_1 du = 0 \\
\frac{dL}{dp_3} &= \frac{\partial \Lambda}{\partial p_3} X_2 + \Lambda \frac{\partial X_2}{\partial p_3} + \mu_2 (q_{23} + q_{2u} du) + \mu_3 q_{33} - \mu_1 du = 0 \\
\frac{dL}{d\dot{p}_2} &= \mu_2 \dot{z}_{22} + \mu_3 \dot{z}_{32} - \mu_1 \left((p_2 - \dot{p}_2) \dot{z}_{22} + (p_3 - \dot{p}_3) \dot{z}_{32} - \dot{z}_2 \right) = 0 \\
\frac{dL}{dp_2} &= \mu_2 \dot{z}_{23} + \mu_3 \dot{z}_{33} - \mu_1 \left((p_2 - \dot{p}_2) \dot{z}_{23} + (p_3 - \dot{p}_3) \dot{z}_{33} - \dot{z}_3 \right) = 0
\end{aligned}
$$

(4.11)
$$
\begin{bmatrix}
q_{2u} q_2 \mathrm{A} \frac{(\dot{z}_{23} - \dot{z}_{22})}{|\dot{z}|} - \mathrm{B} & q_{2u} q_2 \mathrm{A} \frac{(\dot{z}_{33} - \dot{z}_{32})}{|\dot{z}|} + \mathrm{A} \\
\dot{z}_2 & \dot{z}_3
\end{bmatrix}
\begin{bmatrix}
(p_2 - \dot{p}_2) \\
(p_3 - \dot{p}_3)
\end{bmatrix}
=
\begin{bmatrix}
q_{2u} q_2 \mathrm{A} \frac{(\dot{z}_3 - \dot{z}_2)}{|\dot{z}|} - \left(\overline{p_2 - \dot{p}_2}\right) \mathrm{B} + \left(\overline{p_3 - \dot{p}_3}\right) \mathrm{A} \\
0
\end{bmatrix}
$$

[2]The details of obtaining the system of equations in (4.11) are described in Appendix II.

Neither of these effects can be signed *a priori,* and the direction of the change in value added depends upon the relative magnitudes of the variations in excess supplies, domestic prices, and intermediate input coefficients in response to the price wedge. Likewise, one cannot determine unambiguously whether the optimal policy involves tariffs or subsidies; nevertheless, we can draw some interesting conclusions from the expressions in (4.12).

$$\mathrm{A}=\left(\frac{\partial\Lambda}{\partial p_3}X_2+\Lambda\frac{\partial X_2}{\partial p_3}\right)q_{32}-\left(\frac{\partial\Lambda}{\partial p_2}X_2+\Lambda\frac{\partial X_2}{\partial p_2}\right)q_{33}$$

$$\mathrm{B}=\left(\frac{\partial\Lambda}{\partial p_2}X_2+\Lambda\frac{\partial X_2}{\partial p_2}\right)q_{23}-\left(\frac{\partial\Lambda}{\partial p_3}X_2+\Lambda\frac{\partial X_2}{\partial p_3}\right)q_{22}$$

$$\left(p_2-p_2^{\cdot}\right)=\frac{1}{\Xi}\left[z_3^{\cdot}\left(\frac{q_{2u}q_2\mathrm{A}\left(z_3^{\cdot}-z_2^{\cdot}\right)}{\left|z^{\cdot}\right|}+\mathrm{A}\left(\overline{p_3-p_3^{\cdot}}\right)-\mathrm{B}\left(\overline{p_2-p_2^{\cdot}}\right)\right)\right]$$

$$(4.12)\quad \left(p_3-p_3^{\cdot}\right)=\frac{-1}{\Xi}\left[z_2^{\cdot}\left(\frac{q_{2u}q_2\mathrm{A}\left(z_3^{\cdot}-z_2^{\cdot}\right)}{\left|z^{\cdot}\right|}+\mathrm{A}\left(\overline{p_3-p_3^{\cdot}}\right)-\mathrm{B}\left(\overline{p_2-p_2^{\cdot}}\right)\right)\right]$$

$$\Xi=q_{2u}q_2\mathrm{A}\left(\frac{\left(z_3^{\cdot}-z_2^{\cdot}\right)\left(z_{23}^{\cdot}-z_{32}^{\cdot}\right)}{\left|z^{\cdot}\right|}-\left(\overline{p_3-p_3^{\cdot}}\right)-\left(\overline{p_2-p_2^{\cdot}}\right)\right)-z_3^{\cdot}\mathrm{B}-z_2^{\cdot}\mathrm{A}$$

First, note that the optimal commercial policy under value added maximization differs from the policy that maximizes utility. Moreover, the value-added-maximizing policy includes the utility-maximizing price wedge in a weighted sum of income effects, where the weights are the derivatives of value added with respect to exports. Second, when income effects are negligible, the optimal policy for the large country greatly simplifies, but it does not reduce to the utility maximizing policy. This can be more clearly seen in equation (4.13). Depending upon the relative volume of

$$(4.13)\qquad \begin{aligned}(p_2 - \dot{p_2}) &= \frac{\left[-q_3\mathrm{A}\left(\overline{p_3 - \dot{p_3}}\right) + q_3\mathrm{B}\left(\overline{p_2 - \dot{p_2}}\right)\right]}{q_3\mathrm{B} + q_2\mathrm{A}} \\ (p_3 - \dot{p_3}) &= \frac{\left[q_2\mathrm{A}\left(\overline{p_3 - \dot{p_3}}\right) - q_2\mathrm{B}\left(\overline{p_2 - \dot{p_2}}\right)\right]}{q_3\mathrm{B} + q_2\mathrm{A}}\end{aligned}$$

trade and the signs and relative magnitudes of A and B, it is possible that the optimal policy may be a subsidy over some range of parameter values. In addition, the sign of the policy for the intermediate good is likely to be opposite that of the value-added good. Thus, when the optimal tariff schedule includes an export subsidy for HVPs, the appropriate policy in the bulk commodity markets is an export tax. Finally, the optimal policy for a small country is still free trade when income effects are ignored.

Conclusions

The investigation of optimal trade policies has led to a number of interesting conclusions regarding export promotion for HVPs. First, when policy makers seek to maximize national welfare, the optimal trade policy for an exporting country is a tax on both high-value and bulk products. A general export subsidy for either good will reduce national welfare.

Second, when there is more than one importing country, a targeted export subsidy on either good may be improve welfare in the exporting country. In general, the subsidy will be more beneficial for the exporting nation when the targeted market is small relative to the unsubsidized market. Welfare effects are also larger the greater the degree of market power possessed by the exporting country in the unsubsidized market.

Subsidization of value-added exports may also be rationalized as an optimal policy for countries desiring to maximize total value added in high-value industries. A subsidy is more likely the larger the response of value added to changes in high-value exports. The magnitude of the optimal price wedge is dependent upon the market power possessed by the exporting country as well as the relative volume of trade in bulk and high-value commodities.

Finally, regardless which objective function is optimized, the policy rule contains a schedule of price wedges. In most cases it would be incorrect to discuss an optimal policy for one good without recognizing that the maximum value of the criterion function depends upon policies implemented in other markets as well. This fact points again to the notion that trade intervention in one market should be discussed and implemented as part of a set of policies that consider the ramifications of each component for other markets.

CHAPTER V

THE SIMULATION MODEL AND DATA SET

The remaining chapters consist of an empirical application of the theory discussed above through simulations of various exogenous price changes in the meat and feed grain industries. Meat and feed grain industries were selected for a variety of reasons. First, empirical agricultural applications of the theory of welfare-enhancing export subsidies have been confined predominately to analyses of the wheat market (Abbott et al., 1987; Seitzinger & Paarlberg, 1990; Anania, Bohman, & Carter, 1992; and Paarlberg, 1995). Albeit Haley (1990) is one of the few studies to address export subsidies for meat products, he did not consider substitution of other meat products for poultry demand, nor did he adequately address the trade off between feed grain and poultry exports. Second, export subsidies currently exist for poultry and poultry feed; hence, the results obtained from the proposed investigation are relevant to current policies. Finally, a significant share of corn imports by many countries is used for livestock and poultry feed, particularly countries in Africa, the Middle-east, and east Asia. Imports of corn and meat products are closely linked to domestic meat production in these countries, and commercial policies may greatly influence US sales in these markets.

This chapter proceeds with a detailed description of the simulation model and the equations used to calculate derived demand and supply elasticities. Next, the data and parameters values are discussed. The chapter ends with remarks concerning various policy scenarios and other changes to be simulated.

The Simulation Model

Application of the theoretical trade model to actual data is greatly simplified by employing a number of assumptions and restrictions on primary factors and their interaction among production sectors. First, land and capital are prohibited from moving between sectors of the economy; moreover, we can combine these two primary factors into a single, sector-specific factor. By fixing the quantity of sector-specific capital in each industry, the equilibria from the model can be viewed as being attained in the short or medium term, perhaps over a two to three year period following a shock. It should be noted that depreciated capital is assumed to be replaced, but capital growth is excluded by assumption.

Second, the supply of labor to the meat and feed grain industries is assumed to be perfectly elastic. This assumption reflects the smallness of the these sectors relative to the rest of the economy, in that final and intermediate good price changes do not induce factor flows of sufficient magnitude to alter the returns to labor, the only remaining mobile input. The shape of the labor supply curve is incorporated into the empirical model by holding the wage rate constant, effectively making the model partial equilibrium in nature.[1]

Finally, we only consider the use of feed grains by meat producers. Corn and soy bean meal used in the dairy industry or other agricultural and manufacturing sectors are subtracted from the total supply of these feed grains. Consequently, the supply of corn and soy bean meal used in the model below can be viewed as a residual supply.

The simulations consider trade among three countries: the United States, Japan, and the rest of the world (ROW). Each country produces and trades three meat products (beef, pork, and broilers) from a variable input (labor), an industry-specific input (capital), and feed grains (corn and soy bean meal) in a linearly homogeneous production process. Feed grains are also produced from labor and

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[1]The empirical model is a partial equilibrium version of the specific-factor trade model (Mayer, 1974; Dixit & Norman, 1980) and has been employed in similar agricultural applications by Paarlberg (1995).

industry-specific capital in each country, and they may be traded internationally. As in chapter II, all primary factors are assumed to be internationally immobile.

Following the conventions established in chapter II, variables are defined below.

$X_1^h(\mathbf{p}^h, \mathbf{v}^h)$ = the gross production of beef in country *h*.

$X_2^h(\mathbf{p}^h, \mathbf{v}^h)$ = the gross production of pork in country *h*.

$X_3^h(\mathbf{p}^h, \mathbf{v}^h)$ = the gross production of broilers in country *h*.

$X_4^h(\mathbf{p}^h, \mathbf{v}^h)$ = the gross production of corn in country *h*.

$X_5^h(\mathbf{p}^h, \mathbf{v}^h)$ = the gross production of soy bean meal in country *h*.

K_i^h = the capital input into the production of good *i* in country *h, i* = 1,2,3,4,5.

w^h = the price of labor in country *h*.

r_i^h = the price of capital in sector *i* in country *h, i* = 1,2,3,4,5.

p_i^h = the output price of good *i* in country *h, i* = 1,2,3,4,5.

m^h = income in country

$c_{ij}^{hj} = \dfrac{\partial c^{hj}(\omega^h)}{\omega_i^h}$ is the input coefficient of the i^{th} factor in the production of one unit of the j^{th} good in country *h,* where $c^{hj}(\omega^h)$ is the unit cost function for in the j^{th} industry (*i* = L,K,4,5; *j* = 1,2,3,4,5).

$d_i\,(p,m)$ = Marshallian demand for good *i* = 1,2,3.

$\theta_{Li}^h = \dfrac{w^h c_{Li}^h}{p_i^h}$; $\theta_{Ki}^h = \dfrac{r_i^h c_{Ki}^h}{p_i^h}$ for *i* = 1,2,3,4,5 are primary input cost shares.

$\theta_{ij}^h = \frac{p_i^h c_{ij}^h}{p_j^h}$ for $i =$ 4,5 and $j = 1,2,3$ are intermediate input cost shares.[2]

Unlike the general equilibrium version in chapter II, the supply of labor to the meat and feed grain sectors is infinitely elastic, and hence a country's labor endowment is not fully employed by the meat and feed grain sectors. Therefore, we do not need an employment equation for the labor market. Capital, on the other hand, is assumed to be fixed within a particular sector and may not be used in the production of any goods outside its specific sector. Equation (5.1) below expresses the condition that sector-specific capital must be fully employed in each industry.

(5.1) $K_i^h = c_{Ki}^h X_i^h(\mathbf{p}^h)$ $\quad i = 1,2,3,4,5;\ h =$ US, JAP, ROW.

As in chapter II, it is assumed that all industries price their products and purchase their inputs competitively. Equations (5.2) and (5.3) state that marginal costs equal output price in equilibrium in each industry.

(5.2) $p_i = wc_{Li} + r_i c_{Ki} + p_4 c_{4i} + p_5 c_{5i}$ for $i =$ 1,2,3

(5.3) $p_j = wc_{Lj} + r_j c_{Kj}$ for $j =$ 4,5

Using equations (5.1)-(5.3) we may derive expressions for changes in final and intermediate good supply as a function of output prices. Formulating the total differential of (5.1) in rate-of-change notation, we see in (5.4) that the output supply rate of change depends upon variations in the specific-factor endowment and the quantity of capital used to produce a unit of output. This rather restrictive condition is the result of the limited substitution of factors across industries, as well as the

(5.4) $\hat{X}_i = \hat{K}_i - \hat{c}_{Ki}$ $\quad i = 1,2,3,4,5$

---

[2]In order to conserve notation, country superscripts are omitted below except when necessary to avoid confusion.

partial equilibrium structure of the model. Holding capital endowments in each industry constant and substituting for the capital input coefficient rate of change, we obtain the desired statement of supply changes as a function of prices.[3]

$$(5.5)\quad \hat{X}_i = \frac{(1-\theta_{Ki})\sigma^i_{KL}}{\theta_{Ki}}\hat{p}_i - \frac{\theta_{4i}\left[(1-\theta_{Ki})\sigma^i_{KL} + \theta_{Ki}\sigma^i_{4L}\right]}{\theta_{Ki}}\hat{p}_4 - \frac{\theta_{5i}\left[(1-\theta_{Ki})\sigma^i_{KL} + \theta_{Ki}\sigma^i_{5L}\right]}{\theta_{Ki}}\hat{p}_5 \quad \text{for i = 1,2,3.}$$

$$(5.6)\quad \hat{X}_j = \frac{(1-\theta_{Kj})\sigma^j_{KL}}{\theta_{Kj}}\hat{p}_j \quad \text{for } j = 4,5.$$ [4]

Equations (5.5) and (5.6) imply own-price and cross-price supply elasticities that are comparable to those derived in chapter II. In particular, output price changes with fixed capital endowments force marginal factor productivities and, hence, factor returns from their equilibrium levels. In order to restore equilibrium, producers seek to substitute capital for labor and intermediate inputs to minimize production costs. Thus, as equations (5.5) and (5.6) make clear, the magnitude of the supply response to price changes depends critically on the importance of capital in the production process and on the ability to substitute capital for other inputs. In general, the smaller capital's share of production costs and the greater the ability to substitute capital for other inputs, the larger the supply response to price changes.

Thus far the specification of the empirical model has been general enough to allow for a wide variety of linear homogeneous production functions Implementation of the model requires specification of a particular functional form. This study

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[3]The derivation of equations (5.5) and (5.6) is detailed in the Appendix III.

[4]It has been assumed that $\hat{w} = 0$ in equations (5.5) and (5.6); consequently, input substitution elasticities (σ^i_{jL}, j = K,4,5; i = 1,2,3,4,5) are Morischima substitution elasticities. Details are found in the Appendix III.

employs the constant elasticity form shown in equation (5.7) because a minimal number of parameters need be assumed or drawn from other sources.

$$(5.7)\qquad \begin{aligned} X_i(p) &= e^{\beta_i} p_i^{\varepsilon_{ii}} \prod_{j=4}^{5} p_j^{\varepsilon_{ij}} \text{ for } i = 1,2,3; \\ X_i(p) &= e^{\beta_i} p_i^{\varepsilon_{ii}} \text{ for } i = 4,5; \end{aligned}$$

where β_i is a factor of proportionality, and ε_{ij} is the elasticity of supply for good i with respect to good j.[5]

The supply elasticities employed in (5.7) are calculated using the formulas implied in equations (5.5) and (5.6). Alternatively, one could estimate or borrow estimates of supply elasticities from previous studies; however, there are two advantages of using calculated elasticities over borrowed estimates. First, one does not need to impose restrictions on elasticity values to satisfy the homogeneity property of supply functions since the restrictions are implied in the formulation of the elasticities. Second, the calculated elasticities are internally consistent in that the input substitution elasticities implied by the own-price elasticity are the same as those implied by cross-price elasticities. Unless one estimates the particular equations used in a simulation model, it is very unlikely that one would find parameter values that satisfied this restriction. Finally, the above formulation demonstrates the importance of input substitution elasticities as the primary parameter of interest in determining supply responses to price changes. Unfortunately, insufficient emphasis has been placed on estimating these values for particular industries in the past; therefore, input substitution elasticity values are assumed in this study.

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[5]The vector of factor endowments is held constant throughout the analysis and, consequently, no longer appears as an argument of supply functions or intermediate input demands.

In a like manor, intermediate good demand is approximated by the constant elasticity function of output prices in equation (5.8) for its ease of implementation. In order to maintain a strong theoretical relationship between value-added good supplies and intermediate good demands, elasticities are derived from equations (5.5), (9.9), and (5.10). Demands for feed grains are defined in (5.9) as the sum of input demands in each of the meat industries. Totally differentiating this exact relationship and reformulating it as rates of change, we find that the demand for feed grain depends on both the changes in the supply of meat and quantity of feed

(5.8) $d(p)_i = e^{\alpha_i}\prod_{j=1}^{5} p_j^{\varepsilon_{ij}}$ for $i = 4,5$, where α_i is a constant and η_{ij} is the supply elasticity.

grain used to produce one unit of meat. Substituting equation (5.5) for output supply changes and expressing input coefficient changes as a function of output prices, the desired statement defining intermediate demand elasticities is achieved in (5.11).

(5.9) $$d_j(p) = \sum_{i=1}^{3} c_{ji} X_i(p) \quad \text{where } j = 4,5.$$

(5.10) $$\hat{d}_j = \sum_{i=1}^{3} \lambda_{ji}\left(\hat{c}_{ji} + \hat{X}_i\right) \quad \text{where } \lambda_{ji} = \frac{X_i c_{ji}}{d_j} \text{ and } j = 4,5.$$

(5.11) $$\hat{d}_j = \sum_{i=1}^{3} \frac{\lambda_{ji}\sigma^j_{KL}}{\theta_{Ki}}\hat{p}_i - \sum_{i=1}^{3} \lambda_{ji}\left[\frac{\theta_{ji}\sigma^j_{KL}}{\theta_{Ki}} + \sigma^j_{jL}\right]\hat{p}_j + 2\sum_{i=1}^{3} \lambda_{ji}\theta_{hi}\left[\frac{\sigma^j_{KL}}{\theta_{Ki}} + \sigma^j_{hL}\right]\hat{p}_h \quad \text{where } j,h = 4,5 \text{ and } j \neq h.$$

As with the supply elasticities, the intermediate demand elasticities used in the simulation exercises are point elasticities calculated from the formulas implied by equation (5.11). The calculated elasticities are internally consistent in terms of the input substitution elasticities, and they satisfy homogeneity restrictions. In addition, the input demand elasticities are consistent with value-added and intermediate good supply elasticities. For all simulations it is assumed that these elasticities remain constant, even as prices and quantities move away from their initial equilibrium values.

Consumer demands for value-added goods are structured according to the general principles discussed in chapter II. Individual consumers are assumed to maximize utility subject to a budget constraint. Utility is presumed to be directly separable with homothetic subutility functions, thus allowing consumer purchasing decisions to be viewed as a two stage process. In the first stage, consumers maximize their general utility function by apportioning their income to each commodity grouping, treating each group of goods as a composite commodity with a price index as its price. Once group expenditure levels are determined, consumers select quantities of each good to maximize their respective subutility functions given commodity prices. The result is a system of product demands for each group that are conditional on the expenditure levels chosen in the first stage.

In the simulation model we assume that meat products form a commodity group that is separable from expenditures on other goods. Individual meat demands are represented by the following constant elasticity function of meat prices and group expenditure (m) Elasticities are chosen to satisfy homogeneity, symmetry and

(5.12) $$d_i(\mathbf{p},m) = e^{\alpha_i}\prod_{j=1}^{3} p_j^{\eta_{ij}} m^{\delta_i}\text{, where}$$

α_i is a constant of proportionality;

η_{ij} is the Marshallian elasticity of demand for good i with respect to price j, and

δ_i is the income elasticity for good i.

adding-up conditions. The parameter restrictions are summarized in (5.13).

The homogeneity property of demand functions states that commodity demands do not change when all prices are altered by a common factor of proportionality. This implies that the sum of demand and income elasticities must equal zero for each good. The adding-up condition asserts that the sum of expenditures on each commodity in a group must add up to the total group expenditure level. Adding up implies that the product of income elasticities and budget shares must sum to one. The constant elasticity form for demands is homothetic, requiring demands to be linear in income. The result is that adding up and homotheticity may only be satisfied for this functional form when the income elasticity for each good is set equal to one. Finally, the symmetry property of demand systems states that income-compensated cross price effects are equal $\left(\partial h_i(p,u) / \partial p_j = \partial h_j(p,u) / \partial p_i \right)$. Combining the symmetry condition with the assumption

$$\sum_{j=1}^{3} \eta_{ij} + \delta_i = 0 \quad \Rightarrow \quad \sum_{j=1}^{3} \eta_{ij} = -1 \ \text{ for } \delta_i = 1$$

$$\text{(4.13)} \quad \sum_{i=1}^{3} \omega_i \delta_i = 1 \quad \text{where } \omega_i = p_i d_i / m$$

$$\eta_{ij} = \eta_{ji} \, \omega_j / \omega_i \qquad \text{for } i \neq j$$

that all income elasticities are equal yields the condition that the uncompensated cross-price elasticities between two goods are proportional.

Equilibrium in each country occurs when the price paid by consumers equals the price charged by producers. This "law of one price" restriction is imposed naturally in the computer model by entering equations (5.7), (5.8), and (5.12) as they appear above, using the same variable in the supply and demand equations. Specifying one equation for each supply and demand variable in each country provides 30 equations. An additional equilibrium condition requires world supply to equal the world demand for each good. This market clearing restriction is represented in the simulation model by five equation in the form of (5.14). Finally, equilibrium prices for each good are allowed differ between countries by the sum of transportation costs, transfer costs, and policy measures. This price linkage closes out the model and provides an additional ten equations similar to (5.15).

$$(5.14)\quad \begin{aligned}&\left(X_i^{US}(\mathbf{p}^{US})-d_i^{US}(\mathbf{p}^{US})\right)+\left(X_i^{JAP}(\mathbf{p}^{JAP})-d_i^{JAP}(\mathbf{p}^{JAP})\right)\\&+\left(X_i^{ROW}(\mathbf{p}^{ROW})-d_i^{ROW}(\mathbf{p}^{ROW})\right)=0 \text{ for } i=1,2,3,4,5.\end{aligned}$$

$$(5.15)\quad p_i^j=\left(\left(p_i^{US}+\gamma_i^j+p_i^{US}s_i^j\right)\left(1+\tau_i^j+t_i^j\right)\right)\mu^j \text{ for } i=1,2,3,4,5;\ j= \text{JAP, ROW}.$$

Variables in equation (5.15) are defined as follows.

γ_i^j is the transportation cost for good *i* from the US to country *j*.

s_i^j is the export subsidy/tariff on good *i* for exports from the US to country *j*.

τ_i^j is the import tariff/subsidy levied by country *j* on imports of good *i*.

t_i^j is the marketing margin and other transfer costs incurred in process of importing good *i* into country *j*.

μ^j is the foreign currency exchange rate per dollar for country *j*.

There are a number of assumptions imbedded in the price linkage equation (5.15). First, export policy measures are only employed by the United States, and the subsidy or tariff is a percentage of the domestic price. Second, import policies used by Japan and the rest of the world are calculated as a percentage of the US export price, including transportation costs and export policy measures. Third, transfer costs are also treated as a percentage markup over the transportation-inclusive US export price. Fourth, transportation is assumed to be made by American firms or by foreign firms at a price denominated in dollars. Finally, since transfer, transportation, and policy costs are dependent upon the US price, exchange rate changes will affect all components of the price wedge proportionally.

The simulation model is programmed and solved in GAMS (Brooke, Kendrick, & Meeraus, 1988). Since the solution algorithms used by GAMS require optimization of a criterion function, positive slack variables are added to equations (5.7), (5.8), (5.12), (5.14), and (5.15) in the computer program. By minimizing the sum of the

Table 5.1: Price And Quantity Data

Commodity	Supply (1000 MT)	Demand (1000 MT)	Price ($/MT)
United States			
Beef	10411	11339	3959
Pork	7800	7942	2180
Broilers	9401	8885	1160
Corn	121324	87717	82
Soy Bean Meal	20911	15765	214
Japan			
Beef	581	1205	7743
Pork	1400	2091	3832
Broilers	1336	1767	2124
Corn	2	6811	290
Soy Bean Meal	1162	2089	490
ROW			
Beef	36001	34449	3452
Pork	58125	57292	1673
Broilers	18444	18529	1667
Corn	91727	118525	128
Soy Bean Meal	28968	33187	260

slack variables, GAMS is able to determine the equilibrium prices and quantities that satisfy the restrictions described above.

The Data Set And Parameters

The base model is calibrated to the 1992, price and quantity data shown in Table 5.1. The sources for the values used to calibrate the model are outlined in great detail in appendix III. In general, production and consumption quantities for all countries, as well as US prices and production costs, were tabulated by the Economic Research Service (ERS)and Foreign Agricultural Service (FAS) branches of the United States Department of Agriculture (USDA). Japanese prices and production costs were taken from sources published by the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF).

Supply and intermediate demand elasticities were calculated using equations (5.5), (5.6) and (5.11). Cost of production data (USDA, 1993b; MAFF, 1994) were used to determine the share of production costs in each industry that could be attributed to fixed factors of production (land rental, taxes, insurance, and depreciation on buildings and equipment). The share of costs attributed to fixed factors is utilized as a proxy for the sector-specific factor's share of production cost. Intermediate input cost shares and utilization shares are calculated using the price and quantity data above. Since cost of production data and other elasticity estimates do not exist for the rest of the world, U.S. values were used as a proxy.

As mentioned above, reliable estimates of input substitution elasticities are not available in the existing literature; consequently, three sets of values are employed to test the sensitivity of the simulation results to parameter assumptions. First, a relatively low value (.1) is postulated for all input substitution elasticities. The resulting supply and input demand elasticities under the low level of input substitution are summarized in Table 5.2. Second, values are chosen for input substitution

Table 5.2: Low Substitution Supply And Input Demand Elasticities

	Country		
Supply Elasticity	United States	Japan	ROW
ε_{11}	0.443	0.448	0.443
ε_{14}	-0.020	-0.025	-0.009
ε_{15}	-0.004	-0.005	-0.003
ε_{22}	0.768	1.020	0.768
ε_{24}	-0.108	-0.157	-0.067
ε_{25}	-0.067	-0.101	-0.043
ε_{33}	1.268	2.154	1.268
ε_{34}	-0.224	-0.552	-0.079
ε_{35}	-0.125	-0.278	-0.054
ε_{44}	0.154	0.114	0.154
ε_{55}	0.167	0.172	0.167
Input Demand Elasticity			
η_{41}	0.177	0.094	0.121
η_{42}	0.333	0.519	0.555
η_{43}	0.398	0.825	0.188
η_{44}	-0.240	-.406	-0.171
η_{45}	0.017	0.018	0.011
η_{51}	0.083	0.037	0.059
η_{52}	0.436	0.646	0.629
η_{53}	0.472	0.803	0.227
η_{54}	0.197	0.356	0.094
η_{55}	-0.195	-0.240	-0.152

Table 5.3: SWOPSIM Scenario Supply And Input Demand Elasticities

	Country		
Supply Elasticity	United States	Japan	ROW
ε_{11}	0.603	0.399	0.603
ε_{14}	-0.009	0.003	-0.004
ε_{15}	0.001	0.005	0.000
ε_{22}	0.998	0.877	0.998
ε_{24}	-0.091	-0.074	-0.056
ε_{25}	-0.035	-0.013	-0.022
ε_{33}	0.799	1.271	0.799
ε_{34}	-0.069	-0.222	-0.024
ε_{35}	-0.016	-0.070	-0.007
ε_{44}	0.400	0.400	0.400
ε_{55}	0.200	0.300	0.200
Input Demand Elasticity			
η_{41}	0.241	0.083	0.164
η_{42}	0.433	0.446	0.722
η_{43}	0.251	0.487	0.118
η_{44}	-0.570	-0.650	-0.523
η_{45}	0.098	0.130	0.065
η_{51}	0.113	0.033	0.080
η_{52}	0.566	0.555	0.818
η_{53}	0.297	0.474	0.143
η_{54}	0.292	0.390	0.166
η_{55}	-0.741	-0.860	-0.711

Table 5.4: High Substitution Supply And Input Demand Elasticities

	Country		
Supply Elasticity	United States	Japan	ROW
ε_{11}	0.886	0.896	0.886
ε_{14}	-0.022	-0.029	-0.011
ε_{15}	-0.001	-0.001	-0.001
ε_{22}	1.536	2.041	1.536
ε_{24}	-0.168	-0.263	-0.103
ε_{25}	-0.073	-0.136	-0.047
ε_{33}	2.536	4.307	2.536
ε_{34}	-0.390	-1.024	-0.138
ε_{35}	-0.185	-0.475	-0.081
ε_{44}	0.616	0.457	0.616
ε_{55}	0.334	0.345	0.334
Input Demand Elasticity			
η_{41}	0.354	0.187	0.242
η_{42}	0.666	1.038	1.111
η_{43}	0.795	1.649	0.376
η_{44}	-0.781	-1.111	-0.643
η_{45}	0.122	0.139	0.081
η_{51}	0.167	0.074	0.118
η_{52}	0.871	1.291	1.259
η_{53}	0.944	1.605	0.455
η_{54}	0.488	0.829	0.239
η_{55}	-0.989	-1.080	-0.903

elasticities to produce supply and input demand elasticities that closely match values found in the 1989 SWOPSIM database for the United States and Japan (Sullivan, Roningen, & Leetmaa, 1992).[6] Elasticities for the SWOPSIM scenario are shown in Table 5.3. Finally, input substitution elasticities were selected that were slightly larger than the values used to produce the SWOPSIM elasticities. Supply and input demand elasticities used in the high substitution scenario are displayed in Table 5.4.

Whereas the primary concern of this study is with effect of price changes induced by government policy or other exogenous forces on the location of marginal production, the demand functions specified for meat products are the same for all of the simulation scenarios. Demand elasticities for meat products in the United States were taken from demand studies by Moschini and Meilke (1989) and Alston and Chalfant (1993). Hayes, Wahl and Williams (1990) provided estimates for Japanese demand elasticities.

Unfortunately, it is not possible to use the estimated demand elasticities directly since the estimated and the simulation data sets differ. Consequently, the compensated own-price elasticities evaluated at the mean of the estimated data sets were used to calculate the uncompensated own and cross-price elasticities, given the restrictions in (5.13) and the expenditure shares implied by the base data. Except for beef, the same compensated own-price elasticities were used for the United States and the rest of the world. A slightly higher value was chosen for the compensated own-price demand elasticity for beef in the rest of the world to eliminate rather large, complementary cross-price effects between beef and chicken. The resulting Marshallian elasticities employed in the simulation model are presented in Table 5.5.

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[6]The values of the input substitution elasticities used to produce the SWOPSIM and high substitution scenarios are listed in the appendix to this chapter.

Table 5.5: Demand Elasticities For Meat Products

Country	Commodity			
	Beef	Pork	Broilers	Income
United States				
Beef	-0.968	-0.055	0.023	1.000
Pork	-0.142	-0.838	-0.020	1.000
Broilers	0.005	-0.035	-0.970	1.000
Japan				
Beef	-1.043	0.016	0.027	1.000
Pork	0.017	-1.003	-0.014	1.000
Broilers	0.066	-0.032	-1.034	1.000
ROW				
Beef	-0.934	-0.031	-0.035	1.000
Pork	-0.039	-0.989	0.028	1.000
Broilers	-0.133	0.087	-0.954	1.000

Policy Scenarios

There are any number of policy combinations that one could examine with the model described above; however, not all possible combinations are independent of one another, nor are they all relevant to the markets in question. Examining equation (5.15), we can readily see that there is no distinction between identical changes in import tariff levels and transfer costs. This equivalence does not exist between transportation costs and export subsidies because the total value of the subsidy is dependent upon the U.S. price. Thus, a 10% decrease in transportation costs will result in a different equilibrium than a 10% export subsidy, because the actual value of the subsidy changes as the U.S. price moves towards the new equilibrium level. Consequently, it is desirable to consider both changes in export subsidy levels and transportation costs. Finally, the exchange rate is unique in that it is able to affect all variables in the price equation proportionally. It is, therefore, relevant to consider whether exchange rate fluctuations also affect prices and trade volumes proportionally across commodities.

In light of the above considerations, the following scenarios are simulated and their results discussed in the succeeding chapters. First, a general export subsidy on broiler exports from the U.S. is examined as the subsidy level increases from zero to 10%, 30%, 50%, and 70%. Similar exercises are performed for a targeted export subsidy to Japan. Second, the effect of exchange rate fluctuations on U.S. exports of meat and feed grains is assessed. Both currency appreciation and depreciation of up to 50% are simulated to discover whether meats and feed grains are symmetrically affected by variations in currency values. Finally, changes in transportation costs are considered. In particular, the cost of transporting meat products is reduced by 10-50% to determine the magnitude of the adjustments in meat production and trade volumes.

CHAPTER VI

SUBSIDIES FOR U.S. BROILER EXPORTS

This chapter considers the implementation of subsidies for exports of broiler meat by the United States. Starting from the initial equilibrium captured in the base model, the system is perturbed by introducing a targeted subsidy on broiler exports to Japan. In chapter IV it was mentioned that a targeted export subsidy may improve the welfare of the exporting country when markets are characterized by an appropriate set of excess supply elasticities and market power conditions; consequently, we are interested in the welfare changes brought about by the targeted subsidy for poultry exports. Another primary concern is the effect of the subsidy on the location of marginal poultry production. In particular, we want to determine whether the subsidy has a significant impact on production levels in the importing country and how production changes affect trade volumes for the underlying intermediate goods. Finally, the results produced by the targeted subsidy are compared to the equilibrium attained with a general subsidy for U.S. broiler exports.

Export Subsidy Targeted To Japan

Export subsidies for frozen poultry existed under the Export Enhancement Program in 1992. These subsidies were authorized for poultry exports to Singapore and a number of countries in western Africa and the Middle East; however, the primary importing countries in these regions were Singapore, Saudi Arabia, Kuwait and the United Arab Emirates. Poultry imports by these countries accounted for approximately 14.39% of all poultry imports by countries other than Japan, and imports by these countries fell only twenty-five thousand metric tons short of Japanese poultry imports. The fact that these targeted countries and Japan imported similar quantities of poultry increases the relevancy of the present simulations for contemporary U.S. trade policy.

The total value of U.S. subsidies paid for poultry exports in 1992 was in excess of 14.4 million dollars, with an average subsidy rate of 65.8% of the unit value over the period from 1985-1992 (GAO, 1993a). Although comprising a major share of poultry exports to the targeted countries, U.S. sales of poultry do not account for all the poultry imported by these countries in 1992, nor were all U.S. exports subsidized. Consequently, EEP subsidies are ignored in establishing the base model.

A targeted subsidy is introduced into the simulation model as an *ad velorem* wedge between the U.S. and Japanese broiler prices. From equation (6.1) we can see that the subsidy (s_i^j) is a fraction of the U.S. price at the port of export, and as a consequence the subsidy influences the value of tariff and transfer costs incurred upon reaching the port of destination. We would expect that the price wedge

$$p_i^j = \left(\left(p_i^{US} + \gamma_i^j + p_i^{US} s_i^j\right)\left(1 + \tau_i^j + t_i^j\right)\right)\mu^j \quad \text{for } i = 1,2,3,4,5;\ j = \text{ JAP, ROW.} \tag{6.1}$$

created by this structure to be greater than a simple additive subsidy; nevertheless, this specification more closely resembles the actual imputation of subsidy and tariff values.

From the comparative static exercises in chapter III, we would expect the U.S. broiler price to rise in response to the export subsidy. Feed grain prices, however, may rise or fall depending upon the relative response of excess supplies of feed grain to changes in the broiler price in the United States, Japan, and the rest of the world. In addition, the results from chapter IV suggest that the targeted subsidy is more likely to enhance U.S. welfare as the United States possesses more market power in ROW's broiler market. Noting that the quantity of broilers imported by the rest of the world is small relative to total broiler demand, we should expect the targeted subsidy to reduce welfare in the United States.

Four separate simulations were performed for each substitution elasticity scenario, increasing the subsidy rate with each run. For purposes of discussion, the results from the SWOPSIM scenario are summarized in the tables below, and the output from the high and low substitution simulations are tabled in Appendix IV. In general, the qualitative results are identical for all three runs; nevertheless, some differences do occur in the findings from the SWOPSIM case, These differences are largely due to the SWOPSIM scenario's significantly lower degree of primary factor substitution in the broiler sector.

In Tables 6.1-6.3, the percentage changes in supply, demand, prices, and trade volumes for each good and country at the various subsidy rates are listed. As projected, both U.S. broiler production and price rise as a result of increased exports to Japan. With a 10% export subsidy, U.S. broiler exports increase by more than 19%, and exports to Japan rise by nearly 43%. Of equal importance is the fact that ROW broiler imports fall by more than 163%. In other words, the export subsidy prompts the rest of the world to become a net exporter of broilers by indirectly raising the world broiler price.

The impact of export competition from the rest of the world is evidenced by an rising marginal cost of increasing broiler exports. In particular, with a 10% subsidy it costs an average of $720.00 to increase exports by one metric ton, a rate that is more than 60% of the domestic price. With a 70% subsidy, the marginal export cost exceeds the actual price of the product by 13%.

In contrast to rising world broiler prices, the Japanese broiler price falls at nearly ten times the percentage rate of the U.S. price increase. Such a significant price decline causes Japanese broiler production to contract dramatically,

Table 6.1: U.S. Price And Quantity Changes Under A Targeted Subsidy SWOPSIM Substitution Scenario

	Base	U.S. Subsidy Rate			
		10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
U.S. Supply					
Beef	10411	-0.00	-0.01	-0.03	-0.05
Pork	7800	0.01	0.02	0.03	0.04
Broilers	9401	0.50	1.63	3.07	5.09
Corn	121324	-0.01	-0.01	-0.00	0.05
Meal	20911	-0.01	-0.02	-0.03	-0.01
U.S. Demand					
Beef	11339	0.02	0.07	0.13	0.21
Pork	7942	-0.02	-0.05	-0.09	-0.16
Broilers	8885	-0.60	-1.94	-3.61	-5.86
Corn	87717	0.16	0.52	0.95	1.50
Meal	15765	0.21	0.68	1.23	1.95
U.S. Trade Volume					
Beef	-928	0.31	1.00	1.87	3.07
Pork	-142	-1.23	-3.94	-7.09	-11.01
Broilers	516	19.35	63.25	118.10	193.73
Corn	33607	-0.45	-1.41	-2.49	-3.74
Meal	5146	-0.68	-2.16	-3.88	-6.01
	—U.S. Dollars Per MT—				
U.S. Price					
Beef	3959	-0.01	-0.02	-0.05	-0.07
Pork	2180	0.00	0.02	0.03	0.05
Broilers	1160	0.62	2.04	3.86	6.42
Corn	82	-0.01	-0.04	-0.01	0.12
Meal	214	-0.04	-0.10	-0.13	-0.04

Table 6.2: Japanese Price And Quantity Changes Under A Targeted Subsidy SWOPSIM Substitution Scenario

		U.S. Subsidy Rate			
	Base	10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
Japanese Supply					
Beef	581	-0.00	-0.01	-0.02	-0.03
Pork	1400	0.00	0.01	0.02	0.03
Broilers	1336	-8.27	-24.54	-40.40	-55.78
Corn	2	0.00	0.00	0.00	0.00
Meal	1162	-0.01	-0.03	-0.03	-0.01
Japanese Demand					
Beef	1205	-0.18	-0.57	-1.05	-1.65
Pork	2091	0.09	0.30	0.55	0.86
Broilers	1767	7.28	25.76	52.35	94.18
Corn	6811	-3.25	-10.23	-17.99	-26.88
Meal	2089	-3.15	-9.91	-17.47	-26.18
Japanese Trade Volume					
Beef	-624	-0.34	-1.10	-2.02	-3.17
Pork	-691	0.27	0.88	1.61	2.54
Broilers	-431	55.48	181.67	339.87	559.04
Corn	-6809	-3.25	-10.23	-18.00	-26.89
Meal	-927	-7.08	-22.30	-39.33	-58.98
	—U.S. Dollars Per MT—				
Japanese Price					
Beef	7743	-0.01	-0.02	-0.04	-0.06
Pork	3832	0.00	0.01	0.02	0.04
Broilers	2124	-6.57	-19.88	-33.45	-47.37
Corn	290	-0.01	-0.02	-0.00	0.08
Meal	490	-0.03	-0.09	-0.10	-0.03

Table 6.3: ROW Price And Quantity Changes Under A Targeted Subsidy
SWOPSIM Substitution Scenario

	Base	U.S. Subsidy Rate			
		10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
ROW Supply					
Beef	36001	-0.01	-0.02	-0.03	-0.05
Pork	58125	0.02	0.02	0.04	0.06
Broilers	18444	0.35	1.14	2.14	3.55
Corn	91727	-0.00	-0.01	-0.00	0.03
Meal	28968	-0.01	-0.02	-0.02	-0.01
ROW Demand					
Beef	34449	-0.01	-0.02	-0.05	-0.08
Pork	57292	0.01	0.02	0.04	0.06
Broilers	18529	-0.41	-1.33	-2.49	-4.07
Corn	118525	0.06	0.18	0.33	0.51
Meal	33187	0.09	0.27	0.48	0.71
ROW Trade Volume					
Beef	1552	0.05	0.16	0.31	0.56
Pork	833	0.01	0.06	0.13	0.23
Broilers	-85	-163.87	-537.16	-1006.38	-1658.57
Corn	-26798	0.27	0.84	1.46	2.14
Meal	-4219	0.73	2.27	3.91	5.63
	—U.S. Dollars Per MT—				
ROW Price					
Beef	3452	-0.01	-0.03	-0.05	-0.08
Pork	1673	0.01	0.02	0.04	0.07
Broilers	1667	0.43	1.42	2.69	4.47
Corn	128	-0.01	-0.02	-0.01	0.08
Meal	260	-0.04	-0.09	-0.10	-0.03

simultaneously decreasing the demand for both corn and soy bean meal imports. Although increased broiler production in the United States and the rest of the world strengthen the demand for feed inputs, it is not until the 70% subsidy rate is reached that this effect is able to counteract the decline in Japanese feed demand. Consequently, both corn and soy bean meal prices decline as a result of the broiler subsidy, except at the 70% subsidy level. Feed grain price changes differ slightly in the low and high substitution simulations in that feed prices decline for all subsidy levels.

Lower feed prices encourage pork production to increase slightly in all three countries; nevertheless, pork prices rise in all countries as a consequence of elevated pork demand in Japan and the rest of the world. The gross complementary nature between pork and broiler demand in the United States as well as rising pork prices lead to a decline in U.S. pork demand. Coupled with the increases in pork production, a lower demand for pork leads to modest declines in U.S. pork imports.

Turning to welfare issues, it is clear from Tables 6.4-5.6 that Japan gains from the export subsidy, but the United States and the rest of the world are hurt by the policy. This is a uniform result for all three elasticity assumptions. It is also true in all three scenarios that the cost of the subsidy slightly exceeds the benefits accrued to broiler producers for all subsidy rates. As the subsidy rate increases, the spread between subsidy costs and producer benefits also rises.

As expected, Japan benefits from the export subsidy, primarily through consumer surplus gains. The beef sector in the rest of the world suffers the greatest losses, primarily because of price declines and gross complementary effects between beef demand and broiler prices.

Table 6.4: U.S. Surplus Changes Under A Targeted Subsidy
SWOPSIM Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus[1]				
Beef	-3	-10	-18	-30
Pork	1	3	5	8
Broilers	68	225	427	718
Corn	-1	-4	-1	12
Meal	0	-1	0	2
Consumer Surplus				
Beef	154	503	941	1545
Pork	-300	-982	-1839	-3029
Broilers	-64	-210	-393	-647
Total Welfare				
Total Change	-217	-775	-1556	-2731
Percent Change	-0.006	-0.02	-0.04	-0.08
Subsidy Cost	72	299	678	1310

[1]Because consumer surplus is infinite for constant elasticity demand functions, producer and consumer surplus are calculated from the prices required for demand and supply to equal one metric ton.

Table 6.5: Japanese Surplus Changes Under A Targeted Subsidy
SWOPSIM Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	0	-1	-2	-3
Pork	0	1	1	2
Broilers	-179	-494	-754	-959
Corn	0	0	0	0
Meal	0	0	-1	0
Consumer Surplus				
Beef	-183	-596	-1091	-1714
Pork	115	376	692	1092
Broilers	255	834	1537	2433
Total Welfare				
Total Change	8	120	382	851
Percent Change	0.00	0.05	0.15	0.33

Table 6.6: ROW Surplus Changes Under A Targeted Subsidy
SWOPSIM Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	-10	-34	-63	-103
Pork	6	20	38	63
Broilers	133	440	835	1399
Corn	-1	-3	-1	9
Meal	-3	-6	-8	-2
Consumer Surplus				
Beef	-717	-2355	-4420	-7301
Pork	247	808	1514	2494
Broilers	-119	-388	-728	-1201
Total Welfare				
Total Change	-464	-1518	-2833	-4642
Percent Change	-0.01	-0.02	-0.04	-0.06

General Export Subsidy

A general subsidy lowers the import price of all broiler exports from the United States. Price and production reactions to such a policy differ quite dramatically from the targeted subsidy in some respects. First, in Tables 6.7-6.9 we notice that U.S. broiler production and the domestic price rise much more rapidly and to a greater extent than with a targeted subsidy. By greatly expanding the size of the subsidized market, even a small general subsidy prompts rather modest increases in world broiler demand; moreover, U.S. broiler production and price rise more with a 10% general subsidy than with a 70% targeted subsidy.

Second, the sharply climbing broiler price in the United States tends to moderate the price declines in Japan relative to the targeted subsidy. Consequently, Japanese broiler production does not decline as significantly, and broiler imports rise to only 50-65% of the levels under the targeted subsidy.

Third, despite declines in broiler production throughout the world, corn and soy bean meal demand rises as a result of increased production in the United States. U.S. exports of both intermediate products decline significantly, but the United States remains a net exporter of both commodities.[2] Unlike under a targeted subsidy, corn and soybean meal prices rise in all countries under a general subsidy.

Finally, we see in Tables 6.10-6.12 that welfare gains and losses reflect the relative magnitudes of the price and output effects caused by the two policies. Welfare losses in the United States are more than a ten times as great under the general subsidy, but Japanese gains are less than a quarter their level under the targeted subsidy. The rest of the world is the clear beneficiary of the general subsidy, primarily as a result of consumer surplus gains.

Conclusions

Economic theory predicts that general export subsidies decrease the welfare of the subsidizing country except in particular instances when market linkages between goods allow the export subsidy to create a welfare enhancing terms-of-trade effect in a connected market (Feenstra, 1986). In chapter IV it was demonstrated that the proper linkages do not exist between value-added and

[2]The United States did, however, become a net importer of soy bean meal at high subsidy levels under the high substitution elasticity assumption.

Table 6.7: U.S. Price And Quantity Changes Under A General Subsidy
SWOPSIM Substitution Scenario

		U.S. Subsidy Rate			
	Base	10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
U.S. Supply					
Beef	10411	0.03	0.11	0.22	0.37
Pork	7800	-0.09	-0.31	-0.62	-1.10
Broilers	9401	5.21	18.73	39.33	76.24
Corn	121324	0.24	0.85	1.71	3.08
Meal	20911	0.09	0.32	0.67	1.24
U.S. Demand					
Beef	11339	0.09	0.30	0.57	0.98
Pork	7942	-0.12	-0.41	-0.79	-1.36
Broilers	8885	-6.04	-18.98	-33.42	-50.11
Corn	87717	1.33	4.52	8.85	15.45
Meal	15765	1.76	6.04	11.86	20.81
U.S. Trade Volume					
Beef	-928	0.68	2.34	4.57	7.81
Pork	-142	-1.73	-5.60	-10.20	-15.80
Broilers	516	198.90	668.05	1292.03	2251.90
Corn	33607	-2.58	-8.73	-16.92	-29.20
Meal	5146	-5.04	-17.18	-33.63	-58.72
	—U.S. Dollars Per MT—				
U.S. Price					
Beef	3959	0.06	0.22	0.42	0.71
Pork	2180	-0.02	-0.07	-0.12	-0.20
Broilers	1160	6.63	24.24	52.11	104.83
Corn	82	0.61	2.13	4.34	7.88
Meal	214	0.45	1.62	3.38	6.36

Table 6.8: Japanese Prices And Quantity Changes Under A General Subsidy SWOPSIM Substitution Scenario

		U.S. Subsidy Rate			
	Base	10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
Japanese Supply					
Beef	581	0.03	0.09	0.17	0.29
Pork	1400	-0.05	-0.17	-0.32	-0.57
Broilers	1336	-3.66	-11.73	-21.31	-33.73
Corn	2	0.00	0.00	0.00	0.00
Meal	1162	0.11	0.40	0.83	1.54
Japanese Demand					
Beef	1205	-0.14	-0.46	-0.87	-1.49
Pork	2091	0.06	0.19	0.36	0.61
Broilers	1767	2.99	10.35	20.77	38.18
Corn	6811	-1.58	-5.21	-9.80	-16.28
Meal	2089	-1.51	-5.01	-9.49	-15.92
Japanese Trade Volume					
Beef	-624	-0.29	-0.96	-1.84	-3.15
Pork	-691	0.27	0.91	1.75	3.00
Broilers	-431	23.61	78.79	151.22	261.11
Corn	-6809	-1.58	-5.21	-9.80	-16.28
Meal	-927	-3.54	-11.78	-22.43	-37.81
	—U.S. Dollars Per MT—				
Japanese Price					
Beef	7743	0.06	0.19	0.37	0.63
Pork	3832	-0.02	-0.05	-0.10	-0.16
Broilers	2124	-2.81	-9.07	-16.66	-26.83
Corn	290	0.39	1.37	2.78	5.05
Meal	490	0.37	1.33	2.78	5.24

Table 6.9: ROW Price And Quantity Changes Under A General Subsidy
SWOPSIM Substitution Scenario

		U.S. Subsidy Rate			
	Base	10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
ROW Supply					
Beef	36001	0.04	0.14	0.28	0.47
Pork	58125	-0.06	-0.19	-0.37	-0.64
Broilers	18444	-2.26	-7.35	-13.63	-22.21
Corn	91727	0.16	0.55	1.10	1.99
Meal	28968	0.07	0.27	0.55	1.03
ROW Demand					
Beef	34449	0.03	0.11	0.20	0.34
Pork	57292	-0.06	-0.19	-0.37	-0.65
Broilers	18529	2.74	9.45	18.90	34.54
Corn	118525	-0.52	-1.75	-3.38	-5.81
Meal	33187	-0.62	-2.10	-4.11	-7.15
ROW Trade Volume					
Beef	1552	0.29	1.01	1.99	3.41
Pork	833	-0.07	-0.20	-0.29	-0.20
Broilers	-85	1087.71	3655.98	7076.62	12346.39
Corn	-26798	-2.84	-9.63	-18.73	-32.49
Meal	-4219	-5.37	-18.37	-36.09	-63.32
	—U.S. Dollars Per MT—				
ROW Price					
Beef	3452	0.07	0.25	0.48	0.82
Pork	1673	-0.03	-0.09	-0.16	-0.26
Broilers	1667	-2.81	-9.07	-16.66	-26.83
Corn	128	0.39	1.37	2.78	5.05
Meal	260	0.37	1.34	2.79	5.24

Table 6.10: U.S. Surplus Changes Under A General Subsidy
SWOPSIM Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	25	84	162	278
Pork	-10	-32	-63	-110
Broilers	739	2880	6785	15821
Corn	61	213	436	796
Meal	9	30	62	112
Consumer Surplus				
Beef	1574	5330	10324	17707
Pork	-3629	-12240	-23590	-40182
Broilers	-660	-2236	-4336	-7446
Total Welfare				
Total Change	-2082	-7684	-16557	-33209
Percent Change	-0.06	-0.22	-0.48	-0.96
Subsidy Value	191	1713	6337	20185

Table 6.11: Japanese Surplus Changes Under A General Subsidy
SWOPSIM Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	3	9	17	30
Pork	-2	-6	-12	-21
Broilers	-80	-247	-430	-644
Corn	0	0	0	0
Meal	2	8	16	30
Consumer Surplus				
Beef	-83	-275	-527	-902
Pork	51	170	326	558
Broilers	109	364	698	1200
Total Welfare				
Total Change	0	23	88	251
Percent Change	0.00	0.01	0.03	0.10

Table 6.12: ROW Surplus Changes Under A General Subsidy
SWOPSIM Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	90	303	584	1004
Pork	-41	-135	-257	-437
Broilers	-855	-2693	-4788	-7362
Corn	46	161	328	598
Meal	28	101	210	396
Consumer Surplus				
Beef	4711	15750	30230	51910
Pork	-1652	-5519	-10574	-18097
Broilers	769	2564	4905	8382
Total Welfare				
Total Change	3096	10532	20638	36394
Percent Change	0.04	0.15	0.28	0.50

intermediate goods for a general subsidy to increase the welfare of the subsidizing country. The simulations discussed above confirm this result.

Targeted export subsidies may enhance welfare in a second-best sense when market conditions are such that the subsidy allows the exporter to price discriminate in international markets; however, a critical condition for the validity of this conclusion is that there exists an importing country other than the subsidized importer. The simulations show that a small subsidy targeting broiler exports to Japan creates a sufficient increase in the world broiler price to reverse ROW's net importer status. Thus, the targeted subsidy does not enhance U.S. welfare.

The simulations also demonstrated that a small subsidy, targeted or general, is capable of causing rather substantial shifts in the location of marginal broiler production. In a country which imports the majority of the intermediate inputs used to produce a subsidized value-added good, the export subsidy will cause imports of the intermediate inputs to fall in proportion to the decline in domestic production of the value added good. Hence, there is a clear trade off in promoting the export of one or the other good, and trade policies, such as subsidies, should be constructed taking full consideration of the effects on these connected markets.

Finally, subsidies for exports of broiler meat have a moderate effect on trade flows of beef and pork. The direction of the broiler price change in the targeted and unsubsidized countries influences demand for beef and pork through the gross substitution or complementary elements of that country's demand structure. In large countries, such as ROW, these demand shifts may create price ripples in international markets that influence trade volumes for unsubsidized commodities. With either type of subsidy, these indirect effects caused a slight increase in U.S. beef imports and a more substantial decline in imports of pork.

CHAPTER VII

EXCHANGE RATE MOVEMENTS AND TRADE RESPONSES

Since Schuh's (1974) seminal article, agricultural economists have become increasingly aware of the real exchange rate's influence on U.S. exports of agricultural commodities. Some authors have sought to theoretically establish the response of prices and trade volumes for individual commodities to exchange rate movements (Kost, 1976; Bredahl & Gallagher, 1977; Chambers & Just, 1979). The importance of cross-price effects established by Chambers and Just is echoed in the discussion in chapter III. Other authors have attempted to empirically estimate exchange rate pass through and the linkages that exist between U.S. monetary policy, exchange rates, and agricultural exports (Batten & Belongia, 1986; Jabara & Schwartz, 1987; Pompelli & Pick, 1990; Thraen, Hwang, & Larson, 1992). In brief, these authors have found that exchange rate changes are passed through to agricultural commodity prices to a limited degree, varying by commodity and industry structure. Likewise, agricultural export levels tend to react differently to exchange rate changes by commodity, a consequence, to some extent, of export competition and trade restrictions.

The objective of this chapter is to extend the above literature by simulating real exchange rate changes to determine whether observed trends in U.S. agricultural exports can be replicated. In addition, theoretical results in chapter III suggest that exports and prices of value-added goods may respond differently to exchange rate movements than bulk commodities. Thus, we are also interested in determining whether the simulations provide evidence of a predictable pattern in these responses.

Exchange Rate And Agricultural Export Trends

Over the last fifteen years the value of the U.S. dollar relative to other currencies has fluctuated significantly. Figures 7.1-7.3 show that in 1978 the U.S. currency began a moderate and sustained appreciation against the Japanese yen, reaching its peak in 1985. In the mid 1980s, following the Plaza Accord, the dollar embarked on a long and rather large depreciation against many world currencies. From 1985 to 1993 the real yen/dollar exchange rate[1] depreciated on average 5% a year for a total depreciation of more than 30%. Over this same time period, U.S. meat exports have also fluctuated; however, the most prominent trend in the last decade has been a dramatic and sustained increase in exports of all three meats. Beef, pork, and broiler exports increased at an average rate of more than 18% per year, totaling a 284%, 234%, and 279% increase from 1985 to 1993 for the three meats respectively. These facts raise the question of whether a currency depreciation as large as 30% can prompt an expansion of meat exports of the magnitudes that have occurred in recent years.

Unlike meat exports, shipments of corn and soy bean meal do not show a clear trend over the last decade. Figures 7.4 and 7.5 show that exports of both feed grains have experienced significant declines over the period of sustained exchange rate depreciation, particularly over the last five years The comparative static results in chapter III indicate that counterintuitive price and trade responses are possible.

Exchange Rate Depreciation

Tables 7.1-7.3 displays the results from simulating U.S. currency depreciation under the SWOPSIM substitution assumption. Price and quantity movements in the United States are in the direction one would expect from a decrease in the price of

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[1]The real exchange rate was calculated as the nominal exchange rate multiplied by the ratio of U.S. and Japanese wholesale price indices. Data were collected by the IMF (1979-1995).

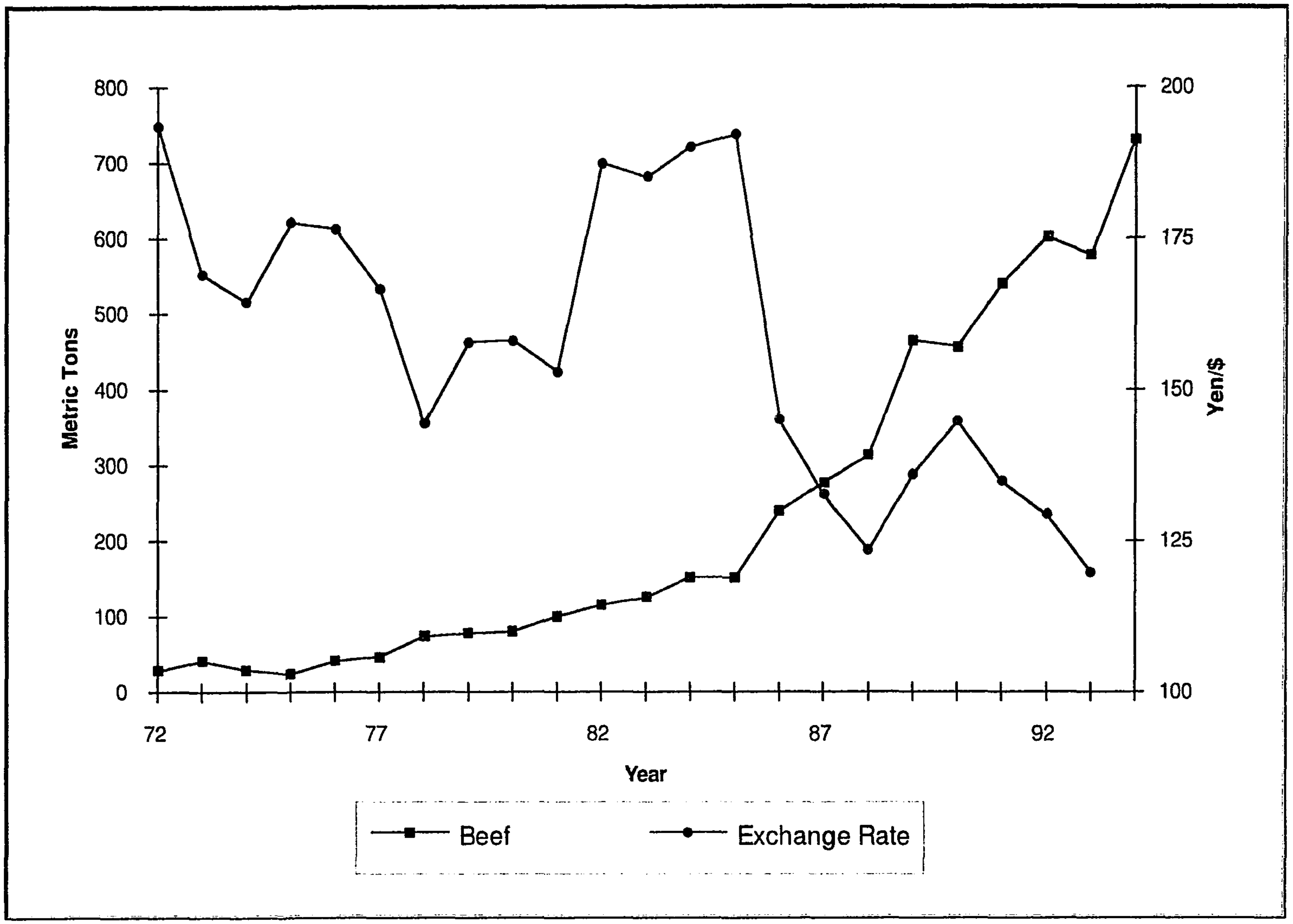

Figure 7.1: U.S. Beef Exports And The Real Yen/Dollar Exchange Rate

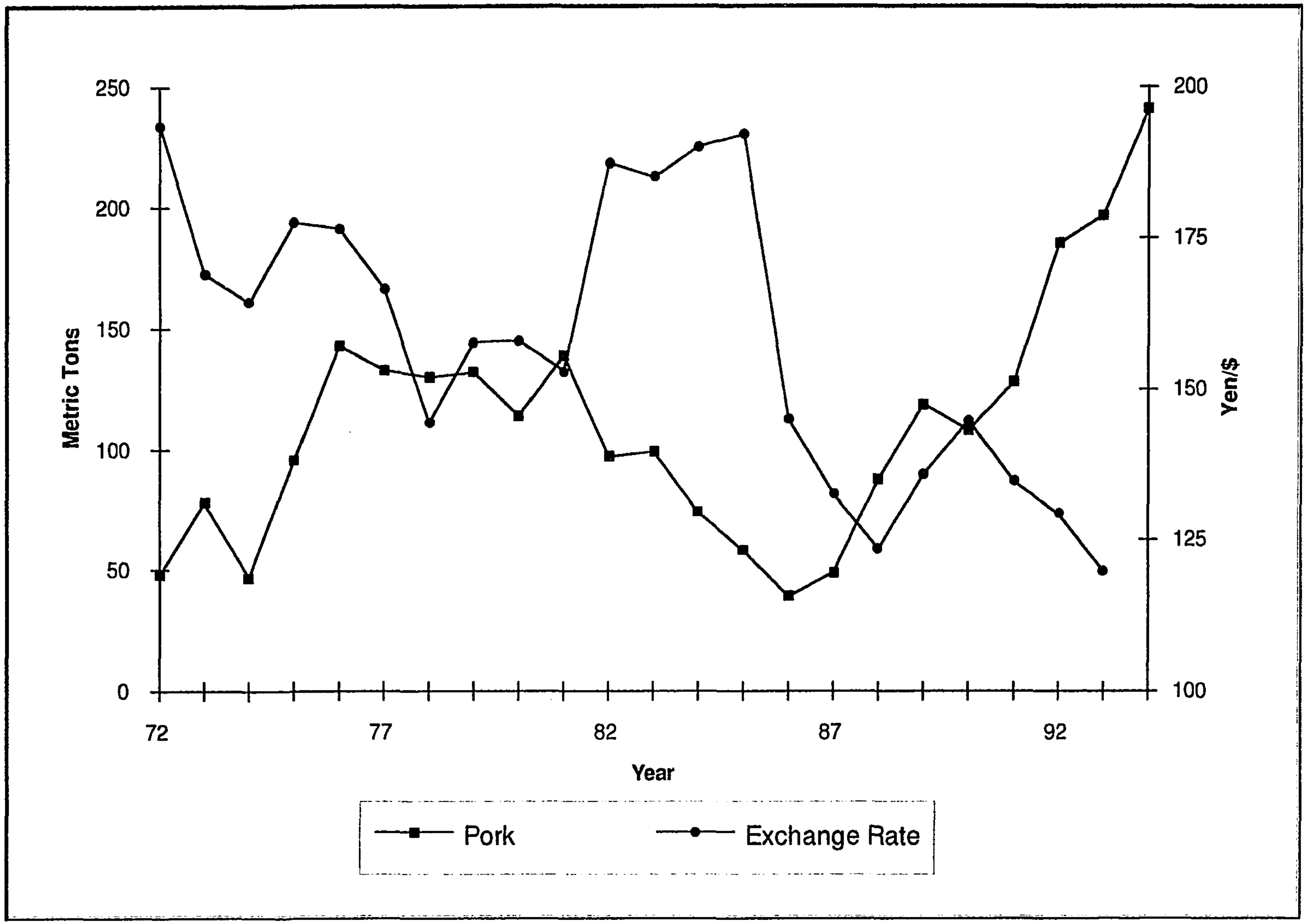

Figure 7.2: U.S. Pork Exports And The Real Yen/Dollar Exchange Rate

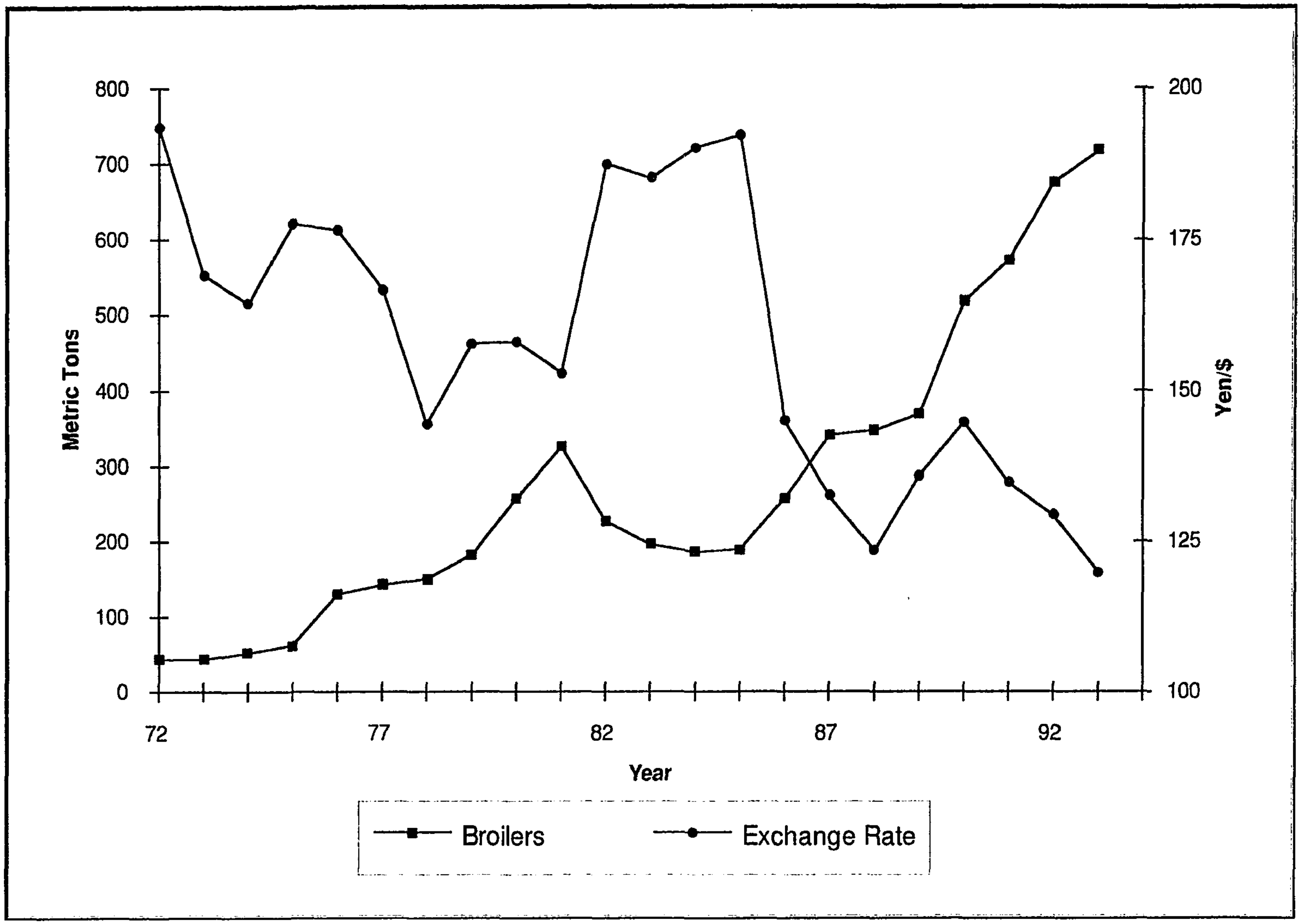

Figure 7.3: U.S. Broiler Exports And The Real Yen/Dollar Exchange Rate

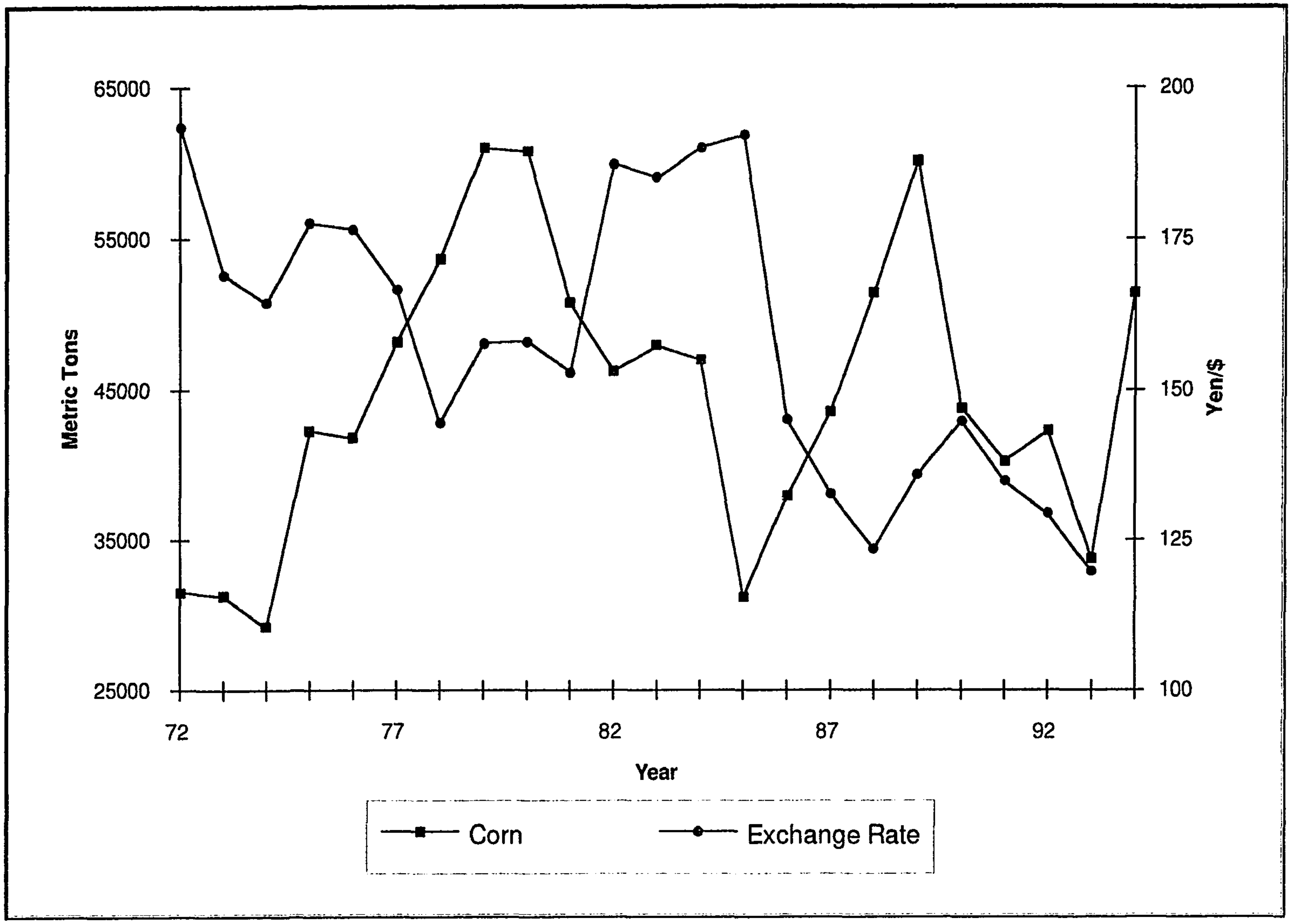

Figure 7.4: U.S. Corn Exports And The Real Yen/Dollar Exchange Rate

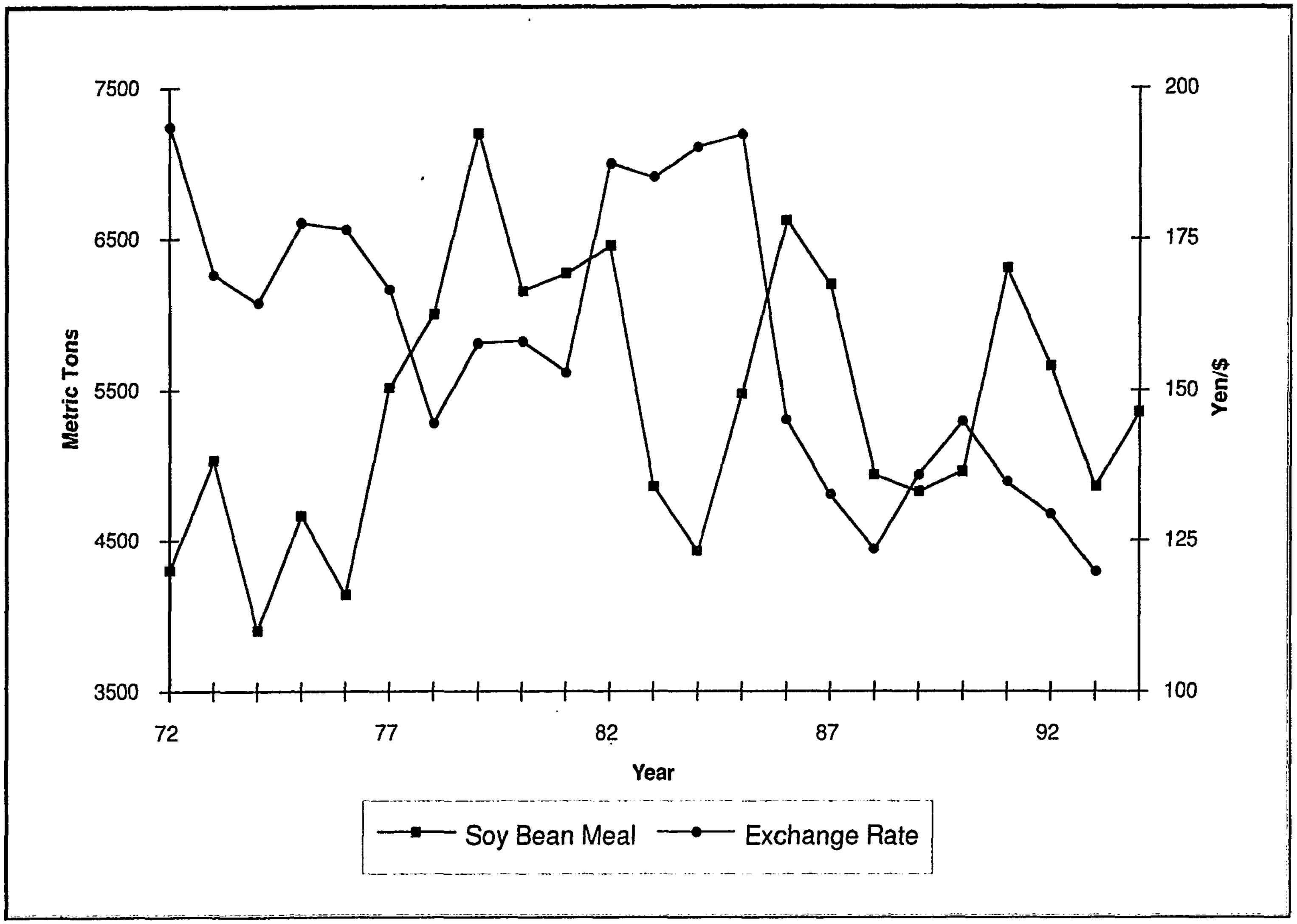

Figure 7.5: U.S. Soy Bean Meal Exports and The Real Yen/Dollar Exchange Rate

Table 7.1: U.S. Price and Quantity Changes Under Dollar Depreciation
SWOPSIM Substitution Scenario

		Depreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
U.S. Supply						
Beef	10411	4.46	9.78	16.24	24.33	34.82
Pork	7800	6.39	14.24	24.12	36.93	54.27
Broilers	9401	6.85	15.01	24.93	37.27	53.16
Corn	121324	3.88	8.33	13.53	19.73	27.36
Meal	20911	1.98	4.24	6.85	9.95	13.71
U.S. Demand						
Beef	11339	-7.06	-14.49	-22.32	-30.62	-39.45
Pork	7942	-7.18	-14.74	-22.72	-31.15	-40.11
Broilers	8885	-8.84	-17.75	-26.72	-35.77	-44.90
Corn	87717	2.90	6.43	10.80	16.34	23.58
Meal	15765	3.37	7.34	12.08	17.89	25.22
U.S. Trade Volume						
Beef	-928	-136.33	-286.70	-455.00	-647.11	-872.60
Pork	-142	-752.89	-1606.8	-2595.2	-3771.0	-5224.4
Broilers	516	277.03	579.10	914.23	1294.91	1741.68
Corn	33607	6.44	13.29	20.65	28.58	37.22
Meal	5146	-2.28	-5.25	-9.17	-14.39	-21.53
	—U.S. Dollars Per MT—					
U.S. Price						
Beef	3959	7.64	17.04	28.89	44.35	65.43
Pork	2180	7.71	17.23	29.31	45.15	66.88
Broilers	1160	9.76	21.71	36.69	56.02	81.96
Corn	82	9.99	22.16	37.33	56.85	83.04
Meal	214	10.30	23.06	39.29	60.66	90.14

Table 7.2: Japanese Price and Quantity Changes Under Dollar Depreciation
SWOPSIM Substitution Scenario

		Depreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
Japanese Supply						
Beef	581	-1.60	-3.29	-5.08	-7.01	-9.11
Pork	1400	-3.51	-7.10	-10.79	-14.62	-18.64
Broilers	1336	-3.83	-7.80	-11.96	-16.39	-21.22
Corn	2	0.00	0.00	-10.00	-10.00	-10.00
Meal	1162	-0.71	-1.47	-2.27	-3.12	-4.06
Japanese Demand						
Beef	1205	4.05	8.58	13.70	19.59	26.51
Pork	2091	4.58	9.67	15.42	21.99	29.67
Broilers	1767	4.06	8.63	13.86	20.00	27.49
Corn	6811	-1.74	-3.52	-5.36	-7.28	-9.32
Meal	2089	-4.04	-8.22	-12.61	-17.25	-22.25
Japanese Trade Volume						
Beef	-624	9.32	19.63	31.19	44.35	59.68
Pork	-691	20.95	43.66	68.53	96.17	127.55
Broilers	-431	28.54	59.56	93.88	132.81	178.47
Corn	-6809	-1.74	-3.52	-5.35	-7.28	-9.32
Meal	-927	-8.20	-16.69	-25.57	-34.96	-45.05
—U.S. Dollars Per MT—						
Japanese Price						
Beef	7743	-3.90	-7.92	-12.07	-16.41	-21.00
Pork	3832	-4.37	-8.82	-13.36	-18.02	-22.87
Broilers	2124	-3.89	-7.91	-12.13	-16.61	-21.48
Corn	290	-4.24	-8.65	-13.26	-18.14	-23.40
Meal	490	-2.37	-4.82	-7.36	-10.04	-12.90

Table 7.3: ROW Price and Quantity Changes Under Dollar Depreciation
SWOPSIM Substitution Scenario

		Depreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
ROW Supply						
Beef	36001	-1.26	-2.62	-4.11	-5.75	-7.63
Pork	58125	-0.67	-1.43	-2.32	-3.39	-4.72
Broilers	18444	-3.00	-6.14	-9.46	-13.03	-16.96
Corn	91727	-1.72	-3.55	-5.53	-7.70	-10.11
Meal	28968	-0.48	-0.98	-1.52	-2.09	-2.73
ROW Demand						
Beef	34449	2.19	4.63	7.40	10.62	14.46
Pork	57292	0.93	2.00	3.25	4.75	6.62
Broilers	18529	4.06	8.63	13.86	20.00	27.47
Corn	118525	0.60	1.22	1.88	2.57	3.26
Meal	33187	-0.54	-1.21	-2.03	-3.08	-4.46
ROW Trade Volume						
Beef	1552	-77.77	-163.54	-259.52	-369.10	-497.77
Pork	833	-110.96	-237.70	-385.55	-563.06	-784.78
Broilers	-85	1537.07	3213.49	5073.91	7187.39	9668.06
Corn	-26798	8.51	17.57	27.25	37.69	49.04
Meal	-4219	-0.98	-2.74	-5.56	-9.87	-16.36
—U.S. Dollars Per MT—						
ROW Price						
Beef	3452	-2.11	-4.37	-6.81	-9.48	-12.48
Pork	1673	-0.96	-2.04	-3.27	-4.70	-6.43
Broilers	1667	-3.89	-7.91	-12.13	-16.61	-21.48
Corn	128	-4.24	-8.65	-13.26	-18.15	-23.40
Meal	260	-2.37	-4.82	-7.36	-10.04	-12.90

U.S. goods relative to the rest of the world; namely, supply, exports and prices all rise in response to increased foreign demand for American goods. With the exception of broiler production, the magnitude of output increases in the United States reflect the relative sizes of the own price supply elasticities. The supply response of all goods increases nonlinearly as the rate of depreciation climbs. For example, the percentage change in beef production is a little over 44% of the rate of depreciation when the currency drops by 10%, but when the currency depreciates by 50%, beef production rises at a rate that is 69% of the depreciation rate. The fact that all outputs respond in this manner would seem to suggest that a similar trend should occur in excess supplies as well.

An inspection of trade volume changes reveals that excess supplies of all goods except soy bean meal do increase in a nonlinear fashion similar to production. Excess supply of soy bean meal, on the other hand, decreases in at an accelerating rate as the dollar depreciates. As the currency depreciates, the excess supply of soy bean meal in the United States declines because demands for the input rise faster than supply; however, this occurrence is not merely an artifact of the relative magnitudes of supply and demand elasticities for soy bean meal. Viewing the tables in Appendix V shows that this is a robust result. In fact, in the low substitution scenario the demand and supply elasticities for soybean meal are very similar in absolute magnitude, yet the declines in the excess supply are the larger than in the other simulations.

This points to a fundamental difference in the trade response of intermediate and value-added goods to exchange rate fluctuations. As foreign demand for value-added goods surges in reply to a relative decline in their prices, the domestic demand for intermediate inputs may climb faster than domestic production of these products. The shifts in an intermediate product's demand are not only a function of that product's own price, but also the prices of the goods for which they are an input. The result may be falling excess supplies of intermediate goods which manifests itself as more slowly rising or even falling export levels. In an extreme case, a country that was a net exporter of intermediate goods prior to the depreciation may become a net importer.

Supply and price movements are less dramatic in Japan and the rest of the world, but many of the same trends can be observed, albeit in the opposite direction. In particular, production of all goods fall as does demand for soy bean meal; nevertheless, excess demand for soy bean meal falls as the decline in domestic demand is greater than the decline in production. In Japan a similar response occurs for imports of corn. A further result is that a fairly small currency depreciation is capable of causing the rest of the world to reverse its net trade status in both pork and beef. Moreover, trade volume changes in meat products are several times larger than changes in feed grain trade. Both of these facts suggest that the location of marginal production in value-added industries may be more sensitive to price fluctuations than their underlying inputs.

As was noted in the discussion of price changes in chapter III, the manner in which transportation costs are assigned influences the magnitude of price responses to exchange rate movements. Comparing Tables 7.2 and 7.3, one notices that the percentage changes for beef and pork prices in Japan are significantly larger than in the rest of the world. This reflects the fact that transportation costs for beef and pork are added to the U.S. price to arrive at the Japanese price for these goods; however, transportation costs are subtracted from the U.S. price to derive the beef and pork price in the rest of the world. The higher transportation-inclusive price increases the positive component of the Japanese price derivative relative to the rest of the world, thus causing a larger price response in Japanese markets. When transportation costs are imputed in the same manner for ROW and Japan, beef and pork prices fall by nearly identical amounts in the two countries. Percentage changes in production and other variables also adjust to the alternative specification of transportation costs, but the changes do not affect the qualitative results discussed above.

Exchange Rate Appreciation

In most respects the effects of currency appreciation are mirror images of currency depreciation; however, a comparison of price changes in tables 7.1 and 7.4 reveals a puzzling asymmetry. In the United States currency appreciation leads prices to fall fairly uniformly across industries and in a smaller absolute magnitude than with a currency depreciation. Demand changes in the United States are similar in absolute magnitude with either a rising or falling currency value, but production changes are noticeably smaller when the dollar appreciates. This relatively weaker response to rising dollar prices is also reflected in the price and quantity changes in Japan and the rest of the world. The source of the asymmetry is not clear from the simulation results, and it may warrant further empirical investigation to determine whether this phenomenon is observed in actual data or simply a byproduct of the current model structure.

Summary and conclusions

Evidence from recent export data for the meat and feed grain industries in the United States suggests that there may be a strong connection between observed export trends and fluctuations in the value of the dollar. Meat products tend to move in a countercyclical fashion with exchange rate changes, rising with a currency depreciation and falling with an appreciation. Although there is evidence that feed grain exports follow a similar pattern, the connection seems to be much weaker.

The simulation results support the hypothesis that recent export trends for meat and feed grains are due, in part, to exchange rate movements. In particular,

Table 7.4: U.S. Price and Quantity Changes Under Dollar Appreciation
SWOPSIM Substitution Scenario

		Appreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
U.S. Supply						
Beef	10411	-3.81	-7.11	-10.00	-12.56	-14.85
Pork	7800	-5.31	-9.80	-13.64	-16.96	-19.87
Broilers	9401	-5.84	-10.88	-15.29	-19.16	-22.61
Corn	121324	-3.43	-6.50	-9.27	-11.79	-14.10
Meal	20911	-1.76	-3.34	-4.77	-6.08	-7.29
U.S. Demand						
Beef	11339	6.73	13.17	19.33	25.24	30.92
Pork	7942	6.84	13.36	19.58	25.54	31.25
Broilers	8885	8.77	17.47	26.09	34.64	43.10
Corn	87717	-2.42	-4.45	-6.18	-7.65	-8.92
Meal	15765	-2.91	-5.44	-7.67	-9.65	-11.43
U.S. Trade Volume						
Beef	-928	125.00	240.63	348.35	449.28	544.33
Pork	-142	674.18	1285.23	1844.46	2360.30	2839.20
Broilers	516	-257.45	-499.13	-727.83	-945.61	-1154.1
Corn	33607	-6.08	-11.85	-17.34	-22.60	-27.64
Meal	5146	1.75	3.09	4.10	4.85	5.39
—U.S. Dollars Per MT—						
U.S. Price						
Beef	3959	-6.35	-11.71	-16.30	-20.29	-23.78
Pork	2180	-6.37	-11.72	-16.28	-20.22	-23.65
Broilers	1160	-8.12	-14.97	-20.83	-25.89	-30.31
Corn	82	-8.35	-15.46	-21.59	-26.93	-31.62
Meal	214	-8.50	-15.63	-21.70	-26.93	-31.50

Table 7.5: Japanese Price and Quantity Changes Under Dollar Appreciation SWOPSIM Substitution Scenario

	Base	Appreciation Rate 10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
Japanese Supply						
Beef	581	1.53	2.99	4.40	5.76	7.08
Pork	1400	3.44	6.82	10.14	13.42	16.66
Broilers	1336	3.74	7.41	11.04	14.62	18.19
Corn	2	0.00	0.00	0.00	10.00	10.00
Meal	1162	0.69	1.35	1.99	2.61	3.21
Japanese Demand						
Beef	1205	-3.66	-7.00	-10.06	-12.88	-15.49
Pork	2091	-4.14	-7.92	-11.37	-14.56	-17.51
Broilers	1767	-3.66	-7.01	-10.08	-12.93	-15.58
Corn	6811	1.70	3.37	5.02	6.64	8.24
Meal	2089	3.92	7.73	11.46	15.11	18.71
Japanese Trade Volume						
Beef	-624	-8.50	-16.30	-23.53	-30.24	-36.51
Pork	-691	-19.50	-37.76	-54.97	-71.26	-86.74
Broilers	-431	-26.61	-51.70	-75.53	-98.32	-120.24
Corn	-6809	1.70	3.37	5.02	6.64	8.24
Meal	-927	7.96	15.72	23.32	30.79	38.13
	—U.S. Dollars Per MT—					
Japanese Price						
Beef	7743	3.81	7.54	11.21	14.82	18.38
Pork	3832	4.32	8.59	12.83	17.04	21.22
Broilers	2124	3.79	7.50	11.16	14.78	18.36
Corn	290	4.11	8.11	12.02	15.85	19.62
Meal	490	2.31	4.57	6.78	8.96	11.11

Table 7.6: ROW Price and Quantity Changes Under Dollar Appreciation SWOPSIM Substitution Scenario

		Appreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
ROW Supply						
Beef	36001	1.18	2.29	3.35	4.35	5.31
Pork	58125	0.60	1.13	1.62	2.07	2.49
Broilers	18444	2.90	5.72	8.47	11.18	13.84
Corn	91727	1.62	3.17	4.64	6.06	7.43
Meal	28968	0.46	0.90	1.32	1.73	2.13
ROW Demand						
Beef	34449	-1.98	-3.79	-5.46	-7.01	-8.45
Pork	57292	-0.83	-1.58	-2.26	-2.89	-3.47
Broilers	18529	-3.66	-7.01	-10.08	-12.92	-15.56
Corn	118525	-0.56	-1.10	-1.61	-2.10	-2.56
Meal	33187	0.45	0.82	1.14	1.40	1.63
ROW Trade Volume						
Beef	1552	71.33	137.33	198.83	256.49	310.80
Pork	833	98.75	187.77	268.82	343.24	412.04
Broilers	-85	-1427.9	-2767.9	-4035.4	-5241.9	-6396.2
Corn	-26798	-8.06	-15.71	-23.02	-30.03	-36.76
Meal	-4219	0.39	0.32	-0.12	-0.84	-1.80
	—U.S. Dollars Per MT—					
ROW Price						
Beef	3452	1.99	3.88	5.69	7.42	9.09
Pork	1673	0.88	1.68	2.42	3.12	3.77
Broilers	1667	3.79	7.50	11.16	14.78	18.36
Corn	128	4.11	8.11	12.02	15.85	19.62
Meal	260	2.31	4.57	6.78	8.96	11.11

U.S. meat exports increase substantially in response to an exchange rate depreciation. Corn exports, on the other hand, increase moderately, and soy bean meal trade actually declines. The different responses in the meat and feed grain markets to exchange rate fluctuations are the result of larger changes in the demand for feed grains than for meat. This occurs because feed grains, and intermediate goods in general, are sensitive not only to movements in the good's own price but also the prices of the goods in which they are used. Furthermore, the relatively larger prices for value-added goods amplify the impact of these cross-price effects on the price response of intermediate goods to a change in the real exchange rate.

In the last ten years there has been both a sustained depreciation of the dollar and a steady climb in the quantity of meat exported by the United States. In the years between 1985 and 1993, the dollar has declined in value relative to the Japanese yen by more than 30%, and over the same period U.S. exports of beef, pork and broiler meat have risen in excess of 230%. Based on simulation results it may be reasonable to conclude that a currency depreciation of 20-30% is capable of producing the growth in meat exports observed in the United States over the last decade. While other forces, such as Japanese tariff reduction and the establishment of the North American Free Trade Agreement, have certainly played a role in expanding meat exports over the last decade, the simulation outcomes indicate that the role of exchange rate movements in determining the level of meat exports warrants further empirical investigation.

Finally, the simulations provide evidence that price movements induced by exchange rate variability can have a substantial influence on the location of marginal production in value-added industries. This fact could have important implications for exchange rate policies of countries desiring to increase their domestic production of high-value goods. First, a strong currency policy may conflict with other policies to promote value-added production by encouraging imports of value-added goods. Second, exchange rate movements will affect the commodity composition of trade. Currency depreciation promotes the expansion of a country's high-value industries, increasing exports or decreasing imports by a larger percentage than bulk commodities. Conversely, currency appreciation favors bulk commodities, causing smaller declines in domestic production relative to value-added industries.

CHAPTER VIII

TRANSPORTATION COST REDUCTIONS

The last chapter sought to explain the sharp rise in U.S. meat exports over the last decade as a consequence of the depreciating dollar. A competing hypothesis is that the invention of better, more reliable refrigerated transportation has lowered the cost of shipping chilled meat between countries, opening new markets for meat exports. Consumers in many countries, including Japan, prefer fresh cuts of meat to meat that has been frozen to facilitate transportation (Khan, Ramaswami, & Sapp, 1990). Consequently, the availability of lower cost fresh meat imports may significantly increase trade in meat products. Moreover, the possibility of further improvements in meat preservation and transportation technologies, such as meat irradiation, increases the relevance of an investigation of the trade impact caused by transportation cost reductions.

The first objective of this chapter is to determine how large a reduction in transportation costs is necessary to produce a 300% increase in meat exports. Second, we want to examine the feed grain industry to ascertain how the rise in the relative cost of feed grain transportation impacts U.S. feed grain consumption and trade. Finally, we consider how transportation cost reductions influence the location of marginal meat production.

Tables 8.1-8.3 summarize the changes in prices and quantities in the three countries as transportation costs for meat products fall. Production declines in the U.S. beef and pork industries reflect the fact that the reduction in transportation costs reduces the wedge between U.S. and ROW prices, inducing prices to fall in the United States and rise in the rest of the world. Consequently, American imports of beef and pork increase substantially. Since the United States is the low-cost producer of broilers, prices and exports both climb rapidly as transportation costs fall.

Table 8.1: U.S. Price and Quantity Changes After Transportation Cost Reduction
SWOPSIM Substitution Scenario

		Rate Of Cost Reduction				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
U.S. Supply						
Beef	10411	-0.56	-1.11	-1.67	-2.22	-2.77
Pork	7800	-2.03	-4.05	-6.07	-8.07	-10.07
Broilers	9401	2.15	4.33	6.53	8.75	10.99
Corn	121324	-0.10	-0.20	-0.30	-0.40	-0.51
Meal	20911	-0.05	-0.10	-0.16	-0.21	-0.26
U.S. Demand						
Beef	11339	1.08	2.18	3.29	4.42	5.56
Pork	7942	1.84	3.75	5.73	7.79	9.91
Broilers	8885	-2.46	-4.83	-7.12	-9.33	-11.46
Corn	87717	-0.35	-0.72	-1.11	-1.52	-1.95
Meal	15765	-0.38	-0.79	-1.22	-1.69	-2.18
U.S. Trade Volume						
Beef	-928	19.45	39.07	58.88	78.87	99.05
Pork	-142	214.63	432.58	653.97	878.94	1107.65
Broilers	516	81.56	162.09	241.60	320.12	397.67
Corn	33607	0.56	1.17	1.82	2.51	3.26
Meal	5146	0.96	2.00	3.12	4.32	5.61
—U.S. Dollars Per MT—						
U.S. Price						
Beef	3959	-0.92	-1.84	-2.76	-3.66	-4.57
Pork	2180	-2.06	-4.12	-6.17	-8.21	-10.23
Broilers	1160	2.67	5.39	8.15	10.95	13.79
Corn	82	-0.24	-0.49	-0.74	-1.00	-1.26
Meal	214	-0.26	-0.52	-0.78	-1.04	-1.30

Table 8.2: Japanese Price and Quantity Changes After Transportation Cost Reduction—SWOPSIM Substitution Scenario

		Rate Of Cost Reduction				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
Japanese Supply						
Beef	581	-0.79	-1.58	-2.38	-3.19	-4.01
Pork	1400	-3.12	-6.24	-9.38	-12.52	-15.68
Broilers	1336	-1.45	-2.86	-4.22	-5.55	-6.84
Corn	2	0.00	0.00	0.00	0.00	0.00
Meal	1162	-0.06	-0.13	-0.19	-0.26	-0.32
Japanese Demand						
Beef	1205	1.99	4.05	6.20	8.42	10.74
Pork	2091	3.69	7.65	11.92	16.53	21.52
Broilers	1767	1.22	2.44	3.66	4.88	6.10
Corn	6811	-2.26	-4.52	-6.77	-9.03	-11.29
Meal	2089	-2.49	-4.97	-7.46	-9.96	-12.46
Japanese Trade Volume						
Beef	-624	4.57	9.30	14.18	19.24	24.47
Pork	-691	17.47	35.79	55.06	75.38	96.88
Broilers	-431	9.50	18.87	28.11	37.22	46.21
Corn	-6809	-2.26	-4.52	-6.78	-9.04	-11.30
Meal	-927	-5.53	-11.05	-16.58	-22.11	-27.67
	—U.S. Dollars Per MT—					
Japanese Price						
Beef	7743	-1.95	-3.90	-5.85	-7.79	-9.72
Pork	3832	-3.56	-7.12	-10.67	-14.21	-17.74
Broilers	2124	-1.18	-2.33	-3.45	-4.55	-5.61
Corn	290	-0.16	-0.32	-0.48	-0.64	-0.81
Meal	490	-0.21	-0.43	-0.64	-0.86	-1.07

Table 8.3: ROW Price and Quantity Changes After Transportation Cost Reduction
SWOPSIM Substitution Scenario

	Base	Rate Of Cost Reduction 10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
ROW Supply						
Beef	36001	0.25	0.50	0.75	1.01	1.27
Pork	58125	0.35	0.72	1.09	1.48	1.88
Broilers	18444	-0.94	-1.86	-2.75	-3.63	-4.48
Corn	91727	-0.06	-0.13	-0.19	-0.26	-0.32
Meal	28968	-0.04	-0.09	-0.13	-0.17	-0.22
ROW Demand						
Beef	34449	-0.35	-0.70	-1.06	-1.42	-1.79
Pork	57292	-0.38	-0.78	-1.18	-1.58	-2.00
Broilers	18529	1.12	2.23	3.33	4.44	5.54
Corn	118525	0.24	0.49	0.76	1.03	1.32
Meal	33187	0.27	0.54	0.83	1.14	1.46
ROW Trade Volume						
Beef	1552	13.47	27.10	40.91	54.89	69.06
Pork	833	51.08	103.43	157.15	212.36	269.18
Broilers	-85	446.94	888.29	1324.14	1754.62	2179.81
Corn	-26798	1.28	2.61	4.00	5.45	6.95
Meal	-4219	2.38	4.86	7.45	10.13	12.92
	—U.S. Dollars Per MT—					
ROW Price						
Beef	3452	0.41	0.82	1.24	1.67	2.11
Pork	1673	0.34	0.69	1.05	1.43	1.82
Broilers	1667	-1.18	-2.33	-3.45	-4.55	-5.61
Corn	128	-0.16	-0.31	-0.48	-0.64	-0.80
Meal	260	-0.21	-0.43	-0.64	-0.85	-1.07

It would appear that transportation cost reductions are not able to explain rising U.S. exports of meat other than broilers. This conclusion is highly dependent upon the type and specification of the simulation model. Since the present model only considers the net trade position of a country, we are unable to detect any quantity of U.S. exports of beef or pork. Furthermore, it matters greatly whether the transportation cost wedge between U.S. and ROW meat prices is positive or negative. As was mentioned in chapter III, a reduction in transportation costs that are subtracted from a country's domestic price will have the opposite price and trade response than when costs are added to domestic prices.

Tables 8.1-8.3 reflect a negative price wedge, thus assuming that ROW prices for beef and pork are below those in the United States. This specification was chosen because the average per unit value of chilled and frozen beef and pork imported into the United States from the rest of the world in 1992-1993 does lie between 30-50% below the average value of U.S. beef and pork exports over this same period (USDA, 1994). Unfortunately, this price difference may indicate a variance in the quality of the meat exported and imported rather than lower average production costs in the rest of the world.

Tables 8.4-8.6 display the effect of reversing the sign of the transportation cost wedge between beef and pork prices in the United States and the rest of the world. Not surprisingly the United States shows marked decreases in its imports of both pork and beef, becoming a net exporter of pork with a 10% reduction in transportation costs. Beef production is less responsive to the reduction in transportation costs than pork, and the U.S. has not quite reached a zero excess supply of beef with a 50% decline in shipping costs. It is important to note that despite the reversal in the direction of U.S. trade volumes, the absolute magnitude of the effects remain roughly invariant to the sign change.

Table 8.4: U.S. Price and Quantity Changes After Transportation Cost Reduction SWOPSIM Substitution Scenario (Positive Price Wedge)

		Rate Of Cost Reduction				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
U.S. Supply						
Beef	10411	0.56	1.13	1.70	2.26	2.83
Pork	7800	1.95	3.90	5.86	7.81	9.77
Broilers	9401	2.07	4.17	6.29	8.43	10.58
Corn	121324	0.29	0.58	0.87	1.17	1.47
Meal	20911	0.11	0.23	0.35	0.47	0.60
U.S. Demand						
Beef	11339	-0.96	-1.90	-2.83	-3.75	-4.65
Pork	7942	-1.86	-3.66	-5.40	-7.09	-8.71
Broilers	8885	-2.60	-5.10	-7.52	-9.85	-12.10
Corn	87717	1.42	2.84	4.25	5.66	7.06
Meal	15765	1.84	3.67	5.51	7.33	9.16
U.S. Trade Volume						
Beef	-928	-18.05	-35.93	-53.64	-71.18	-88.55
Pork	-142	-211.42	-419.35	-623.97	-825.39	-1023.77
Broilers	516	82.51	163.84	244.03	323.08	401.03
Corn	33607	-2.67	-5.32	-7.94	-10.55	-13.13
Meal	5146	-5.16	-10.31	-15.43	-20.54	-25.62
	—U.S. Dollars Per MT—					
U.S. Price						
Beef	3959	0.95	1.90	2.86	3.82	4.78
Pork	2180	2.04	4.09	6.15	8.21	10.27
Broilers	1160	2.68	5.40	8.17	10.99	13.84
Corn	82	0.72	1.45	2.20	2.95	3.72
Meal	214	0.57	1.17	1.78	2.40	3.03

Table 8.5: Japanese Price and Quantity Changes After Transportation Cost Reduction—SWOPSIM Substitution Scenario (Positive Price Wedge)

		Rate Of Cost Reduction				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
Japanese Supply						
Beef	581	-0.11	-0.23	-0.34	-0.45	-0.56
Pork	1400	-0.24	-0.48	-0.71	-0.94	-1.17
Broilers	1336	-1.63	-3.21	-4.74	-6.23	-7.68
Corn	2	0.00	0.00	0.00	0.00	0.00
Meal	1162	0.15	0.28	0.44	0.59	0.74
Japanese Demand						
Beef	1205	0.27	0.54	0.81	1.08	1.34
Pork	2091	0.24	0.48	0.72	0.95	1.17
Broilers	1767	1.22	2.43	3.64	4.85	6.05
Corn	6811	-0.94	-1.86	-2.76	-3.64	-4.51
Meal	2089	-0.92	-1.83	-2.72	-3.61	-4.48
Japanese Trade Volume						
Beef	-624	0.63	1.26	1.88	2.50	3.11
Pork	-691	1.22	2.43	3.61	4.78	5.93
Broilers	-431	10.04	19.92	29.64	39.19	48.60
Corn	-6809	-0.94	-1.86	-2.76	-3.65	-4.51
Meal	-927	-2.25	-4.48	-6.69	-8.87	-11.02
	—U.S. Dollars Per MT—					
Japanese Price						
Beef	7743	-0.29	-0.59	-0.87	-1.16	-1.44
Pork	3832	-0.23	-0.45	-0.67	-0.89	-1.10
Broilers	2124	-1.18	-2.32	-3.44	-4.52	-5.58
Corn	290	0.46	0.93	1.41	1.89	2.38
Meal	490	0.47	0.96	1.46	1.97	2.50

Table 8.6: ROW Price and Quantity Changes After Transportation Cost Reduction SWOPSIM Substitution Scenario (Positive Price Wedge)

		Rate Of Cost Reduction				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
ROW Supply						
Beef	36001	-0.18	-0.36	-0.53	-0.70	-0.88
Pork	58125	-0.25	-0.50	-0.74	-0.98	-1.22
Broilers	18444	-0.96	-1.89	-2.80	-3.69	-4.55
Corn	91727	0.19	0.37	0.56	0.75	0.95
Meal	28968	0.09	0.19	0.29	0.39	0.49
ROW Demand						
Beef	34449	0.29	0.57	0.86	1.14	1.41
Pork	57292	0.25	0.50	0.75	0.99	1.23
Broilers	18529	1.11	2.22	3.32	4.42	5.51
Corn	118525	-0.56	-1.11	-1.66	-2.20	-2.73
Meal	33187	-0.66	-1.31	-1.95	-2.60	-3.23
ROW Trade Volume						
Beef	1552	-10.54	-20.98	-31.32	-41.55	-51.69
Pork	833	-35.03	-69.47	-103.37	-136.74	-169.60
Broilers	-85	449.92	893.59	1331.09	1762.54	2188.06
Corn	-26798	-3.11	-6.20	-9.26	-12.30	-15.32
Meal	-4219	-5.80	-11.59	-17.35	-23.11	-28.83
	—U.S. Dollars Per MT—					
ROW Price						
Beef	4446	-0.29	-0.59	-0.87	-1.16	-1.44
Pork	2687	-0.23	-0.45	-0.67	-0.89	-1.10
Broilers	1667	-1.18	-2.32	-3.44	-4.52	-5.58
Corn	128	0.46	0.93	1.41	1.89	2.38
Meal	260	0.47	0.96	1.46	1.97	2.50

Japanese trade volumes, on the other hand, are significantly impacted by altering the price wedge assumption. With the a negative price wedge, Japanese prices fall and imports rise by a much larger percentage than under the alternative specification. This occurs because Japan benefits from the reduction in U.S. prices as well as in transportation costs when the price wedge is negative; however, when the price wedge is positive, U.S. prices rise, diminishing the impact of the transportation cost decline. This relationship is evident in the fact that Japanese price reductions are roughly twice the size of U.S. price declines when the beef and pork price wedges is negative, but they are identical to the price declines in the rest of the world when the price wedges are positive.

Conclusions

Although the simulations do not clearly indicate whether reductions in transportation cost would increase U.S. meat exports, they do show that it is possible for 20% reduction in transportation costs to cause trade volumes for pork and broilers to be altered by 300% or more. This is not true for beef even with a 50% decline in costs.

As production locations and quantities are altered in the meat industry, adjustments occur in the feed grain markets. The United States, as the low-cost producer of feed grains, has an abundant supply of corn and soybean meal and is more intensive in its use of these feeds in meat production. Japan and the rest of the world often substitute other coarse grains and protein sources for corn and soy bean meal in meat production, and consequently will require less corn and meal to produce a given quantity of meat. Under the negative price wedge assumption, pork and beef production decreases in the United States as meat transport costs decline, releasing relatively more corn and meal than is demanded by the rest of the world. The net effect is a decline in feed grain prices but an increase in the volume of feed grain trade. Altering the sign of the price wedge reverses this progression. Demands for feed grains increase in the United States, driving up prices and reducing excess supplies.

Lowering the cost of transporting meat influences the location of marginal production in a predictable manner. The lowest cost producer of a meat product will expand its output and replace production in other countries through trade. The magnitude of these production effects are significant, but not large. A 50% decrease in shipping cost does not prompt more than a 5% change in beef production in any country. The same cost reduction may cause up to a 15% change in broiler or pork production. Thus it would appear that transportation costs are not as influential as export subsidies or currency fluctuations in altering the location of production in value-added industries.

CHAPTER IX

CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

In summary, this study has sought to expand the current body of economic knowledge in three respects. First, by constructing a general equilibrium model that explicitly accounts for the demand and substitution linkages between intermediate and value-added goods, we have identified the channels through which these two types of goods interact. Input substitution elasticities are the fundamental parameters that summarize the linkages between intermediate and final goods, and the relative magnitude of these substitution effects critically determine the impact of price changes in one market on production, prices, and trade volumes in connected markets.

Second, the analysis of optimal policies has assessed the applicability of current arguments for export subsidies in the case of high-value agricultural and bulk commodity exports. In addition, maximization of value added in the HVP industry was examined as an alternative political objective to utility maximization, and conditions were derived for which export subsidies are the optimal trade policy. One theoretical conclusion from the existing literature is that export subsidies may enhance the welfare of the exporting nation by acting as a second-best price discrimination mechanism; however, particular relationships must exist among the relative sizes of the excess supply elasticities in the trading countries. The simulations discussed in chapter VI indicate that a targeted subsidy for broiler exports to Japan does not result in welfare-improving price changes.

Finally, simulations of three exogenous price changes were conducted to provide indications of the direction and magnitude of price, output, and trade responses. The first price shock considered was a subsidy, both targeted to Japan and general, for exports of broiler meat. The simulation results indicate that a small export subsidy, targeted or general, is capable of causing rather substantial shifts in the location of marginal broiler production. As a consequence of the intermediate demand linkage between high-value and bulk commodities, we may also conclude that subsidization of value-added exports to a country which imports the majority of its intermediate inputs will cause imports of the intermediate input to fall in proportion to the decrease in domestic production of the value added good. Hence, there is a clear trade off in promoting the export of one or the other good, and it is reasonable to suggest that policy makers should consider such effects when crafting trade policies.

Comparative static results in chapter III imply that exchange rate movements will affect intermediate and value-added goods differently. The simulations discussed in chapter VII provide evidence that value-added goods will experience larger trade volume fluctuations than intermediate goods following an exchange rate shock. Results from the simulation of exchange rate fluctuations also suggest that currency devaluation may have played a large role in the establishing recent trends in meat and feed exports.

Lowering the cost of transporting meat also influences prices and trade volumes for both meat and feed grains; however, the size of changes in production and prices appears to be significantly smaller than when exchange rates or export subsidies are the driving force behind change. In the meat industries the lowest cost producer of the meat product will expand its output and replace production in other countries through trade. Changes in the feed grain markets depend upon whether the low-cost producer of the various meat products is also relatively intensive in their use of feed grains. Countries that have an abundant supply of feeds, tend to be more intensive in their use. When such a country is also the low-cost producer of meats, feed grain prices may rise and trade volumes fall in response to a reduction in the cost of transporting meat. The contrary result is true when the low-cost producer of meats is relatively less intensive in their use of feed grains.

Suggestions For Future Research

The empirical framework employed in this study has the advantage of explicitly incorporating input substitution elasticity parameters to maintain consistency among supply elasticities for value-added goods and intermediate input demand elasticities. Moreover, there are strong connections between economic trade theory and the empirical work. Unfortunately, some of the simplifying assumptions made in this study place rather severe restrictions on the supply side of the model.

First, by assuming that capital is specific to a particular sector in conjunction with an infinitely elastic supply of the variable primary input, meat and feed grain industries no longer compete for primary resources, and that production linkage between markets has been eliminated. Similarly, by assuming both supply and input substitution elasticities are invariant to price changes, we have excluded the possibility that input coefficients may respond to price changes. In other words, we have implicitly assumed a fixed coefficient model. The present framework also presumes perfectly competitive behavior on the part of firms in all countries. Though not conclusive, there is evidence of market power among poultry and livestock producers and processors in the United States. Finally, the present study has not incorporated production dynamics or time linkages between exchange rates and production.

Competition for primary inputs could be reintroduced in future studies by allowing capital to be shared among producers according to industry groupings. Producers of beef, pork, and chicken may compete for capital that is specific to the meat sector of the economy. The cost of introducing resource competition is that either the number of sector-specific factors must be increased or the number of traded goods reduced. Future researchers could introduce variable input coefficients without relaxing the assumption of constant input substitution elasticities by using production functions that allow cost shares to vary with prices. A superior alternative is to employ an estimated supply function that incorporates variable input substitution elasticities. Finally, the entire empirical model could be improved by recasting it in a framework incorporating imperfectly competitive meat producers and production dynamics.

In addition to modeling considerations, the results of this study point to some potentially fruitful research endeavors. The importance of input substitution elasticities was stressed in the theoretical chapters of this study. Although the role of these parameters is well known among economists, estimates of input substitution elasticities exist for relatively few industries. Consequently, there is a need for econometric studies of important industries in traded sectors of the economy to provide reliable estimates of substitution among productive inputs.

More importantly, the fact that value-added goods appear to be more intensely affected by exchange rate movements implies that the commodity composition of trade will vary as currency values change. Empirical research is needed to examine existing trade data for evidence of trade composition shifts following a currency depreciation or appreciation. Estimates of parameters that capture the responsiveness of particular commodity groups to exchange rate changes—such as cars and steel or automobile parts, clothing and textile fibers, computers and component parts, processed and bulk food products, etc.—would be valuable to policy makers and industry analysts for assessing the impact of expected exchange rate movements on specific traded goods. At a more basic level, the exchange rate's ability to influence the share of a country's trade consisting of manufactured goods or raw materials could provide further insight into the process of economic development, identifying the types of monetary and fiscal policies that promote growth in domestic value-added industries.

Finally, all three of the exogenous price shocks studied had a significant impact on the location of marginal production of high-value goods. The magnitudes derived from the simulation output should be viewed with caution since many structural and policy barriers to adjustment were not incorporated in this study. Thus, econometric studies are needed to estimate the size of actual production shifts resulting from trade policy, exchange rate changes and other price shocks. Moreover, the further simulation studies would be useful to determine the impact of market structure and domestic policies on the response of production in value-added industries to price shocks.

APPENDIX I

DERIVATION OF INPUT COEFFICIENTS AS FUNCTIONS OF PRICES

In order to derive explicit expressions of the input coefficients as functions of output prices, we begin by defining the input substitution elasticities for labor and capital, labor and land and labor and the intermediate input. The input substitution elasticities measure the percentage change in the factor intensity ratios for a one percent change in the relative factor prices, and they are defined as follows.

$$\sigma_{KL}^{j} \equiv \frac{\hat{c}_{Ki} - \hat{c}_{Li}}{\hat{w} - \hat{r}}; \quad \sigma_{TL}^{j} \equiv \frac{\hat{c}_{Ti} - \hat{c}_{Li}}{\hat{w} - \hat{g}}; \quad \sigma_{3L}^{j} \equiv \frac{\hat{c}_{32} - \hat{c}_{L2}}{\hat{w} - \hat{p}_3} \quad \text{for } i = 1,2,3 \quad j = 1,2$$

In addition to the substitution elasticities, the following three restriction on the rates of change for the input coefficients are used to solve for the input coefficients as functions of relative factor price changes. These restrictions are implied by cost minimization, and they state that around the optimum costs cannot be reduced further by varying input coefficients for given factor prices.

$$\text{(1A.1)} \quad \theta_{L1}\hat{c}_{L1} + \theta_{K1}\hat{c}_{K1} + \theta_{T1}\hat{c}_{T1} + \theta_{31}\hat{c}_{31} = 0$$

$$\text{(1A.2)} \quad \theta_{L2}\hat{c}_{L2} + \theta_{K2}\hat{c}_{K2} + \theta_{T2}\hat{c}_{T2} + \theta_{32}\hat{c}_{32} = 0$$

$$\text{(1A.3)} \quad \theta_{L3}\hat{c}_{L3} + \theta_{K3}\hat{c}_{K3} + \theta_{T3}\hat{c}_{T3} = 0$$

Following the method of Jones (1965), the cost minimization equations and the definitions above can be used to arrive at the following expressions for the rates of change in the input coefficients as relative factor prices change. Equations (1A.4)-(1A.6) show that input coefficients change according to a weighted sum of relative factor price changes.

$$\text{(1A.4)} \quad \begin{aligned} \hat{c}_{L1} &= -\theta_{K1}\sigma_{KL}^{1}(\hat{w} - \hat{r}) - \theta_{T1}\sigma_{TL}^{1}(\hat{w} - \hat{g}) - \theta_{31}\sigma_{3L}^{1}(\hat{w} - \hat{p}_3) \\ \hat{c}_{K1} &= (1 - \theta_{K1})\sigma_{KL}^{1}(\hat{w} - \hat{r}) - \theta_{T1}\sigma_{TL}^{1}(\hat{w} - \hat{g}) - \theta_{31}\sigma_{3L}^{1}(\hat{w} - \hat{p}_3) \\ \hat{c}_{T1} &= -\theta_{K1}\sigma_{KL}^{1}(\hat{w} - \hat{r}) + (1 - \theta_{T1})\sigma_{TL}^{1}(\hat{w} - \hat{g}) - \theta_{31}\sigma_{3L}^{1}(\hat{w} - \hat{p}_3) \\ \hat{c}_{31} &= -\theta_{K1}\sigma_{KL}^{1}(\hat{w} - \hat{r}) - \theta_{T1}\sigma_{TL}^{1}(\hat{w} - \hat{g}) + (1 - \theta_{31})\sigma_{3L}^{1}(\hat{w} - \hat{p}_3) \end{aligned}$$

$$\hat{c}_{L2} = -\theta_{K2}\sigma^2_{KL}(\hat{w}-\hat{r}) - \theta_{T2}\sigma^2_{TL}(\hat{w}-\hat{g}) - \theta_{32}\sigma^2_{3L}(\hat{w}-\hat{p}_3)$$

$$\hat{c}_{K2} = (1-\theta_{K2})\sigma^2_{KL}(\hat{w}-\hat{r}) - \theta_{T2}\sigma^2_{TL}(\hat{w}-\hat{g}) - \theta_{32}\sigma^2_{3L}(\hat{w}-\hat{p}_3)$$

(1A.5)

$$\hat{c}_{T2} = -\theta_{K2}\sigma^2_{KL}(\hat{w}-\hat{r}) + (1-\theta_{T2})\sigma^2_{TL}(\hat{w}-\hat{g}) - \theta_{32}\sigma^2_{3L}(\hat{w}-\hat{p}_3)$$

$$\hat{c}_{32} = -\theta_{K2}\sigma^2_{KL}(\hat{w}-\hat{r}) - \theta_{T2}\sigma^2_{TL}(\hat{w}-\hat{g}) + (1-\theta_{32})\sigma^2_{3L}(\hat{w}-\hat{p}_3)$$

$$\hat{c}_{L3} = -\theta_{K3}\sigma^3_{KL}(\hat{w}-\hat{r}) - \theta_{T3}\sigma^3_{TL}(\hat{w}-\hat{g})$$

(1A.6)

$$\hat{c}_{K3} = (1-\theta_{K3})\sigma^3_{KL}(\hat{w}-\hat{r}) - \theta_{T3}\sigma^3_{TL}(\hat{w}-\hat{g})$$

$$\hat{c}_{T3} = -\theta_{K3}\sigma^3_{KL}(\hat{w}-\hat{r}) + (1-\theta_{T3})\sigma^3_{TL}(\hat{w}-\hat{g})$$

We can now substitute (1A.4)-(1A.6) into equations (2.13)-(2.15) to obtain a relationship between the percentage change in output for a percent change in factor prices.

(1A.7)

$$\begin{bmatrix} \lambda_{L1} & \lambda_{L2} & \lambda_{L3} \\ \lambda_{K1} & \lambda_{K2} & \lambda_{K3} \\ \lambda_{T1} & \lambda_{T2} & \lambda_{T3} \end{bmatrix} \begin{bmatrix} \hat{X}_1 \\ \hat{X}_2 \\ \hat{X}_3 \end{bmatrix} = \begin{bmatrix} \hat{L} \\ \hat{K} \\ \hat{T} \end{bmatrix} + \begin{bmatrix} \beta_{KL} & \beta_{TL} & \beta_{3L} \\ -\beta_{KK} & \beta_{TK} & \beta_{3K} \\ \beta_{KT} & -\beta_{TT} & \beta_{3T} \end{bmatrix} \begin{bmatrix} (\hat{w}-\hat{r}) \\ (\hat{w}-\hat{g}) \\ (\hat{w}-\hat{p}_3) \end{bmatrix},$$

where

$$\beta_{Kj} = \sum_{i=1}^{3} \lambda_{ji}\theta_{Ki}\sigma^i_{KL} \text{ for } j = L, T \quad \beta_{KK} = \sum_{i=1}^{3} \lambda_{Ki}(1-\theta_{Ki})\sigma^i_{KL}$$

(1A.8)

$$\beta_{Tj} = \sum_{i=1}^{3} \lambda_{ji}\theta_{Ti}\sigma^i_{TL} \text{ for } j = L, K \quad \beta_{TT} = \sum_{i=1}^{3} \lambda_{Ti}(1-\theta_{Ti})\sigma^i_{TL} \ .$$

$$\beta_{3j} = \sum_{i=1}^{2} \lambda_{ji}\theta_{3i}\sigma^i_{3L} \text{ for } j = L, K, T$$

Each row of the β matrix gives the percent change in factor usage for a 1% change in a factor price holding outputs and other factor prices constant. The β coefficients themselves are weighted sums of the relative factor intensity adjustments in each industry in response to relative factor price changes.

Using the rate of change equations for prices, (2.16)-(2.18), we can solve for $(\hat{w}-\hat{r})$, $(\hat{w}-\hat{g})$ and $(\hat{w}-\hat{p}_3)$ and obtain the following expressions for relative factor price changes as a function of output price changes.

$$(1A.9) \quad (\hat{w}-\hat{r})=\frac{1}{|\theta|}\left[-\left(\theta_{T3}-\tilde{\theta}_{T1}\right)\hat{p}_2-\left(\tilde{\theta}_{T1}-\tilde{\theta}_{T2}\right)\hat{p}_3\right]$$

$$(1A.10) \quad (\hat{w}-\hat{g})=\frac{1}{|\theta|}\left[\left(\theta_{K3}-\tilde{\theta}_{K1}\right)\hat{p}_2-\left(\tilde{\theta}_{K2}-\tilde{\theta}_{K1}\right)\hat{p}_3\right]$$

$$(1A.11) \quad (\hat{w}-\hat{p}_3)=\frac{1}{|\theta|}\left[\left(\theta_{T1}\left(\theta_{K3}-\tilde{\theta}_{K1}\right)-\theta_{K1}\left(\theta_{T3}-\tilde{\theta}_{T1}\right)\right)\hat{p}_2-\left(\theta_{T3}\left(\tilde{\theta}_{K2}-\tilde{\theta}_{K1}\right)+\theta_{K3}\left(\tilde{\theta}_{T1}-\tilde{\theta}_{T2}\right)\right)\hat{p}_3\right]$$

$$(1A.12) \quad |\theta|=\left(\theta_{T3}-\tilde{\theta}_{T1}\right)\left(\tilde{\theta}_{K2}-\tilde{\theta}_{K1}\right)+\left(\theta_{K3}-\tilde{\theta}_{K1}\right)\left(\tilde{\theta}_{T1}-\tilde{\theta}_{T2}\right)\gtrless 0$$

for the conditions implied by (2.9) - (2.12).

It is interesting to note that the relative factor price changes are weighted sums of output price changes where the weights are elements of the determinant of the θ matrix. The weights, however, do not sum to one, so the relative factor price changes are not pure weighted averages of output price changes.

Substituting (1A.9)-(1A.11) into the right hand side of equation (1A.7), we obtain the percentage change in total factor usage for a percent change in output prices, holding output levels constant. Each δ_i is a weighted sum of relative factor and intermediate input intensity changes as relative output prices change. Using the definitions from (1A.8), (1A.13)-(1A.15) can be expanded and rearranged into the definitions for ψ_{ij} and ϕ_{ij} in (2.20). Thus, the expressions for the δ_i are rewritten more compactly in (2.19) using the definitions from (2.20).

$$(1A.13) \quad \delta_L=\frac{1}{|\theta|}\begin{bmatrix}\left(\left(\beta_{TL}+\theta_{T1}\beta_{3L}\right)\left(\theta_{K3}-\tilde{\theta}_{K1}\right)-\left(\beta_{KL}+\theta_{K1}\beta_{3L}\right)\left(\theta_{T3}-\tilde{\theta}_{T1}\right)\right)\hat{p}_2 \\ -\left(\left(\beta_{TL}+\theta_{T3}\beta_{3L}\right)\left(\tilde{\theta}_{K2}-\tilde{\theta}_{K1}\right)+\left(\beta_{KL}+\theta_{K3}\beta_{3L}\right)\left(\tilde{\theta}_{T1}-\tilde{\theta}_{T2}\right)\right)\hat{p}_3\end{bmatrix}$$

$$\delta_K = \frac{1}{|\theta|}\begin{bmatrix} \left((\beta_{TK} + \theta_{T1}\beta_{3K})\left(\theta_{K3} - \tilde{\theta}_{K1}\right) + (\beta_{KK} - \theta_{K1}\beta_{3K})\left(\theta_{T3} - \tilde{\theta}_{T1}\right)\right)\hat{p}_2 \\ +\left(-(\beta_{TK} + \theta_{T3}\beta_{3K})\left(\tilde{\theta}_{K2} - \tilde{\theta}_{K1}\right) + (\beta_{KK} - \theta_{K3}\beta_{3K})\left(\tilde{\theta}_{T1} - \tilde{\theta}_{T2}\right)\right)\hat{p}_3 \end{bmatrix} \tag{1A.14}$$

$$\delta_T = \frac{1}{|\theta|}\begin{bmatrix} \left(-(\beta_{TT} - \theta_{T1}\beta_{3T})\left(\theta_{K3} - \tilde{\theta}_{K1}\right) - (\beta_{KT} + \theta_{K1}\beta_{3T})\left(\theta_{T3} - \tilde{\theta}_{T1}\right)\right)\hat{p}_2 \\ +\left((\beta_{TT} - \theta_{T3}\beta_{3T})\left(\tilde{\theta}_{K2} - \tilde{\theta}_{K1}\right) - (\beta_{KT} + \theta_{K3}\beta_{3T})\left(\tilde{\theta}_{T1} - \tilde{\theta}_{T2}\right)\right)\hat{p}_3 \end{bmatrix} \tag{1A.15}$$

APPENDIX II

DERIVATION OF EQUATIONS IN CHAPTERS III AND IV

Derivation of the system of equations in (3.10) begins by differentiating equations (2.25), (2.26), and (3.9) with respect to prices and utility. The expressions in (2A.4) and (2A.5) for the change in foreign prices are substituted into (2A.1)-(2A.3). Rearranging (2A.1)-(2A.3) to isolate price and utility changes on the left hand side of the equality and subsidy changes on the right hand side yields the system of differential equations in (3.10).

(2A.1)
$$-du+\left((p_2-p_2^{\bullet})z_{22}^{\bullet}+(p_3-p_3^{\bullet})z_{32}^{\bullet}-z_2^{\bullet}\right)dp_2^{\bullet}$$
$$+\left((p_2-p_2^{\bullet})z_{23}^{\bullet}+(p_3-p_3^{\bullet})z_{33}^{\bullet}-z_3^{\bullet}\right)dp_3^{\bullet}=0$$

(2A.2) $$q_{22}dp_2+q_{23}dp_3+q_{2u}du+z_{22}^{\bullet}dp_2^{\bullet}+z_{23}^{\bullet}dp_3^{\bullet}=0$$

(2A.3) $$q_{32}dp_2+q_{33}dp_3+z_{32}^{\bullet}dp_2^{\bullet}+z_{33}^{\bullet}dp_3^{\bullet}=0$$

(2A.4) $$dp_2^{\bullet}=dp_2+p_2ds_2$$

(2A.5) $$dp_3^{\bullet}=dp_3+p_3ds_3$$

The system of equations in (4.11) can be obtained directly from the first-order conditions in (4.10) and the derivative of the lagrangian with respect to μ_1. Beginning with the derivatives of the lagrangian with respect to home country prices, one can solve for μ_2 and μ_3 as functions of μ_1. The expressions in (2A.6) and (2A.7) are substituted into the derivatives of the lagrangian with respect to foreign

(2A.6) $$\mu_2=\frac{\left(\frac{\partial\Lambda}{\partial p_3}X_2+\Lambda\frac{\partial X_2}{\partial p_3}\right)q_{32}+\left(\frac{\partial\Lambda}{\partial p_2}X_2+\Lambda\frac{\partial X_2}{\partial p_2}\right)q_{33}}{|q|}$$

(2A.7) $$\mu_3=\frac{\left(\frac{\partial\Lambda}{\partial p_2}X_2+\Lambda\frac{\partial X_2}{\partial p_2}\right)q_{23}+\left(\frac{\partial\Lambda}{\partial p_3}X_2+\Lambda\frac{\partial X_2}{\partial p_3}\right)q_{22}}{|q|}$$

(2A.8) $$|q|=q_{22}q_{33}-q_{23}q_{32}$$

prices. These first order conditions are solved for μ_1 and set equal to each other. The resulting statement is rearranged and simplified to isolate the price wedges on the left-hand side of the equal sign. Making the appropriate substitutions, we arrive at the first equation from the system in (4.11).

$$\text{(2A.9)} \quad \begin{aligned} &\left[q_{2u} q_2 \mathrm{A} \frac{(\dot{z}_{23} - \dot{z}_{22})}{|\dot{z}|} - \mathrm{B} \quad q_{2u} q_2 \mathrm{A} \frac{(\dot{z}_{33} - \dot{z}_{32})}{|\dot{z}|} + \mathrm{A} \right] \begin{bmatrix} (p_2 - \dot{p}_2) \\ (p_3 - \dot{p}_3) \end{bmatrix} \\ &= \left[q_{2u} q_2 \mathrm{A} \frac{(\dot{z}_3 - \dot{z}_2)}{|\dot{z}|} - (p_2 - \dot{p}_2)\mathrm{B} + (p_3 - \dot{p}_3)\mathrm{A} \right] \end{aligned}$$

The second equation from the system in (4.11) is simply the balance of payments restriction; however, since the system is evaluated around the free trade equilibrium, $q_1 + p_2 q_2 + p_3 q_3$—the excess demand for the home country—is set equal to zero. Thus, rearranging the balance of payments equation so that the price wedges are on the left-hand side of the equal sign results in the second equation to complete the system in (4.11).

APPENDIX III

ELASTICITY DERIVATIONS AND DATA MANIPULATIONS

Derivation Of Supply Elasticity Equations

In order to arrive at the supply elasticities in equations (5.5) and (5.6), we must first derive the expression for the rate of change of capital input per unit output as a function of factor and output prices. Starting with the definition of the elasticity of input substitution between capital and labor in (3A.1), we can solve for the change in per unit capital inputs as a function of factor prices and per unit labor input changes. Totally differentiating equations (5.2) and (5.3) and dividing by p_i yields the following expression for the rate of price changes.

(3A.1) $$\hat{c}_{Ki} = \sigma^{i}_{KL}\left(\hat{w} - \hat{r}\right) + \hat{c}_{Li}$$

(3A.2) $$\hat{p}_i = \left(\theta_{Li}\hat{w} + \theta_{Ki}\hat{r}_i + \theta_{4i}\hat{p}_4 + \theta_{5i}\hat{p}_5\right) + \left(\theta_{Li}\hat{c}_{Li} + \theta_{Ki}\hat{c}_{Ki} + \theta_{4i}\hat{c}_{4i} + \theta_{5i}\hat{c}_{5i}\right) \quad \text{for } i = 1,2,3.$$

$$\hat{p}_j = \left(\theta_{Lj}\hat{w} + \theta_{Kj}\hat{r}_j\right) + \left(\theta_{Lj}\hat{c}_{Lj} + \theta_{Kj}\hat{c}_{Kj}\right) \quad \text{for } j = 4,5.$$

Since producers minimize costs at the optimal level of output given factor prices, changes in per unit input coefficients cannot further reduce cost. Thus, in equilibrium the second expression on the right hand side in parentheses is zero. We can use this fact to solve for $\hat{c}_{Li}$ and substitute the results into (3A.1).

(3A.3) $$\hat{c}_{Ki} = \frac{-\theta_{Li}\sigma^{i}_{KL}}{\theta_{Li} + \theta_{Ki}}\left(\hat{w} - \hat{r}_i\right) - \frac{\left(\theta_{4i}\hat{c}_{4i} + \theta_{5i}\hat{c}_{5i}\right)}{\theta_{Li} + \theta_{Ki}} \quad \text{for } i = 1,2,3.$$

$$\hat{c}_{Kj} = -\theta_{Lj}\sigma^{j}_{KL}\left(\hat{w} - \hat{r}_j\right) \quad \text{for } j = 4,5.$$

Employing the definition of the input substitution elasticity between intermediate inputs and labor, we can use a similar process to replace the changes in intermediate input coefficients with expressions in output price changes. The resulting statement shows that the elasticities calculated from these formulas satisfy the restrictions implied by the fact that supply functions are homogeneous of degree zero in input prices. Specifically, the sum of the supply elasticities with respect to input prices must be zero. Recognizing that $-\hat{c}_{Ki} = \hat{X}_i$, we see clearly that changing all input prices in the same proportion will not result in any change in the quantity supplied.

$$\text{(3A.5)} \qquad \hat{c}_{Ki} = -(1-\theta_{Ki})\sigma^{i}_{KL}(\hat{w}-\hat{r}) + \theta_{4i}\sigma^{i}_{4L}(\hat{w}-\hat{p}_4) + \theta_{5i}\sigma^{i}_{5L}(\hat{w}-\hat{p}_5) \qquad \text{for } i = 1,2,3.$$

We can now take the final steps to arrive at equations (5.5) and (5.6) by recalling that it is assumed the supply of labor to the meat and feed grain sectors is infinitely elastic; hence, the change in wage rates in these industries is zero. We can also substitute for $\hat{r}_i$ by solving the expressions in the first set of parentheses on the right hand side of (3A.2) for $\hat{r}_i$. Collecting terms, we arrive at the desired form. A process similar to the above description was used to solve for the intermediate input demand elasticities in (5.11).

Data Sources And Manipulations

<u>Quantity Data</u>

Supply and demand data were extracted from the *Production, Supply and Distribution Database* (USDA, 1995b) using the associated PS&D View software. It was necessary to balance the data set to eliminate nonzero world excess supply resulting from measurement and round-off error. This was accomplished in GAMS by minimizing the sum of squared deviations from the actual data. The form of the criterion function is given in (3A.6). The tilde denotes the estimated value for supply or demand, and the weights in the denominator are the respective good's share of world supply or demand.

$$\text{(3A.6)} \qquad error = \sum_{j}\sum_{i=1}^{5}\left(\frac{(X_{ij}-\tilde{X}_{ij})}{\phi_{ij}}\right)^2 + \left(\frac{(d_{ij}-\tilde{d}_{ij})}{\psi_{ij}}\right)^2 \qquad \text{for } j = \text{ US, JAP, ROW.}$$

Once a balanced set of supply and demand values was achieved, it was necessary to determine the portion of corn and soy bean meal that was consumed in beef, pork, and broiler production. These values are not available, so the quantities were approximated by multiplying the share of corn and soy bean meal demand attributed to beef, pork, and poultry production in the SWOPSIM database (Sullivan, Roningen, and Leetmaa, 1992) by the adjusted corn and soybean meal demands for 1992.[1] Poultry's share of demand for each feed grain was adjusted by broiler production's share of total poultry production to arrive a measure of broiler production's demand for feed grains.[2] In order to balance supply with demand, the portion of feed grain demand attributed to sectors other than meat production was subtracted from each country's production level. The exception, however, was Japanese corn supply. Japan meets nearly all of its demand for corn through imports, so the residual corn demand in Japan was deducted from U.S. and Row production according to each country's share of Japanese corn imports.

Price Data

The U.S. beef price is the annual average wholesale price for the carcass equivalent of one pound of Grade 3 choice retail cuts (USDA, 1993). Similarly, the pork price is the average wholesale price for the carcass equivalent of one pound of retail cuts (USDA, 1994d). The broiler price is the annual twelve-city average wholesale price for ready to cook (RTC) broiler meat (USDA, 1994e). The 1992 corn price is the annual average price for No. 2 yellow corn in Chicago (USDA, 1994b). The U.S. soy bean meal price is the annual average price for 48% protein Decatur solvent meal (USDA, 1995a).

[1]Row feed grain demand shares were calculated as the ratio of total Row demand for feed grains in each sector to the total Row demand for feed grains as calculated from the SWOPSIM database.
[2]Implicit in this process is the assumption that each meat product maintains a constant share of total feed grain demand. Although the validity of this assumption is questionable, the alternative would require one to specify a demand function for feed grains used in other sectors of the economy.

Japanese meat prices are also annual averages found in the *Monthly Statistics of Agriculture, Forestry and Fisheries* (MAFF, 1995). The beef and pork prices are the Tokyo wholesale price for dairy bull and hog carcasses respectively. Similarly, the Japanese broiler price is the average wholesale price for RTC broiler meat. Both the Japanese corn and soybean meal prices are average prices paid for these goods in rural areas (MAFF, 1994).

Row prices were calculated from U.S. prices by either adding or subtracting the cost of transportation. Since the United States was a net importer of beef and pork in 1992, the cost of meat transportation was subtracted from the U.S. prices for these meats to obtain the Row price. The United States is a net exporter of the remaining three commodities, and, consequently, the Row price surpasses the U.S. price for these goods by the cost of transportation.

For simplicity, transportation costs from the U.S. to Japan are assumed to be the same as from the United States to the rest of the world. The cost of transporting meat is equal to the cost of transporting chilled meat from the Midwestern United States to Tokyo, Japan (Hayes, 1990) adjusted for inflation by the producer price index (U.S. Bureau of the Census, 1994). Likewise, the grain transportation cost is the production-weighted average cost of transporting feed grain from various locations in the United States to Japan, adjusted for inflation by the producer price index (Jang, 1992).

All goods are assumed to enter the three countries duty free except Japanese imports of beef and pork. Beef imported into Japan in 1992 was subject to a 60% tariff, and pork imports were taxed at an average rate of 22.8% (GATT, 1993). Transfer costs for Japanese prices were calculated from the remaining wedge between Japanese and U.S. prices after tranportation and tariff costs had been removed. Japanese prices were converted to U.S. dollars at a rate of 124.75

yen/dollar (IMF, 1995). All weight and volume conversion to metric tons were accomplished with the aid of *Weights, Measures, and Conversion Factors for Agricultural Commodities and Their Products* (USDA, 1992).

Sector-specific Factor Cost Shares

Sector-specific cost shares were approximated by the share of costs attributed to fixed factors. Shares for the United States were calculated from cost of production statistics (USDA, 1994a). The shares were calculated as the sum of per unit expenditures for general overhead, taxes and insurance, interest, and land rental divided by the average annual price. In the beef industry, the share of costs attributed to fixed factors in the cow/calf industry, weighted by the feeder cattle's share of fed cattle costs, were added to the fixed cost share in the fed cattle sector. Shares for the pork industry were calculated for a farrow-to-finish producer. Since the USDA does not collect production cost statistics for the broiler industry, cost shares were calculated from broiler production cost estimates in Trede, et. al. (1986). Finally, soy bean meal cost shares are the sum of the weighted share of fixed costs in soy bean production and the share of fixed costs in meal production (U.S. Department of Commerce, 1995).

Table 3A.1: Sector-specific Factor Cost Shares

	Country	
Commodity	United States	Japan
Beef	0.184111567	0.182512578
Pork	0.115220126	0.089265689
Broilers	0.073092000	0.044370494
Corn	0.393759341	0.466531646
Soy Bean Meal	0.374565930	0.316016771

Japanese cost shares were calculated in a manner similar to U.S. shares. Fixed costs are the sum of taxes, breeding stock depreciation, building depreciation, depreciation of agricultural implements, interest costs, and land rent (MAFF, 1994). As with the U.S. data, the costs incurred in raising cattle and hogs were incorporated into the cost of fattening livestock. Numbers were not available to calculate the share of costs attributed to fixed factors in the Japanese soy bean crushing industry, so the value for the United States was used as an approximation. Finally, the fixed cost share in the production of 6-row barley was used as an approximation for the cost share in Japanese corn production.

Demand And Supply Elasticities

The compensated demand elasticities for meat products and their sources are listed in Table 3A.2. Similarly, Tables 3A.3 and 3A.4 contain the input substitution elasticities used to calculate the supply and intermediate input demand elasticities for the low substitution, SWOPSIM, and high substitution cases.

Table 3A.2: Compensated Demand Elasticities

	Country		
Elasticity	United States	Japan	Rest of World
η_{11}	-0.349[a]	-0.617[c]	-.0450[d]
η_{22}	-0.599[b]	-0.604[c]	-0.599[b]
η_{33}	-0.823[a]	-0.859[c]	-0.823[a]

[a] Alston and Chalfant (1993)
[b] Moschini and Meilke (1989)
[c] Hayes, Wahl, and Williams (1990)
[d] Assumed

Table 3A.3: U.S. And Row Input Substitution Elasticities

	Substitution Scenario		
Elasticities	Low	SWOPSIM	High
σ^1_{KL}	0.100	0.136	0.200
σ^2_{KL}	0.100	0.130	0.200
σ^3_{KL}	0.100	0.063	0.200
σ^4_{KL}	0.100	0.260	0.400
σ^5_{KL}	0.100	0.120	0.200
σ^i_{4L}	0.100	0.438	0.500
σ^i_{5L}	0.100	0.651	0.800

TABLE 3A.4: Japanese Input Substitution Elasticities

	Substitution Scenario		
Elasticities	Low	SWOPSIM	High
σ^1_{KL}	0.100	0.089	0.200
σ^2_{KL}	0.100	0.086	0.200
σ^3_{KL}	0.100	0.059	0.200
σ^4_{KL}	0.100	0.350	0.400
σ^5_{KL}	0.100	0.174	0.200
σ^i_{4L}	0.100	0.444	0.500
σ^i_{5L}	0.100	0.758	0.800

APPENDIX IV

RESULTS FROM EXPORT SUBSIDY SIMULATIONS: LOW AND HIGH SUBSTITUTION SCENARIOS

Table 4A.1: U.S. Price And Quantity Changes Under A Targeted Subsidy
Low Substitution Scenario

	Base	U.S. Subsidy Rate			
		10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
U.S. Supply					
Beef	10411	0.00	-0.00	-0.01	-0.03
Pork	7800	0.03	0.09	0.13	0.11
Broilers	9401	0.84	2.62	4.64	7.19
Corn	121324	-0.02	-0.05	-0.07	-0.03
Meal	20911	-0.05	-0.13	-0.20	-0.18
U.S. Demand					
Beef	11339	0.02	0.07	0.13	0.20
Pork	7942	-0.01	-0.03	-0.06	-0.12
Broilers	8885	-0.59	-1.83	-3.23	-5.05
Corn	87717	0.27	0.82	1.43	2.17
Meal	15765	0.32	0.98	1.75	2.73
U.S. Trade Volume					
Beef	-928	0.29	0.91	1.65	2.67
Pork	-142	-2.11	-6.41	-10.32	-12.69
Broilers	516	25.47	79.13	140.18	217.91
Corn	33607	-0.76	-2.33	-3.99	-5.76
Meal	5146	-1.15	-3.51	-6.16	-9.10
	—U.S. Dollars Per MT—				
U.S. Price					
Beef	3959	-0.01	-0.03	-0.05	-0.08
Pork	2180	-0.00	-0.00	-0.00	0.03
Broilers	1160	0.61	1.92	3.44	5.48
Corn	82	-0.12	-0.34	-0.45	-0.18
Meal	214	-0.27	-0.79	-1.17	-1.07

Table 4A.2: U.S. Surplus Changes Under a Targeted Subsidy
Low Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	-3	-9	-17	-29
Pork	3	8	12	13
Broilers	70	220	396	628
Corn	-12	-34	-45	-18
Meal	-2	-5	-7	-3
Consumer Surplus				
Beef	157	486	861	1342
Pork	-289	-896	-1599	-2542
Broilers	-63	-196	-349	-554
Total Welfare				
Total Change	-215	-754	-1492	-2568
Percent Change	-0.01	-0.02	-0.04	-0.07
Subsidy Value	76	328	744	1405

Table 4A.3: U.S. Price And Quantity Changes Under A Targeted Subsidy
High Substitution Scenario

		U.S. Subsidy Rate			
	Base	10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
U.S. Supply					
Beef	10411	0.00	-0.01	-0.02	-0.03
Pork	7800	0.02	0.07	0.12	0.13
Broilers	9401	1.57	4.35	6.99	10.07
Corn	121324	-0.04	-0.15	-0.25	-0.25
Meal	20911	-0.04	-0.15	-0.25	-0.27
U.S. Demand					
Beef	11339	0.02	0.06	0.09	0.13
Pork	7942	-0.01	-0.03	-0.04	-0.07
Broilers	8885	-0.57	-1.55	-2.44	-3.49
Corn	87717	0.51	1.42	2.27	3.16
Meal	15765	0.66	1.85	2.97	4.15
U.S. Trade Volume					
Beef	-928	0.29	0.80	1.31	1.94
Pork	-142	-1.78	-5.49	-8.94	-11.33
Broilers	516	38.41	106.01	169.45	243.47
Corn	33607	-1.47	-4.26	-6.82	-9.13
Meal	5146	-2.19	-6.29	-10.09	-13.82
	—U.S. Dollars Per MT—				
U.S. Price					
Beef	3959	-0.01	-0.02	-0.03	-0.05
Pork	2180	0.00	0.00	0.00	0.01
Broilers	1160	0.59	1.62	2.58	3.73
Corn	82	-0.06	-0.24	-0.40	-0.40
Meal	214	-0.13	-0.45	-0.73	-0.81

Table 4A.4: U.S. Surplus Changes Under A Targeted Subsidy
High Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
<u>Producer Surplus</u>				
Beef	-2	-7	-11	-17
Pork	1	5	8	9
Broilers	67	187	301	437
Corn	-6	-24	-40	-40
Meal	-1	-3	-5	-5
<u>Consumer Surplus</u>				
Beef	150	408	647	925
Pork	-270	-780	-1227	-1760
Broilers	-61	-166	-263	-378
<u>Total Welfare</u>				
Total Change	-205	-756	-1417	-2322
Percent Change	-0.01	-0.02	-0.04	-0.07
Subsidy Value	83	376	827	1493

Table 4A.5: Japanese Price And Quantity Changes Under A Targeted Subsidy
Low Substitution Scenario

	Base	U.S. Subsidy Rate			
		10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
Japanese Supply					
Beef	581	0.00	0.00	-0.01	-0.02
Pork	1400	0.03	0.10	0.14	0.13
Broilers	1336	-13.54	-37.88	-58.42	-75.03
Corn	2	0.00	0.00	0.00	0.00
Meal	1162	-0.03	-0.11	-0.16	-0.15
Japanese Demand					
Beef	1205	-0.18	-0.57	-1.05	-1.66
Pork	2091	0.10	0.32	0.57	0.89
Broilers	1767	7.28	25.86	52.70	94.94
Corn	6811	-5.43	-16.70	-28.59	-41.27
Meal	2089	-5.29	-16.29	-27.93	-40.34
Japanese Trade Volume					
Beef	-624	-0.34	-1.10	-2.03	-3.18
Pork	-691	0.23	0.76	1.45	2.42
Broilers	-431	71.83	223.41	397.15	621.80
Corn	-6809	-5.43	-16.71	-28.60	-41.28
Meal	-927	-11.88	-36.58	-62.73	-90.72
	—U.S. Dollars Per MT—				
Japanese Price					
Beef	7743	-0.01	-0.03	-0.04	-0.07
Pork	3832	0.00	0.00	0.00	0.02
Broilers	2124	-6.57	-19.94	-33.60	-47.57
Corn	290	-0.08	-0.22	-0.29	-0.12
Meal	490	-0.22	-0.65	-0.96	-0.88

Table 4A.6: Japanese Surplus Changes Under A Targeted Subsidy
Low Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	0	-1	-2	-3
Pork	1	2	4	4
Broilers	-173	-452	-651	-782
Corn	0	0	0	0
Meal	-1	-4	-5	-5
Consumer Surplus				
Beef	-183	-597	-1097	-1724
Pork	116	379	697	1100
Broilers	255	837	1546	2447
Total Welfare				
Total Change	15	164	492	1037
Percent Change	0.0055	0.0636	0.1908	0.4026

Table 4A.7: Japanese Price And Quantity Changes Under A Targeted Subsidy High Substitution Scenario

	Base	U.S. Subsidy Rate			
		10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
Japanese Supply					
Beef	581	0.00	-0.01	-0.02	-0.03
Pork	1400	0.06	0.09	0.15	0.17
Broilers	1336	-25.36	-61.80	-83.09	-93.95
Corn	2	0.00	0.00	0.00	0.00
Meal	1162	-0.03	-0.13	-0.21	-0.23
Japanese Demand					
Beef	1205	-0.18	-0.59	-1.08	-1.70
Pork	2091	0.10	0.32	0.58	0.91
Broilers	1767	7.30	26.09	53.42	96.36
Corn	6811	-10.60	-30.82	-49.37	-65.85
Meal	2089	-10.29	-30.04	-48.32	-64.73
Japanese Trade Volume					
Beef	-624	-0.34	-1.12	-2.07	-3.26
Pork	-691	0.23	0.78	1.47	2.42
Broilers	-431	108.53	298.52	476.55	686.27
Corn	-6809	-10.60	-30.83	-49.38	-65.87
Meal	-927	-23.14	-67.53	-108.62	-145.59
	—U.S. Dollars Per MT—				
Japanese Price					
Beef	7743	-0.01	-0.02	-0.03	-0.04
Pork	3832	0.00	0.00	0.00	0.00
Broilers	2124	-6.59	-20.09	-33.90	-47.93
Corn	290	-0.04	-0.16	-0.26	-0.26
Meal	490	-0.11	-0.37	-0.60	-0.67

Table 4A.8: Japanese Surplus Changes Under A Targeted Subsidy
High Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	0	-1	-1	-2
Pork	0	2	3	3
Broilers	-162	-371	-475	-518
Corn	0	0	0	0
Meal	-1	-2	-3	-4
Consumer Surplus				
Beef	-184	-603	-1111	-1745
Pork	116	382	705	1114
Broilers	256	844	1564	2475
Total Welfare				
Total Change	25	251	682	1323
Percent Change	0.01	0.10	0.27	0.52

Table 4A.9: ROW Price And Quantity Changes Under A Targeted Subsidy
Low Substitution Scenario

		U.S. Subsidy Rate			
	Base	10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
ROW Supply					
Beef	36001	0.00	-0.01	-0.02	-0.03
Pork	58125	0.01	0.04	0.06	0.07
Broilers	18444	0.56	1.75	3.12	4.92
Corn	91727	-0.01	-0.03	-0.04	-0.02
Meal	28968	-0.04	-0.12	-0.16	-0.15
ROW Demand					
Beef	34449	-0.01	-0.02	-0.03	-0.05
Pork	57292	0.02	0.05	0.07	0.07
Broilers	18529	-0.40	-1.25	-2.23	-3.50
Corn	118525	0.09	0.27	0.48	0.72
Meal	33187	0.12	0.37	0.67	0.99
ROW Trade Volume					
Beef	1552	0.04	0.10	0.17	0.32
Pork	833	-0.17	-0.46	-0.56	-0.16
Broilers	-85	-209.57	-652.46	-1162.80	-1830.04
Corn	-26798	0.43	1.32	2.26	3.27
Meal	-4219	1.20	3.70	6.27	8.83
	—U.S. Dollars Per MT—				
ROW Price					
Beef	3452	-0.01	-0.03	-0.06	-0.09
Pork	1673	0.00	-0.01	-0.01	0.03
Broilers	1667	0.43	1.33	2.39	3.82
Corn	128	-0.08	-0.22	-0.29	-0.12
Meal	260	-0.22	-0.65	-0.97	-0.88

Table 4A.10: ROW Surplus Changes Under A Targeted Subsidy
Low Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	-12	-37	-67	-105
Pork	5	17	33	58
Broilers	134	421	758	1210
Corn	-9	-26	-34	-14
Meal	-17	-49	-73	-66
Consumer Surplus				
Beef	-694	-2165	-3883	-6199
Pork	253	787	1394	2170
Broilers	-121	-375	-662	-1027
Total Welfare				
Total Change	-461	-1427	-2534	-3973
Percent Change	-0.01	-0.02	-0.03	-0.05

Table 4A.11: ROW Price And Quantity Changes Under A Targeted Subsidy
High Substitution Scenario

		U.S. Subsidy Rate			
	Base	10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
ROW Supply					
Beef	36001	-0.01	-0.02	-0.03	-0.04
Pork	58125	0.01	0.03	0.05	0.07
Broilers	18444	1.07	2.94	4.71	6.81
Corn	91727	-0.03	-0.10	-0.16	-0.16
Meal	28968	-0.04	-0.12	-0.20	-0.22
ROW Demand					
Beef	34449	-0.01	-0.02	-0.03	-0.04
Pork	57292	0.01	0.03	0.05	0.07
Broilers	18529	-0.39	-1.06	-1.68	-2.41
Corn	118525	0.17	0.49	0.78	1.07
Meal	33187	0.27	0.80	1.29	1.73
ROW Trade Volume					
Beef	1552	0.03	0.03	-0.05	-0.15
Pork	833	-0.11	-0.29	-0.31	0.08
Broilers	-85	-317.17	-870.12	-1387.73	-2001.79
Corn	-26798	0.85	2.49	3.99	5.28
Meal	-4219	2.41	7.17	11.55	15.13
	—U.S. Dollars Per MT—				
ROW Price					
Beef	3452	-0.01	-0.02	-0.04	-0.05
Pork	1673	0.00	0.00	0.00	0.01
Broilers	1667	0.41	1.13	1.80	2.59
Corn	128	-0.04	-0.16	-0.26	-0.26
Meal	260	-0.11	-0.37	-0.60	-0.67

Table 4A.12: ROW Surplus Changes Under A Targeted Subsidy
High Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	-9	-26	-43	-65
Pork	3	11	18	29
Broilers	129	357	573	833
Corn	-5	-18	-30	-30
Meal	-8	-28	-45	-50
Consumer Surplus				
Beef	-682	-1847	-2925	-4224
Pork	241	659	1047	1495
Broilers	-119	-323	-509	-722
Total Welfare				
Total Change	-450	-1215	-1914	-2734
Percent Change	-0.01	-0.02	-0.03	-0.04

Table 4A.13: U.S. Price And Quantity Changes Under A General Subsidy
Low Substitution Scenario

		U.S. Subsidy Rate			
	Base	10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
U.S. Supply					
Beef	10411	-0.03	-0.10	-0.19	-0.30
Pork	7800	-0.44	-1.49	-2.84	-4.73
Broilers	9401	7.74	28.03	59.10	113.93
Corn	121324	0.44	1.49	2.87	4.82
Meal	20911	0.49	1.71	3.36	5.79
U.S. Demand					
Beef	11339	0.06	0.21	0.37	0.55
Pork	7942	-0.22	-0.72	-1.37	-2.27
Broilers	8885	-6.27	-19.37	-33.36	-48.66
Corn	87717	2.09	7.08	13.72	23.45
Meal	15765	3.23	11.11	21.89	38.21
U.S. Trade Volume					
Beef	-928	1.12	3.65	6.64	10.13
Pork	-142	12.13	41.16	79.23	133.06
Broilers	516	249.13	844.15	1651.14	2913.50
Corn	33607	-3.86	-13.10	-25.46	-43.81
Meal	5146	-7.89	-27.10	-53.41	-93.54
	—U.S. Dollars Per MT—				
U.S. Price					
Beef	3959	0.09	0.30	0.58	1.01
Pork	2180	0.08	0.29	0.56	0.93
Broilers	1160	6.91	24.84	51.92	98.77
Corn	82	2.89	10.09	20.17	35.74
Meal	214	3.00	10.67	21.86	40.08

Table 4A.14: U.S. Surplus Changes Under a General Subsidy
Low Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	16	56	112	203
Pork	-34	-116	-221	-370
Broilers	730	2877	6813	15638
Corn	288	1011	2036	3645
Meal	42	149	299	536
Consumer Surplus				
Beef	1566	5203	9813	16137
Pork	-3871	-12861	-24257	-39910
Broilers	-695	-2314	-4376	-7217
Total Welfare				
Total Change	-2181	-8112	-17741	-36434
Percent Change	-0.06	-0.23	-0.51	-1.05
Subsidy Value	223	2116	7962	25097

Table 4A.15: U.S. Price And Quantity Changes Under A General Subsidy
High Substitution Scenario

		U.S. Subsidy Rate			
	Base	10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
U.S. Supply					
Beef	10411	0.02	0.09	0.22	0.46
Pork	7800	-0.28	-0.85	-1.39	-1.88
Broilers	9401	16.57	61.05	126.46	224.64
Corn	121324	0.85	2.55	4.05	5.09
Meal	20911	0.38	1.11	1.65	1.81
U.S. Demand					
Beef	11339	0.09	0.25	0.37	0.41
Pork	7942	-0.16	-0.47	-0.75	-0.98
Broilers	8885	-5.97	-17.36	-27.800	-37.26
Corn	87717	4.23	13.82	25.14	38.77
Meal	15765	5.72	18.97	35.12	55.31
U.S. Trade Volume					
Beef	-928	0.81	1.99	2.01	-0.16
Pork	-142	6.59	20.44	34.33	48.23
Broilers	516	404.56	1411.26	2782.60	4734.36
Corn	33607	-7.96	-26.85	-50.97	-82.80
Meal	5146	-15.98	-53.62	-100.87	-162.09
	—U.S. Dollars Per MT—				
U.S. Price					
Beef	3959	0.06	0.21	0.42	0.73
Pork	2180	0.02	0.05	0.06	-0.10
Broilers	1160	6.55	21.73	39.91	61.72
Corn	82	1.39	4.18	6.66	8.40
Meal	214	1.15	3.36	5.02	5.53

Table 4A.16: U.S. Surplus Changes Under A General Subsidy
High Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	18	66	140	260
Pork	-17	-53	-91	-132
Broilers	746	2962	6687	13107
Corn	139	421	676	857
Meal	17	52	84	106
Consumer Surplus				
Beef	1530	4755	8145	11700
Pork	-3580	-11164	-19242	-27947
Broilers	-655	-2034	-3476	-4974
Total Welfare				
Total Change	-2124	-8298	-19147	-39778
Percent Change	-0.06	-0.24	-0.55	-1.15
Subsidy Value	322	3303	12070	32756

Table 4A.17: Japanese Price And Quantity Changes Under A General Subsidy
Low Substitution Scenario

	Base	U.S. Subsidy Rate			
		10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
Japanese Supply					
Beef	581	-0.02	-0.08	-0.16	-0.26
Pork	1400	-0.46	-1.58	-3.07	-5.21
Broilers	1336	-7.17	-22.58	-39.79	-59.48
Corn	2	0.00	0.00	0.00	0.00
Meal	1162	0.42	1.45	2.88	5.03
Japanese Demand					
Beef	1205	-0.15	-0.52	-1.02	-1.80
Pork	2091	-0.03	-0.10	-0.19	-0.28
Broilers	1767	2.80	9.98	20.86	40.68
Corn	6811	-2.82	-9.36	-17.68	-29.24
Meal	2089	-2.01	-6.77	-13.10	-22.48
Japanese Trade Volume					
Beef	-624	-0.27	-0.93	-1.82	-3.23
Pork	-691	0.85	2.90	5.66	9.71
Broilers	-431	33.71	110.88	208.89	351.17
Corn	-6809	-2.82	-9.36	-17.69	-29.25
Meal	-927	-5.05	-17.08	-33.13	-56.96
	—U.S. Dollars Per MT—				
Japanese Price					
Beef	7743	0.08	0.26	0.52	0.90
Pork	3832	0.07	0.23	0.45	0.76
Broilers	2124	-2.63	-8.78	-16.73	-28.09
Corn	290	1.85	6.46	12.92	22.90
Meal	490	2.47	8.78	17.99	32.99

Table 4A.18: Japanese Surplus Changes Under A General Subsidy
Low Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	2	6	11	20
Pork	-11	-36	-70	-119
Broilers	-87	-264	-449	-638
Corn	0	0	0	0
Meal	14	50	104	193
Consumer Surplus				
Beef	-78	-269	-535	-959
Pork	42	143	286	520
Broilers	102	350	698	1260
Total Welfare				
Total Change	-17	-20	46	278
Percent Change	-0.01	-0.01	0.02	0.11

Table 4A.19: Japanese Price And Quantity Changes Under A General Subsidy
High Substitution Scenario

	Base	U.S. Subsidy Rate			
		10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
Japanese Supply					
Beef	581	0.02	0.09	0.21	0.42
Pork	1400	-0.32	-0.98	-1.59	-2.12
Broilers	1336	-12.93	-39.82	-65.78	-86.27
Corn	2	0.00	0.00	0.00	0.00
Meal	1162	0.33	0.95	1.41	1.55
Japanese Demand					
Beef	1205	-0.13	-0.49	-1.01	-1.85
Pork	2091	0.02	0.11	0.31	0.71
Broilers	1767	3.05	11.90	27.478	58.27
Corn	6811	-5.45	-18.44	-34.73	-54.30
Meal	2089	-4.79	-16.57	-31.95	-51.18
Japanese Trade Volume					
Beef	-624	-0.28	-1.02	-2.15	-3.97
Pork	-691	0.72	2.32	4.17	6.44
Broilers	-431	52.58	172.20	316.55	506.29
Corn	-6809	-5.46	-18.45	-34.74	-54.32
Meal	-927	-11.20	-38.53	-73.78	-117.28
	—U.S. Dollars Per MT—				
Japanese Price					
Beef	7743	0.05	0.19	0.37	0.65
Pork	3832	0.02	0.04	0.02	-0.08
Broilers	2124	-2.86	-10.29	-20.91	-35.83
Corn	290	0.89	2.67	4.27	5.38
Meal	490	0.94	2.76	4.13	4.55

Table 4A.20: Japanese Surplus Changes Under A General Subsidy
High Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	2	6	14	25
Pork	-5	-16	-28	-39
Broilers	-82	-246	-390	-488
Corn	0	0	0	0
Meal	5	16	24	26
Consumer Surplus				
Beef	-83	-310	-666	-1253
Pork	49	185	405	776
Broilers	110	413	894	1698
Total Welfare				
Total Change	-5	48	253	746
Percent Change	0.00	0.02	0.10	0.30

Table 4A.21: ROW Price And Quantity Changes Under A General Subsidy Low Substitution Scenario

	Base	U.S. Subsidy Rate 10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
ROW Supply					
Beef	36001	0.02	0.07	0.14	0.24
Pork	58125	-0.14	-0.49	-0.97	-1.67
Broilers	18444	-3.60	-11.84	-22.17	-36.23
Corn	91727	0.28	0.98	1.89	3.23
Meal	28968	0.41	1.42	2.80	4.88
ROW Demand					
Beef	34449	0.00	-0.01	0.00	0.04
Pork	57292	-0.19	-0.64	-1.25	-2.14
Broilers	18529	2.58	9.15	19.05	36.91
Corn	118525	-0.71	-2.43	-4.74	-8.24
Meal	33187	-0.73	-2.49	-4.91	-8.66
ROW Trade Volume					
Beef	1552	0.56	1.81	3.24	4.76
Pork	833	2.77	9.43	18.20	30.74
Broilers	-85	1341.41	4562.26	8964.19	15905.98
Corn	-26798	-4.13	-14.05	-27.43	-47.50
Meal	-4219	-8.52	-29.31	-57.86	-101.57
	—U.S. Dollars Per MT—				
ROW Price					
Beef	3452	0.10	0.34	0.67	1.16
Pork	1673	0.11	0.37	0.72	1.21
Broilers	1667	-2.63	-8.78	-16.73	-28.09
Corn	128	1.85	6.46	12.92	22.90
Meal	260	2.47	8.79	17.99	32.99

Table 4A.22: ROW Surplus Changes Under A General Subsidy
Low Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	104	355	693	1211
Pork	-19	-67	-137	-261
Broilers	-832	-2654	-4771	-7340
Corn	218	762	1532	2733
Meal	186	666	1375	2548
Consumer Surplus				
Beef	4181	14416	28825	52258
Pork	-1704	-5850	-11608	-20737
Broilers	789	2714	5396	9663
Total Welfare				
Total Change	2925	10343	21305	40075
Percent Change	0.04	0.14	0.29	0.55

Table 4A.23: ROW Price And Quantity Changes Under A General Subsidy
High Substitution Scenario

	Base	U.S. Subsidy Rate			
		10 Percent	30 Percent	50 Percent	70 Percent
	—1000 MT—	—Percent Change From Base—			
ROW Supply					
Beef	36001	0.05	0.18	0.37	0.68
Pork	58125	-0.09	-0.30	-0.57	-0.93
Broilers	18444	-7.28	-24.52	-45.33	-67.88
Corn	91727	0.55	1.64	2.61	3.28
Meal	28968	0.31	0.91	1.36	1.50
ROW Demand					
Beef	34449	0.04	0.15	0.38	0.78
Pork	57292	-0.11	-0.38	-0.71	-1.15
Broilers	18529	2.80	10.89	25.00	52.50
Corn	118525	-1.52	-5.28	-10.44	-17.82
Meal	33187	-1.89	-6.44	-12.39	-20.55
ROW Trade Volume					
Beef	1552	0.37	0.78	0.34	-1.69
Pork	833	1.72	5.41	9.31	13.57
Broilers	-85	2189.34	7694.04	15286.9	26173.15
Corn	-26798	-8.60	-28.99	-55.09	-90.04
Meal	-4219	-17.03	-56.94	-106.83	-171.93
	—U.S. Dollars Per MT—				
ROW Price					
Beef	3452	0.07	0.24	0.48	0.84
Pork	1673	0.03	0.07	0.04	-0.12
Broilers	1667	-2.86	-10.29	-20.91	-35.83
Corn	128	0.89	2.68	4.27	5.38
Meal	260	0.94	2.76	4.14	4.55

Table 4A.24: ROW Surplus Changes Under A General Subsidy
High Substitution Scenario

	U.S. Subsidy Rate			
	10 Percent	30 Percent	50 Percent	70 Percent
	—Million U.S. Dollars—			
Producer Surplus				
Beef	79	278	562	999
Pork	-22	-88	-203	-405
Broilers	-863	-2808	-4936	-6903
Corn	105	317	507	642
Meal	71	209	314	345
Consumer Surplus				
Beef	4723	17800	38746	73939
Pork	-1735	-6428	-13719	-25624
Broilers	836	3110	6655	12448
Total Welfare				
Total Change	3193	12390	27928	55441
Percent Change	0.04	0.17	0.39	0.77

APPENDIX V

SIMULATIONS OF EXCHANGE RATE FLUCTUATIONS: LOW AND HIGH SUBSTITUTION SCENARIOS

Table 5A.1: U.S. Price and Quantity Changes Under Dollar Depreciation
Low Substitution Scenario

		Depreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
U.S. Supply						
Beef	10411	2.97	6.47	10.66	15.81	22.36
Pork	7800	3.32	7.23	11.95	17.77	25.20
Broilers	9401	7.91	17.10	27.90	40.82	56.60
Corn	121324	2.26	4.92	8.08	11.95	16.86
Meal	20911	2.65	5.93	10.07	15.45	22.74
U.S. Demand						
Beef	11339	-7.10	-14.59	-22.53	-30.98	-40.00
Pork	7942	-7.39	-15.20	-23.50	-32.32	-41.72
Broilers	8885	-9.56	-19.11	-28.66	-38.22	-47.81
Corn	87717	4.78	10.41	17.19	25.55	36.24
Meal	15765	8.91	19.71	33.10	50.19	72.87
U.S. Trade Volume						
Beef	-928	-120.07	-250.87	-394.92	-555.92	-739.61
Pork	-142	-595.23	-1247.5	-1970.4	-2783.7	-3717.8
Broilers	516	308.75	640.59	1001.93	1401.94	1854.39
Corn	33607	-4.29	-9.43	-15.69	-23.54	-33.70
Meal	5146	-16.52	-36.29	-60.48	-90.97	-130.83
—U.S. Dollars Per MT—						
U.S. Price						
Beef	3959	7.69	17.19	29.25	45.10	66.93
Pork	2180	7.96	17.92	30.74	47.87	71.94
Broilers	1160	10.65	23.81	40.48	62.31	92.21
Corn	82	15.65	36.56	65.62	108.18	175.10
Meal	214	16.98	41.21	77.63	136.40	241.06

Table 5A.2: Japanese Price and Quantity Changes Under Dollar Depreciation
Low Substitution Scenario

		Depreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
Japanese Supply						
Beef	581	-1.74	-3.58	-5.54	-7.67	-10.00
Pork	1400	-4.37	-8.98	-13.90	-19.20	-25.01
Broilers	1336	-7.19	-15.01	-23.57	-32.99	-43.40
Corn	2	0.00	0.00	0.00	0.00	0.00
Meal	1162	0.44	1.20	2.39	4.25	7.13
Japanese Demand						
Beef	1205	4.03	8.49	13.48	19.12	25.62
Pork	2091	4.36	9.12	14.32	20.01	26.24
Broilers	1767	3.44	7.22	11.43	16.20	21.73
Corn	6811	-4.82	-9.90	-15.31	-21.14	-27.54
Meal	2089	-6.38	-12.77	-19.22	-25.76	-32.48
Japanese Trade Volume						
Beef	-624	9.40	19.73	31.19	44.07	58.78
Pork	-691	22.05	45.80	71.49	99.45	130.08
Broilers	-431	36.38	76.11	119.90	168.67	223.59
Corn	-6809	-4.82	-9.90	-15.31	-21.15	-27.55
Meal	-927	-14.92	-30.28	-46.31	-63.39	-82.13
—U.S. Dollars Per MT—						
Japanese Price						
Beef	7743	-3.86	-7.81	-11.85	-16.01	-20.34
Pork	3832	-4.19	-8.37	-12.54	-16.70	-20.82
Broilers	2124	-3.33	-6.75	-10.28	-13.98	-17.92
Corn	290	-0.98	-1.26	-0.57	1.58	6.09
Meal	490	2.58	7.13	14.73	27.36	49.20

Table 5A.3: ROW Price and Quantity Changes Under Dollar Depreciation
Low Substitution Scenario

		Depreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
ROW Supply						
Beef	36001	-0.92	-1.90	-2.97	-4.16	-5.49
Pork	58125	-0.55	-1.23	-2.05	-3.10	-4.46
Broilers	18444	-4.26	-8.73	-13.46	-18.56	-24.17
Corn	91727	-0.15	-0.20	-0.09	0.24	0.91
Meal	28968	0.43	1.16	2.32	4.12	6.91
ROW Demand						
Beef	34449	2.11	4.41	6.96	9.83	13.12
Pork	57292	0.65	1.30	1.94	2.56	3.12
Broilers	18529	3.51	7.38	11.71	16.64	22.39
Corn	118525	-1.06	-2.26	-3.64	-5.27	-7.26
Meal	33187	-1.77	-3.77	-6.06	-8.74	-11.96
ROW Trade Volume						
Beef	1552	-68.01	-142.07	-223.60	-314.69	-418.61
Pork	833	-83.18	-174.67	-276.59	-392.03	-525.86
Broilers	-85	1689.85	3502.88	5474.33	7655.35	10123.5
Corn	-26798	-4.16	-9.31	-15.79	-24.15	-35.26
Meal	-4219	-16.88	-37.61	-63.60	-97.03	-141.53
—U.S. Dollars Per MT—						
ROW Price						
Beef	3452	-2.06	-4.22	-6.51	-8.96	-11.62
Pork	1673	-0.66	-1.32	-1.96	-2.57	-3.13
Broilers	1667	-3.33	-6.75	-10.28	-13.99	-17.92
Corn	128	-0.98	-1.27	-0.57	1.58	6.09
Meal	260	2.58	7.13	14.73	27.36	49.20

Table 5A.4: U.S. Price and Quantity Changes Under Dollar Depreciation
High Substitution Scenario

		Depreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
U.S. Supply						
Beef	10411	6.49	14.34	24.07	36.48	52.94
Pork	7800	9.28	21.02	36.28	56.80	85.71
Broilers	9401	19.34	42.97	71.92	107.54	151.88
Corn	121324	6.67	14.40	23.52	34.54	48.33
Meal	20911	3.72	8.04	13.14	19.32	27.06
U.S. Demand						
Beef	11339	-7.06	-14.47	-22.25	-30.45	-39.13
Pork	7942	-7.20	-14.74	-22.64	-30.94	-39.69
Broilers	8885	-8.90	-17.34	-25.34	-32.95	-40.24
Corn	87717	8.51	18.69	31.09	46.58	66.59
Meal	15765	11.49	25.01	41.11	60.60	84.77
U.S. Trade Volume						
Beef	-928	-159.13	-337.73	-541.96	-781.40	-1072.0
Pork	-142	-912.65	-1978.9	-3258.9	-4851.0	-6927.8
Broilers	516	505.63	1081.52	1746.69	2526.70	3460.01
Corn	33607	1.87	3.20	3.75	3.11	0.67
Meal	5146	-20.10	-43.97	-72.54	-107.15	-149.73
	—U.S. Dollars Per MT—					
U.S. Price						
Beef	3959	7.65	17.00	28.71	43.85	64.25
Pork	2180	7.73	17.25	29.25	44.87	66.04
Broilers	1160	9.84	21.10	34.09	49.27	67.37
Corn	82	11.06	24.41	40.90	61.87	89.66
Meal	214	11.55	26.04	44.71	69.69	104.83

Table 5A.5: Japanese Price and Quantity Changes Under Dollar Depreciation
High Substitution Scenario

		Depreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
Japanese Supply						
Beef	581	-3.40	-6.94	-10.66	-14.64	-18.95
Pork	1400	-7.62	-15.10	-22.50	-29.86	-37.27
Broilers	1336	-11.66	-24.24	-37.61	-51.42	-65.04
Corn	2	0.00	0.00	-10.00	-10.00	-10.00
Meal	1162	-0.50	-1.00	-1.48	-1.96	-2.42
Japanese Demand						
Beef	1205	4.05	8.61	13.81	19.87	27.15
Pork	2091	4.55	9.67	15.49	22.25	30.35
Broilers	1767	4.01	9.04	15.57	24.33	36.57
Corn	6811	-7.62	-15.70	-24.34	-33.62	-43.59
Meal	2089	-12.91	-25.67	-38.24	-50.52	-62.32
Japanese Trade Volume						
Beef	-624	10.98	23.08	36.59	52.00	70.08
Pork	-691	29.21	59.85	92.44	127.82	167.37
Broilers	-431	52.56	112.21	180.43	259.14	351.53
Corn	-6809	-7.62	-15.71	-24.34	-33.63	-43.60
Meal	-927	-28.46	-56.60	-84.33	-111.39	-137.40
—U.S. Dollars Per MT—						
Japanese Price						
Beef	7743	-3.90	-7.95	-12.18	-16.68	-21.52
Pork	3832	-4.36	-8.81	-13.39	-18.16	-23.21
Broilers	2124	-3.84	-8.26	-13.39	-19.43	-26.56
Corn	290	-3.62	-7.49	-11.66	-16.22	-21.28
Meal	490	-1.44	-2.86	-4.24	-5.58	-6.86

Table 5A.6: ROW Price and Quantity Changes Under Dollar Depreciation
High Substitution Scenario

		Depreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
ROW Supply						
Beef	36001	-1.83	-3.83	-6.05	-8.57	-11.51
Pork	58125	-0.99	-2.18	-3.64	-5.50	-7.97
Broilers	18444	-8.88	-18.57	-29.11	-40.48	-52.49
Corn	91727	-2.25	-4.68	-7.35	-10.33	-13.70
Meal	28968	-0.48	-0.96	-1.44	-1.90	-2.34
ROW Demand						
Beef	34449	2.18	4.68	7.61	11.15	15.58
Pork	57292	0.91	1.97	3.27	4.90	7.07
Broilers	18529	4.02	9.03	15.47	24.04	35.93
Corn	118525	-0.77	-1.81	-3.23	-5.18	-7.91
Meal	33187	-2.75	-6.08	-10.15	-15.16	-21.43
ROW Trade Volume						
Beef	1552	-90.73	-192.66	-309.35	-446.32	-612.80
Pork	833	-131.35	-287.70	-478.86	-720.91	-1042.1
Broilers	-85	2802.95	5996.45	9688.56	14024.5	19221.8
Corn	-26798	4.29	8.01	10.88	12.45	11.92
Meal	-4219	-18.27	-41.19	-69.95	-106.22	-152.44
—U.S. Dollars Per MT—						
ROW Price						
Beef	3452	-2.11	-4.41	-6.95	-9.82	-13.16
Pork	1673	-0.93	-2.02	-3.32	-4.92	-6.97
Broilers	1667	-3.84	-8.25	-13.39	-19.43	-26.56
Corn	128	-3.63	-7.49	-11.66	-16.22	-21.28
Meal	260	-1.45	-2.85	-4.23	-5.58	-6.86

Table 5A.7: U.S. Price and Quantity Changes Under Dollar Appreciation
Low Substitution Scenario

		Appreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
U.S. Supply						
Beef	10411	-2.57	-4.82	-6.80	-17.70	-10.18
Pork	7800	-2.85	-5.35	-7.55	-23.25	-11.28
Broilers	9401	-6.89	-12.95	-18.32	-48.55	-27.42
Corn	121324	-1.96	-3.69	-5.22	-19.81	-7.81
Meal	20911	-2.18	-4.00	-5.53	-10.93	-7.93
U.S. Demand						
Beef	11339	6.74	13.15	19.27	25.42	30.73
Pork	7942	6.99	13.63	19.94	25.92	31.69
Broilers	8885	9.57	19.14	28.71	40.36	47.87
Corn	87717	-4.12	-7.71	-10.89	-23.48	-16.28
Meal	15765	-7.49	-13.89	-19.42	-32.44	-28.50
U.S. Trade Volume						
Beef	-928	111.15	214.75	311.85	509.28	489.68
Pork	-142	547.99	1056.08	1529.93	2726.86	2391.89
Broilers	516	-290.27	-565.47	-828.20	-1579.4	-1323.7
Corn	33607	3.66	6.82	9.60	-10.22	14.29
Meal	5146	14.08	26.29	37.01	54.95	55.11
—U.S. Dollars Per MT—						
U.S. Price						
Beef	3959	-6.36	-11.72	-16.29	-20.48	-23.71
Pork	2180	-6.51	-11.94	-16.54	-20.39	-23.91
Broilers	1160	-8.80	-16.19	-22.48	-29.00	-32.62
Corn	82	-12.09	-21.65	-29.38	-30.12	-41.02
Meal	214	-12.38	-21.69	-28.87	-29.29	-39.01

Table 5A.8: Japanese Price and Quantity Changes Under Dollar Appreciation
Low Substitution Scenario

		Appreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
Japanese Supply						
Beef	581	1.65	3.23	4.74	12.56	7.61
Pork	1400	4.16	8.14	11.97	31.97	19.25
Broilers	1336	6.66	12.87	18.71	38.36	29.47
Corn	2	0.00	0.00	0.00	10.00	0.00
Meal	1162	-0.21	-0.25	-0.15	2.11	0.31
Japanese Demand						
Beef	1205	-3.66	-7.02	-10.11	-12.76	-15.61
Pork	2091	-4.01	-7.72	-11.14	-14.39	-17.27
Broilers	1767	-3.16	-6.08	-8.80	-10.50	-13.75
Corn	6811	4.61	9.06	13.37	27.51	21.66
Meal	2089	6.38	12.78	19.21	52.99	32.21
Japanese Trade Volume						
Beef	-624	-8.62	-16.56	-23.93	-36.33	-37.23
Pork	-691	-20.57	-39.85	-57.97	-108.31	-91.26
Broilers	-431	-33.59	-64.83	-94.09	-161.94	-147.75
Corn	-6809	4.61	9.06	13.37	27.51	21.67
Meal	-927	14.64	29.12	43.50	116.77	72.19
—U.S. Dollars Per MT—						
Japanese Price						
Beef	7743	3.80	7.53	11.22	14.58	18.47
Pork	3832	4.19	8.37	12.56	16.84	20.91
Broilers	2124	3.27	6.48	9.66	11.75	15.96
Corn	290	1.48	3.36	5.53	12.99	10.58
Meal	490	-1.21	-1.43	-0.89	6.24	1.84

Table 5A.9: ROW Price and Quantity Changes Under Dollar Appreciation
Low Substitution Scenario

		Appreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
ROW Supply						
Beef	36001	0.86	1.67	2.44	6.13	3.88
Pork	58125	0.46	0.86	1.19	2.75	1.74
Broilers	18444	4.11	8.09	11.99	29.69	19.58
Corn	91727	0.23	0.51	0.83	7.81	1.56
Meal	28968	-0.20	-0.24	-0.15	2.04	0.30
ROW Demand						
Beef	34449	-1.94	-3.74	-5.42	-6.66	-8.46
Pork	57292	-0.64	-1.27	-1.88	-2.66	-3.07
Broilers	18529	-3.22	-6.18	-8.94	-10.66	-13.94
Corn	118525	0.95	1.81	2.60	1.57	4.02
Meal	33187	1.60	3.05	4.39	7.04	6.80
ROW Trade Volume						
Beef	1552	63.00	121.75	176.84	289.91	277.83
Pork	833	76.35	146.97	212.71	374.99	332.04
Broilers	-85	-1591.8	-3104.1	-4550.6	-8766.8	-7286.8
Corn	-26798	3.41	6.25	8.64	-19.80	12.42
Meal	-4219	13.96	25.66	35.58	41.37	51.36
—U.S. Dollars Per MT—						
ROW Price						
Beef	3452	1.97	3.87	5.71	7.11	9.21
Pork	1673	0.66	1.33	1.98	2.81	3.27
Broilers	1667	3.27	6.48	9.66	11.75	15.96
Corn	128	1.48	3.35	5.53	12.99	10.58
Meal	260	-1.21	-1.43	-0.89	6.24	1.83

Table 5A.10: U.S. Price and Quantity Changes Under Dollar Appreciation
High Substitution Scenario

	Base	Appreciation Rate 10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
U.S. Supply						
Beef	10411	-5.46	-10.13	-14.17	-17.70	-20.83
Pork	7800	-7.51	-13.69	-18.87	-23.25	-27.02
Broilers	9401	-15.86	-28.90	-39.65	-48.55	-55.94
Corn	121324	-5.84	-11.02	-15.64	-19.81	-23.59
Meal	20911	-3.25	-6.11	-8.65	-10.93	-12.99
U.S. Demand						
Beef	11339	6.76	13.23	19.45	25.42	31.18
Pork	7942	6.89	13.49	19.83	25.92	31.77
Broilers	8885	9.37	19.22	29.55	40.36	51.64
Corn	87717	-7.22	-13.42	-18.79	-23.48	-27.61
Meal	15765	-9.87	-18.43	-25.89	-32.44	-38.23
U.S. Trade Volume						
Beef	-928	143.82	275.30	396.57	509.28	614.67
Pork	-142	797.77	1506.82	2145.43	2726.86	3260.94
Broilers	516	-450.36	-857.53	-1231.3	-1579.4	-1908.3
Corn	33607	-2.25	-4.75	-7.43	-10.22	-13.07
Meal	5146	17.06	31.63	44.14	54.95	64.33
—U.S. Dollars Per MT—						
U.S. Price						
Beef	3959	-6.38	-11.79	-16.44	-20.48	-24.04
Pork	2180	-6.41	-11.80	-16.41	-20.39	-23.86
Broilers	1160	-8.64	-16.26	-23.00	-29.00	-34.35
Corn	82	-9.32	-17.27	-24.13	-30.12	-35.38
Meal	214	-9.41	-17.19	-23.74	-29.29	-34.07

Table 5A.11: Japanese Price and Quantity Changes Under Dollar Appreciation
High Substitution Scenario

	Base	Appreciation Rate 10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
Japanese Supply						
Beef	581	3.28	6.45	9.54	12.56	15.51
Pork	1400	7.76	15.67	23.74	31.97	40.35
Broilers	1336	10.73	20.62	29.78	38.36	46.48
Corn	2	0.00	0.00	0.00	10.00	10.00
Meal	1162	0.51	1.03	1.57	2.11	2.67
Japanese Demand						
Beef	1205	-3.64	-6.95	-9.97	-12.76	-15.33
Pork	2091	-4.10	-7.83	-11.25	-14.39	-17.30
Broilers	1767	-3.28	-6.04	-8.41	-10.50	-12.37
Corn	6811	7.24	14.19	20.93	27.51	33.98
Meal	2089	13.03	26.19	39.50	52.99	66.68
Japanese Trade Volume						
Beef	-624	-10.09	-19.43	-28.15	-36.33	-44.04
Pork	-691	-28.14	-55.45	-82.13	-108.31	-134.10
Broilers	-431	-46.71	-88.66	-126.80	-161.94	-194.78
Corn	-6809	7.25	14.20	20.93	27.51	33.99
Meal	-927	28.73	57.73	87.06	116.77	146.93
—U.S. Dollars Per MT—						
Japanese Price						
Beef	7743	3.78	7.46	11.05	14.58	18.04
Pork	3832	4.28	8.51	12.70	16.84	20.96
Broilers	2124	3.39	6.43	9.19	11.75	14.15
Corn	290	3.44	6.73	9.90	12.99	16.00
Meal	490	1.49	3.02	4.60	6.24	7.94

Table 5A.12: ROW Price and Quantity Changes Under Dollar Appreciation
High Substitution Scenario

	Base	Appreciation Rate				
		10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
ROW Supply						
Beef	36001	1.69	3.26	4.73	6.13	7.45
Pork	58125	0.84	1.56	2.19	2.75	3.24
Broilers	18444	8.18	15.78	22.92	29.69	36.20
Corn	91727	2.10	4.09	5.99	7.81	9.57
Meal	28968	0.49	1.00	1.51	2.04	2.58
ROW Demand						
Beef	34449	-1.93	-3.66	-5.23	-6.66	-7.98
Pork	57292	-0.79	-1.48	-2.10	-2.66	-3.17
Broilers	18529	-3.31	-6.11	-8.53	-10.66	-12.58
Corn	118525	0.57	1.01	1.33	1.57	1.75
Meal	33187	2.27	4.16	5.74	7.04	8.13
ROW Trade Volume						
Beef	1552	81.94	156.80	225.81	289.91	349.83
Pork	833	112.65	210.86	297.60	374.99	444.65
Broilers	-85	-2497.1	-4756.2	-6831.5	-8766.8	-10597
Corn	-26798	-4.66	-9.57	-14.63	-19.80	-25.03
Meal	-4219	14.50	25.89	34.72	41.37	46.18
	—U.S. Dollars Per MT—					
ROW Price						
Beef	3452	1.95	3.77	5.49	7.11	8.65
Pork	1673	0.82	1.55	2.21	2.81	3.36
Broilers	1667	3.39	6.43	9.19	11.75	14.15
Corn	128	3.44	6.73	9.91	12.99	16.00
Meal	260	1.48	3.02	4.60	6.24	7.94

APPENDIX VI

SIMULATIONS OF TRANSPORTATION COST REDUCTIONS: LOW AND HIGH SUBSTITUTION SCENARIOS

Table 6A.1: U.S. Price and Quantity Changes After Tranportation Cost Reduction—Low Substitution Scenario

	Base	Rate Of Cost Reduction 10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
U.S. Supply						
Beef	10411	-0.40	-0.81	-1.21	-1.61	-2.01
Pork	7800	-1.56	-3.12	-4.67	-6.22	-7.77
Broilers	9401	3.42	6.91	10.46	14.07	17.75
Corn	121324	0.00	-0.01	-0.02	-0.04	-0.06
Meal	20911	-0.04	-0.09	-0.14	-0.20	-0.26
U.S. Demand						
Beef	11339	1.07	2.15	3.25	4.36	5.48
Pork	7942	1.83	3.73	5.70	7.73	9.84
Broilers	8885	-2.45	-4.79	-7.03	-9.18	-11.24
Corn	87717	0.19	0.36	0.51	0.63	0.73
Meal	15765	0.30	0.57	0.80	0.99	1.14
U.S. Trade Volume						
Beef	-928	17.58	35.32	53.22	71.28	89.50
Pork	-142	188.20	379.90	575.23	774.36	977.43
Broilers	516	104.48	208.33	311.64	414.49	516.97
Corn	33607	-0.52	-0.99	-1.42	-1.80	-2.13
Meal	5146	-1.09	-2.09	-3.00	-3.82	-4.54
	—U.S. Dollars Per MT—					
U.S. Price						
Beef	3959	-0.91	-1.82	-2.72	-3.61	-4.50
Pork	2180	-2.05	-4.10	-6.13	-8.16	-10.17
Broilers	1160	2.66	5.34	8.04	10.76	13.50
Corn	82	-0.02	-0.07	-0.16	-0.27	-0.41
Meal	214	-0.24	-0.52	-0.83	-1.16	-1.52

Table 6A.2: Japanese Price and Quantity Changes After Tranportation Cost Reduction—Low Substitution Scenario

	Base	Rate Of Cost Reduction 10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
Japanese Supply						
Beef	581	-0.87	-1.76	-2.64	-3.54	-4.44
Pork	1400	-3.60	-7.19	-10.76	-14.32	-17.87
Broilers	1336	-2.48	-4.89	-7.22	-9.48	-11.67
Corn	2	0.00	0.00	0.00	0.00	0.00
Meal	1162	-0.03	-0.08	-0.12	-0.16	-0.22
Japanese Demand						
Beef	1205	1.98	4.03	6.16	8.36	10.66
Pork	2091	3.68	7.63	11.88	16.47	21.45
Broilers	1767	1.23	2.48	3.75	5.03	6.34
Corn	6811	-3.00	-5.97	-8.91	-11.82	-14.71
Meal	2089	-3.27	-6.52	-9.74	-12.93	-16.10
Japanese Trade Volume						
Beef	-624	4.63	9.41	14.35	19.45	24.72
Pork	-691	18.42	37.64	57.75	78.86	101.10
Broilers	-431	12.75	25.33	37.74	50.02	62.16
Corn	-6809	-3.00	-5.97	-8.91	-11.83	-14.72
Meal	-927	-7.34	-14.60	-21.79	-28.93	-36.01
	—U.S. Dollars Per MT—					
Japanese Price						
Beef	7743	-1.94	-3.88	-5.82	-7.74	-9.67
Pork	3832	-3.55	-7.10	-10.63	-14.16	-17.69
Broilers	2124	-1.19	-2.37	-3.53	-4.68	-5.81
Corn	290	-0.01	-0.05	-0.10	-0.18	-0.26
Meal	490	-0.20	-0.43	-0.68	-0.96	-1.25

Table 6A.3: ROW Price and Quantity Changes After Tranportation Cost Reduction—Low Substitution Scenario

		Rate Of Cost Reduction				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
ROW Supply						
Beef	36001	0.19	0.38	0.57	0.77	0.97
Pork	58125	0.28	0.58	0.88	1.20	1.53
Broilers	18444	-1.50	-2.97	-4.41	-5.83	-7.23
Corn	91727	0.00	-0.01	-0.02	-0.03	-0.04
Meal	28968	-0.03	-0.07	-0.11	-0.16	-0.21
ROW Demand						
Beef	34449	-0.36	-0.73	-1.10	-1.47	-1.85
Pork	57292	-0.40	-0.81	-1.23	-1.65	-2.09
Broilers	18529	1.12	2.26	3.41	4.57	5.75
Corn	118525	0.02	0.06	0.10	0.15	0.21
Meal	33187	0.01	0.02	0.04	0.08	0.12
ROW Trade Volume						
Beef	1552	12.37	24.90	37.59	50.44	63.45
Pork	833	47.36	95.98	145.96	197.42	250.49
Broilers	-85	569.56	1136.24	1700.44	2262.59	2823.09
Corn	-26798	0.11	0.27	0.49	0.75	1.07
Meal	-4219	0.28	0.65	1.13	1.70	2.37
	—U.S. Dollars Per MT—					
ROW Price						
Beef	3452	0.42	0.85	1.29	1.73	2.18
Pork	1673	0.36	0.72	1.10	1.49	1.90
Broilers	1667	-1.19	-2.37	-3.53	-4.68	-5.82
Corn	128	-0.02	-0.05	-0.10	-0.17	-0.27
Meal	260	-0.20	-0.43	-0.68	-0.96	-1.25

Table 6A.4: U.S. Price and Quantity Changes After Tranportation Cost Reduction—High Substitution Scenario

		Rate Of Cost Reduction				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
U.S. Supply						
Beef	10411	-0.83	-1.65	-2.47	-3.28	-4.09
Pork	7800	-3.11	-6.18	-9.20	-12.17	-15.10
Broilers	9401	6.85	13.93	21.21	28.71	36.42
Corn	121324	-0.02	-0.06	-0.14	-0.24	-0.37
Meal	20911	-0.05	-0.11	-0.19	-0.28	-0.39
U.S. Demand						
Beef	11339	1.09	2.19	3.31	4.45	5.60
Pork	7942	1.83	3.73	5.71	7.78	9.92
Broilers	8885	-2.42	-4.70	-6.83	-8.84	-10.73
Corn	87717	0.36	0.65	0.86	1.00	1.07
Meal	15765	0.62	1.14	1.56	1.88	2.10
U.S. Trade Volume						
Beef	-928	22.57	45.28	68.13	91.14	114.30
Pork	-142	273.25	548.07	824.70	1103.34	1384.25
Broilers	516	166.60	334.60	504.14	675.33	848.27
Corn	33607	-1.01	-1.93	-2.75	-3.48	-4.13
Meal	5146	-2.08	-3.92	-5.52	-6.88	-8.00
	—U.S. Dollars Per MT—					
U.S. Price						
Beef	3959	-0.93	-1.86	-2.79	-3.71	-4.62
Pork	2180	-2.05	-4.09	-6.13	-8.18	-10.22
Broilers	1160	2.63	5.23	7.80	10.33	12.83
Corn	82	-0.02	-0.10	-0.22	-0.39	-0.60
Meal	214	-0.14	-0.32	-0.55	-0.83	-1.15

Table 6A.5: Japanese Price and Quantity Changes After Tranportation Cost Reduction—High Substitution Scenario

		Rate Of Cost Reduction				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
Japanese Supply						
Beef	581	-1.76	-3.52	-5.28	-7.03	-8.79
Pork	1400	-7.09	-13.90	-20.43	-26.70	-32.69
Broilers	1336	-5.04	-9.92	-14.67	-19.27	-23.73
Corn	2	0.00	0.00	0.00	0.00	0.00
Meal	1162	-0.03	-0.09	-0.15	-0.23	-0.33
Japanese Demand						
Beef	1205	2.00	4.07	6.22	8.46	10.78
Pork	2091	3.67	7.62	11.89	16.50	21.51
Broilers	1767	1.25	2.56	3.93	5.37	6.88
Corn	6811	-5.94	-11.68	-17.24	-22.61	-27.80
Meal	2089	-6.44	-12.65	-18.65	-24.42	-29.98
Japanese Trade Volume						
Beef	-624	5.50	11.13	16.93	22.88	29.00
Pork	-691	25.47	51.22	77.36	104.02	131.32
Broilers	-431	20.73	41.24	61.57	81.74	101.77
Corn	-6809	-5.94	-11.68	-17.24	-22.62	-27.81
Meal	-927	-14.47	-28.39	-41.83	-54.75	-67.15
—U.S. Dollars Per MT—						
Japanese Price						
Beef	7743	-1.96	-3.92	-5.88	-7.83	-9.77
Pork	3832	-3.55	-7.09	-10.64	-14.18	-17.72
Broilers	2124	-1.21	-2.44	-3.70	-4.98	-6.28
Corn	290	-0.02	-0.07	-0.14	-0.25	-0.38
Meal	490	-0.11	-0.26	-0.46	-0.68	-0.95

Table 6A.6: ROW Price and Quantity Changes After Tranportation Cost Reduction—High Substitution Scenario

		Rate Of Cost Reduction				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
ROW Supply						
Beef	36001	0.35	0.71	1.07	1.44	1.82
Pork	58125	0.57	1.14	1.73	2.32	2.93
Broilers	18444	-3.03	-6.05	-9.06	-12.06	-15.06
Corn	91727	-0.01	-0.04	-0.09	-0.15	-0.23
Meal	28968	-0.04	-0.09	-0.15	-0.23	-0.32
ROW Demand						
Beef	34449	-0.34	-0.68	-1.02	-1.36	-1.71
Pork	57292	-0.41	-0.82	-1.22	-1.63	-2.04
Broilers	18529	1.15	2.34	3.59	4.90	6.27
Corn	118525	0.05	0.09	0.14	0.19	0.25
Meal	33187	0.05	0.11	0.18	0.26	0.36
ROW Trade Volume						
Beef	1552	15.70	31.55	47.55	63.69	80.00
Pork	833	67.71	135.92	204.76	274.37	344.90
Broilers	-85	906.25	1822.11	2748.22	3685.16	4633.46
Corn	-26798	0.24	0.55	0.93	1.38	1.89
Meal	-4219	0.64	1.46	2.46	3.64	4.99
—U.S. Dollars Per MT—						
ROW Price						
Beef	3452	0.40	0.80	1.21	1.63	2.05
Pork	1673	0.36	0.73	1.10	1.47	1.84
Broilers	1667	-1.21	-2.44	-3.70	-4.98	-6.28
Corn	128	-0.02	-0.06	-0.14	-0.25	-0.38
Meal	260	-0.11	-0.27	-0.45	-0.68	-0.95

Table 6A.7: U.S. Price and Quantity Changes After Tranportation Cost Reduction—Low Substitution Scenario (Positive Price Wedge)

		Rate Of Cost Reduction				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
U.S. Supply						
Beef	36001	0.37	1.92	2.89	3.86	4.84
Pork	58125	1.23	4.28	6.44	8.60	10.77
Broilers	18444	2.87	5.85	8.83	11.84	14.88
Corn	91727	0.35	4.61	7.00	9.44	11.93
Meal	28968	0.40	4.91	7.50	10.20	12.99
U.S. Demand						
Beef	34449	-0.97	-1.92	-2.87	-3.79	-4.71
Pork	57292	-1.95	-3.82	-5.64	-7.39	-9.08
Broilers	18529	-2.81	-5.50	-8.07	-10.53	-12.88
Corn	118525	1.53	3.04	4.55	6.05	7.54
Meal	33187	2.36	4.73	7.11	9.50	11.89
U.S. Trade Volume						
Beef	1552	-15.98	-31.79	-47.41	-62.85	-78.13
Pork	833	-176.29	-347.96	-515.20	-678.19	-837.07
Broilers	-85	100.75	199.64	296.75	392.13	485.86
Corn	-26798	-2.73	-5.42	-8.09	-10.74	-13.35
Meal	-4219	-5.62	-11.24	-16.85	-22.46	-28.06
—U.S. Dollars Per MT—						
U.S. Price						
Beef	3452	0.96	1.92	2.89	3.86	4.84
Pork	1673	2.14	4.28	6.44	8.60	10.77
Broilers	1667	2.91	5.85	8.83	11.84	14.88
Corn	128	2.28	4.61	7.00	9.44	11.93
Meal	260	2.41	4.91	7.50	10.20	12.99

Table 6A.8: Japanese Price and Quantity Changes After Tranportation Cost Reduction—Low Substitution Scenario (Positive Price Wedge)

		Rate Of Cost Reduction				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
Japanese Supply						
Beef	581	-0.17	-0.35	-0.52	-0.69	-0.86
Pork	1400	-0.58	-1.16	-1.73	-2.29	-2.85
Broilers	1336	-3.49	-6.84	-10.06	-13.16	-16.14
Corn	2	0.00	0.00	0.00	0.00	0.00
Meal	1162	0.34	0.68	1.03	1.39	1.76
Japanese Demand						
Beef	1205	0.27	0.53	0.80	1.06	1.32
Pork	2091	0.16	0.32	0.47	0.61	0.75
Broilers	1767	1.05	2.09	3.14	4.17	5.21
Corn	6811	-1.49	-2.95	-4.38	-5.77	-7.14
Meal	2089	-0.88	-1.74	-2.59	-3.41	-4.22
Japanese Trade Volume						
Beef	-624	0.68	1.35	2.02	2.68	3.34
Pork	-691	1.67	3.31	4.92	6.50	8.05
Broilers	-431	15.10	29.78	44.04	57.90	71.39
Corn	-6809	-1.49	-2.95	-4.38	-5.77	-7.14
Meal	-927	-2.41	-4.78	-7.13	-9.44	-11.73
	—U.S. Dollars Per MT—					
Japanese Price						
Beef	7743	-0.29	-0.57	-0.84	-1.11	-1.38
Pork	3832	-0.15	-0.30	-0.44	-0.57	-0.70
Broilers	2124	-1.02	-2.01	-2.98	-3.93	-4.85
Corn	290	1.46	2.96	4.48	6.04	7.64
Meal	490	1.98	4.04	6.18	8.39	10.69

Table 6A.9: ROW Price and Quantity Changes After Tranportation Cost Reduction—Low Substitution Scenario (Positive Price Wedge)

		Rate Of Cost Reduction				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
ROW Supply						
Beef	36001	-0.14	-0.28	-0.42	-0.55	-0.69
Pork	58125	-0.23	-0.46	-0.68	-0.90	-1.11
Broilers	18444	-1.51	-2.97	-4.41	-5.80	-7.17
Corn	91727	0.22	0.45	0.68	0.91	1.14
Meal	28968	0.33	0.66	1.01	1.36	1.71
ROW Demand						
Beef	34449	0.27	0.54	0.81	1.07	1.33
Pork	57292	0.18	0.36	0.53	0.69	0.85
Broilers	18529	0.96	1.91	2.85	3.79	4.73
Corn	118525	-0.51	-1.02	-1.52	-2.01	-2.49
Meal	33187	-0.52	-1.03	-1.54	-2.04	-2.53
ROW Trade Volume						
Beef	1552	-9.28	-18.46	-27.53	-36.50	-45.37
Pork	833	-28.67	-56.57	-83.75	-110.22	-136.02
Broilers	-85	535.02	1060.95	1578.11	2086.85	2587.45
Corn	-26798	-3.04	-6.05	-9.04	-12.00	-14.93
Meal	-4219	-6.33	-12.66	-18.99	-25.32	-31.65
—U.S. Dollars Per MT—						
ROW Price						
Beef	4446	-0.29	-0.57	-0.84	-1.12	-1.38
Pork	2687	-0.15	-0.30	-0.44	-0.57	-0.70
Broilers	1667	-1.02	-2.01	-2.98	-3.93	-4.85
Corn	128	1.46	2.95	4.48	6.05	7.64
Meal	260	1.98	4.04	6.18	8.40	10.69

Table 6A.10: U.S. Price and Quantity Changes After Tranportation Cost Reduction—High Substitution Scenario (Positive Price Wedge)

		Depreciation Rate				
	Base	10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
U.S. Supply						
Beef	10411	0.82	1.64	2.47	3.29	4.12
Pork	7800	2.92	5.87	8.84	11.83	14.84
Broilers	9401	6.47	13.10	19.88	26.79	33.84
Corn	121324	-0.02	1.39	2.10	2.80	3.51
Meal	20911	-0.05	0.66	1.00	1.34	1.69
U.S. Demand						
Beef	11339	-0.97	-1.92	-2.86	-3.78	-4.69
Pork	7942	-1.89	-3.70	-5.45	-7.14	-8.78
Broilers	8885	-2.67	-5.18	-7.54	-9.78	-11.89
Corn	87717	3.15	6.29	9.43	12.57	15.71
Meal	15765	4.18	8.38	12.60	16.84	21.10
U.S. Trade Volume						
Beef	-928	-21.02	-41.88	-62.58	-83.12	-103.52
Pork	-142	-265.99	-529.44	-790.52	-1049.39	-1306.17
Broilers	516	163.88	327.87	492.04	656.47	821.19
Corn	33607	-8.28	-11.39	-17.06	-22.70	-28.33
Meal	5146	-12.98	-22.99	-34.55	-46.14	-57.75
	—U.S. Dollars Per MT—					
U.S. Price						
Beef	3959	0.96	1.92	2.88	3.85	4.81
Pork	2180	2.07	4.14	6.21	8.28	10.36
Broilers	1160	2.76	5.49	8.20	10.89	13.56
Corn	82	1.13	2.27	3.43	4.59	5.76
Meal	214	0.98	1.99	3.02	4.07	5.15

Table 6A.11: Japanese Price and Quantity Changes After Tranportation Cost Reduction—High Substitution Scenario

	Base	Depreciation Rate				
		10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
Japanese Supply						
Beef	581	-0.28	-0.56	-0.83	-1.10	-1.37
Pork	1400	-0.73	-1.45	-2.16	-2.86	-3.56
Broilers	1336	-5.81	-11.40	-16.77	-21.92	-26.85
Corn	2	0.00	0.00	0.00	0.00	0.00
Meal	1162	0.28	0.56	0.85	1.14	1.45
Japanese Demand						
Beef	1205	0.27	0.53	0.79	1.05	1.31
Pork	2091	0.22	0.44	0.66	0.88	1.10
Broilers	1767	1.16	2.37	3.62	4.92	6.27
Corn	6811	-2.79	-5.54	-8.25	-10.93	-13.57
Meal	2089	-2.35	-4.70	-7.04	-9.38	-11.71
Japanese Trade Volume						
Beef	-624	0.77	1.54	2.30	3.06	3.81
Pork	-691	2.15	4.27	6.38	8.47	10.54
Broilers	-431	22.79	45.06	66.84	88.13	108.96
Corn	-6809	-2.79	-5.54	-8.25	-10.93	-13.57
Meal	-927	-5.64	-11.28	-16.93	-22.57	-28.21
—U.S. Dollars Per MT—						
Japanese Price						
Beef	7743	-0.29	-0.57	-0.85	-1.13	-1.41
Pork	3832	-0.21	-0.42	-0.62	-0.83	-1.03
Broilers	2124	-1.12	-2.26	-3.42	-4.58	-5.77
Corn	290	0.72	1.46	2.19	2.94	3.69
Meal	490	0.81	1.63	2.48	3.35	4.24

Table 6A.12: ROW Price and Quantity Changes After Tranportation Cost Reduction—High Substitution Scenario

	Base	Depreciation Rate				
		10%	20%	30%	40%	50%
	—1000 MT—	—Percent Change From Base—				
ROW Supply						
Beef	36001	-0.26	-0.52	-0.78	-1.03	-1.28
Pork	58125	-0.39	-0.78	-1.16	-1.54	-1.92
Broilers	18444	-2.99	-5.95	-8.89	-11.81	-14.70
Corn	91727	0.45	0.90	1.35	1.80	2.25
Meal	28968	0.27	0.54	0.82	1.11	1.40
ROW Demand						
Beef	34449	0.28	0.56	0.83	1.11	1.38
Pork	57292	0.24	0.47	0.70	0.93	1.16
Broilers	18529	1.06	2.16	3.30	4.47	5.70
Corn	118525	-1.11	-2.22	-3.32	-4.42	-5.51
Meal	33187	-1.39	-2.78	-4.17	-5.56	-6.95
ROW Trade Volume						
Beef	1552	-12.26	-24.42	-36.49	-48.47	-60.37
Pork	833	-43.56	-86.71	-129.47	-171.86	-213.92
Broilers	-85	879.26	1761.85	2648.09	3538.29	4432.65
Corn	-26798	-6.45	-12.88	-19.29	-25.70	-32.09
Meal	-4219	-12.75	-25.56	-38.42	-51.32	-64.25
	—U.S. Dollars Per MT—					
ROW Price						
Beef	4446	-0.29	-0.57	-0.85	-1.13	-1.41
Pork	2687	-0.21	-0.42	-0.62	-0.83	-1.03
Broilers	1667	-1.12	-2.26	-3.42	-4.58	-5.77
Corn	128	0.73	1.45	2.20	2.94	3.69
Meal	260	0.81	1.63	2.48	3.35	4.24

APPENDIX VII

GAMS PROGRAM: SWOPSIM SCENARIO

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$TITLE  A SIMULATION MODEL OF HVP TRADE
$OFFUPPER
$OFFSYMXREF
$OFFSYMLIST
SETS
   H       all goods & factors      /beef, pork, broilers, corn, meal,capital, labor/
   G(H)    goods                    /beef, pork, broilers, corn, meal/
   I(G)    final goods              /beef, pork, broilers/
   K       country                  /US, Jap, Row/
   L(H)    inputs                   /labor, capital, corn, meal/
   N(K)    foreign countries        /Jap, Row/
   Q(L)    intermediate inputs      corn, meal/

ALIAS(I,IP)
ALIAS(Q,QP)

TABLE eta(I,IP,K)  Final good demand elasticities in country K

                    beef.US     pork.US    broilers.US
   beef              -0.968      -0.055       0.023
   pork              -0.142      -0.838      -0.020
   broilers           0.005      -0.035      -0.970

   +                beef.Jap    pork.Jap   broilers.Jap
   beef              -1.043       0.016       0.027
   pork               0.017      -1.003      -0.014
   broilers           0.066      -0.032      -1.034

   +                beef.Row    pork.Row   broilers.Row
   beef              -0.934      -0.031      -0.035
   pork              -0.039      -0.989       0.028
   broilers          -0.133       0.087      -0.954

TABLE ietaf(Q,I,K)  demand elasticity for input Q wrt price of I

                    beef.US     pork.US    broilers.US
   corn              0.241       0.433       0.251
   meal              0.113       0.566       0.297

   +                beef.Jap    pork.Jap   broilers.Jap
   corn              0.083       0.446       0.487
   meal              0.033       0.555       0.474

   +                beef.Row    pork.Row   broilers.Row
   corn              0.164       0.722       0.118
   meal              0.080       0.818       0.143
```

TABLE ietai(Q,QP,K) demand elasticity for input Q wrt price of Q

	corn.US	meal.US
corn	-0.570	0.098
meal	0.292	-0.741
+	corn.Jap	meal.Jap
corn	-0.650	0.130
meal	0.390	-0.860
+	corn.Row	meal.Row
corn	-0.523	0.065
meal	0.166	-0.711

Table epsilonff(I,IP,K) good I supply elasticity wrt price of I

	beef.US	pork.US	broilers.US
beef	0.603	0.000	0.000
pork	0.000	0.998	0.000
broilers	0.000	0.000	0.799
+	beef.Jap	pork.Jap	broilers.Jap
beef	0.399	0.000	0.000
pork	0.000	0.877	0.000
broilers	0.000	0.000	1.271
+	beef.Row	pork.Row	broilers.Row
beef	0.603	0.000	0.000
pork	0.000	0.998	0.000
broilers	0.000	0.000	0.799

Table epsilonfi(I,Q,K) good I supply elasticity wrt price of Q

	corn.US	meal.US
beef	-0.009	0.001
pork	-0.091	-0.035
broilers	-0.069	-0.016
+	corn.Jap	meal.Jap
beef	0.003	0.005
pork	-0.074	-0.013
broilers	-0.222	-0.070
+	corn.Row	meal.Row
beef	-0.004	0.000
pork	-0.056	-0.022
broilers	-0.024	-0.007

TABLE epsiloni(Q,QP,K) good Q supply elasticity wrt price of Q

	corn.US	meal.US
corn	0.400	0.000
meal	0.000	0.200
+	corn.Jap	meal.Jap
corn	0.400	0.000
meal	0.000	0.300
+	corn.Row	meal.Row
corn	0.4000	0.000
meal	0.000	0.200

TABLE alphaf(I,K) factor of prop for final good demand function

	US	Jap	Row
beef	13.44007999	11.01609565	14.92595528
pork	14.47964074	11.23743830	13.95497419
broilers	11.91656562	10.12227969	13.35136784

TABLE alphai(Q,K) factor of prop for intermed good demand function

	US	Jap	Row
corn	3.53789532	-0.92917242	4.29734333
meal	2.13310543	-1.14870762	3.25022373

TABLE betaf(I,K) factor of proportionality for final good supply

	US	Jap	Row
beef	-5.56760608	-3.45481924	-7.75274948
pork	-1.58743761	-0.02797201	-3.78022452
broilers	-4.05765607	0.70479910	-4.40057850

TABLE betai(Q,K) factor of proportionality for intermed good supply

	US	Jap	Row
corn	-13.91562226	14.88022129	-12.77119155
meal	-23.65091122	-4.28393888	-25.08578779

TABLE tf(I,N) Tranportation costs for good I in N

	Jap	Row
beef	50.7	-50.7
pork	50.7	-50.7
broilers	50.7	50.7

TABLE ti(Q,N) Tranportation costs for good Q in N

	Jap	Row
corn	4.6	4.6
meal	4.6	4.6

TABLE cpf(I,N) Commercial policy for good I in N

	Jap	Row
beef	0.6	0.0
pork	0.228	0.0
broilers	0.0	0.0

TABLE cpi(Q,N) Commercial policy for good Q in N

	Jap	Row
corn	0.0	0.0
meal	0.0	0.0

TABLE xferf(I,N) Transfer costs for good I in N

	Jap	Row
beef	0.13376623	0.0
pork	0.19812579	0.0
broilers	0.27414517	0.0

TABLE xferi(Q,N) Transfer costs for good Q in N

	Jap	Row
corn	1.26562500	0.0
meal	0.88461538	0.0

TABLE sf(I,N) tax or subsidy for good G on exports

	Jap	Row
beef	0.0	0.0
pork	0.0	0.0
broilers	0.0	0.0

TABLE si(Q,N) tax or subsidy for good G on exports

	Jap	Row
corn	0.0	0.0
meal	0.0	0.0

PARAMETER e(N) exchange rate in foreign currency per dollar

```
/Jap   1
Row    1/;
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```
VARIABLES
   xf(I,K)                 supply of final good I in country K
   xi(Q,K)                 supply of intermediate good Q in country K
   df(I,K)                 demand for final good I in country K
   di(Q,K)                 demand for intermediate good Q in country K
   pf(I,K)                 price of final output I in country K
   pi(Q,K)                 price of intermediate output Q in country K
   slksf(I,K)              slack variable for good I supply
   slksi(Q,K)              slack variable for good Q supply
   slkdf(I,K)              slack variable for good I demand
   slkdi(Q,K)              slack variable for good Q demand
   slkpf(I,N)              slack variable for final price I
   slkpi(Q,N)              slack variable for intermediate price Q
   slkmf(I)                slack variable for market clearing I
   slkmi(Q)                slack variable for market clearing Q
   gamma                   sum of slack variables;

POSITIVE VARIABLES xf(I,K), xi(Q,K), df(I,K), di(Q,K), pf(I,K), pi(Q,K), slksf(I,K),
         slksi(Q,K), slkdf(I,K), slkdi(Q,K), slkpf(I,N), slkpi(Q,N), slkmf(I), slkmi(Q);

FREE VARIABLES   gamma;

EQUATIONS
   SUPPLYF(I,K)               supply for final good I in K
   SUPPLYI(Q,K)               supply for intermediate good Q in K
   DEMANDF(I,K)               demand for final good I in K
   DEMANDI(Q,K)               demand for intermediate good Q in K
   PRICEF(I,N)                relationship between home and foreign prices
   PRICEI(Q,N)                relationship between home and foreign prices
   MKTCLF(I)                  Int market clearing conditions-final goods
   MKTCLI(Q)                  Int market clearing conditions-corn
   ERROR                      sum of slack variables;

*Supply and demand price equations

   SUPPLYF(I,K)..          xf(I,K)-exp(-betaf(I,K)*epsilonff(I,I,K))*
         (pf(I,K)**epsilonff(I,I,K))*(prod(Q, pi(Q,K)**epsilonfi(I,Q,K)))
         +slksf(I,K) =E= 0;

   SUPPLYI(Q,K)..          xi(Q,K)-exp(-betai(Q,K)*epsiloni(Q,Q,K))*
         pi(Q,K)**epsiloni(Q,Q,K)+slksi(Q,K) =E= 0;

   DEMANDF(I,K)..          df(I,K)-exp(-alphaf(I,K)*eta(I,I,K))*
         (prod(IP, pf(IP,K)**eta(I,IP,K)))+slkdf(I,K) =E=0;
```

```
DEMANDI(Q,K)..          di(Q,K)-exp(-alphai(Q,K)*ietai(Q,Q,K))*
        (prod(I, pf(I,K)**ietaf(Q,I,K)))*(prod(QP, pi(QP,K)**
        ietai(Q,QP,K)))+slkdi(Q,K) =E=0;

*Home and foreign price relationships

PRICEF(I,N)..           pf(I,N)-((pf(I,'US')+pf(I,'US')*sf(I,N)+tf(I,N))*
        (1+cpf(I,N)+xferf(I,N)))*e(N)+slkpf(I,N) =E= 0;

PRICEI(Q,N)..           pi(Q,N)-((pi(Q,'US')+pi(Q,'US')*si(Q,N)+ti(Q,N))*
        (1+cpi(Q,N)+xferi(Q,N)))*e(N)+slkpi(Q,N) =E= 0;

*Market equilibrium conditions

MKTCLF(I)..             sum(K, xf(I,K)-df(I,K))+slkmf(I) =E= 0;

MKTCLI(Q)..             sum(K, xi(Q,K)-di(Q,K))+slkmi(Q) =E= 0;

*Sum of slack variables

ERROR..                 sum(K, sum(I, slksf(I,K)+slkdf(I,K))+sum(Q,
        slksi(Q,K)+slkdi(Q,K)))+sum(I, slkmf(I))+sum(N, (sum(I,
        slkpf(I,N))+sum(Q, slkpi(Q,N))))+sum(Q, slkmi(Q))-gamma =E= 0;

*Initial values

xf.l('beef','US')               =1041.1;
xf.l('beef','Jap')              =58.1;
xf.l('beef','Row')              =3600.1;
xf.l('pork','US')               =780.0;
xf.l('pork','Jap')              =140.0;
xf.l('pork','Row')              =5812.5;
xf.l('broilers','US')           =940.1;
xf.l('broilers','Jap')          =133.6;
xf.l('broilers','Row')          =1844.4;
xi.l('corn','US')               =606.62;
xi.l('corn','Jap')              =0.01;
xi.l('corn','Row')              =458.635;
xi.l('meal','US')               =209.11;
xi.l('meal','Jap')              =11.62;
xi.l('meal','Row')              =289.68;
df.l('beef','US')               =1133.9;
df.l('beef','Jap')              =120.5;
df.l('beef','Row')              =3444.9;
df.l('pork','US')               =794.2;
df.l('pork','Jap')              =209.1;
df.l('pork','Row')              =5729.2;
df.l('broilers','US')           =888.5;
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```
df.l('broilers','Jap')          =176.7;
df.l('broilers','Row')          =1852.9;
di.l('corn','US')               =438.585;
di.l('corn','Jap')              =34.055;
di.l('corn','Row')              =592.625;
di.l('meal','US')               =157.65;
di.l('meal','Jap')              =20.89;
di.l('meal','Row')              =331.87;
pf.l('beef','US')               =395.9;
pf.l('pork','US')               =218.0;
pf.l('broilers','US')           =116.0;
pi.l('corn','US')               =8.2;
pi.l('meal','US')               =21.4;
pf.l('beef','JAP')              =774.3;
pf.l('pork','JAP')              =383.2;
pf.l('broilers','JAP')          =212.4;
pi.l('corn','JAP')              =29.0;
pi.l('meal','JAP')              =49.0;
pf.l('beef','ROW')              =345.2;
pf.l('pork','ROW')              =167.3;
pf.l('broilers','ROW')          =166.7;
pi.l('corn','ROW')              =12.8;
pi.l('meal','ROW')              =26.0;
xf.lo('beef','US')              =2;
xf.lo('beef','Jap')             =2;
xf.lo('beef','Row')             =2;
xf.lo('pork','US')              =2;
xf.lo('pork','Jap')             =2;
xf.lo('pork','Row')             =2;
xf.lo('broilers','US')          =2;
xf.lo('broilers','Jap')         =2;
xf.lo('broilers','Row')         =2;
xi.lo('corn','US')              =2;
xi.lo('corn','Jap')             =.005;
xi.lo('corn','Row')             =2;
xi.lo('meal','US')              =2;
xi.lo('meal','Jap')             =2;
xi.lo('meal','Row')             =2;
df.lo('beef','US')              =2;
df.lo('beef','Jap')             =2;
df.lo('beef','Row')             =2;
df.lo('pork','US')              =2;
```

```
df.lo('pork','Jap')          =2;
df.lo('pork','Row')          =2;
df.lo('broilers','US')       =2;
df.lo('broilers','Jap')      =2;
df.lo('broilers','Row')      =2;
di.lo('corn','US')           =2;
di.lo('corn','Jap')          =2;
di.lo('corn','Row')          =2;
di.lo('meal','US')           =2;
di.lo('meal','Jap')          =2;
di.lo('meal','Row')          =2;
pf.lo('beef','US')           =2;
pf.lo('pork','US')           =2;
pf.lo('broilers','US')       =2;
pi.lo('corn','US')           =2;
pi.lo('meal','US')           =2;
pf.lo('beef','JAP')          =2;
pf.lo('pork','JAP')          =2;
pf.lo('broilers','JAP')      =2;
pi.lo('corn','JAP')          =2;
pi.lo('meal','JAP')          =2;
pf.lo('beef','ROW')          =2;
pf.lo('pork','ROW')          =2;
pf.lo('broilers','ROW')      =2;
pi.lo('corn','ROW')          =2;
pi.lo('meal','ROW')          =2;
xf.up('beef','US')           =5000;
xf.up('beef','Jap')          =500;
xf.up('beef','Row')          =10000;
xf.up('pork','US')           =5000;
xf.up('pork','Jap')          =3000;
xf.up('pork','Row')          =10000;
xf.up('broilers','US')       =5000;
xf.up('broilers','Jap')      =3000;
xf.up('broilers','Row')      =5000;
xi.up('corn','US')           =1000;
xi.up('corn','Jap')          =.04;
xi.up('corn','Row')          =1000;
xi.up('meal','US')           =1000;
xi.up('meal','Jap')          =100;
xi.up('meal','Row')          =1000;
df.up('beef','US')           =5000;
```

```
   df.up('beef','Jap')          =500;
   df.up('beef','Row')          =10000;
   df.up('pork','US')           =5000;
   df.up('pork','Jap')          =5000;
   df.up('pork','Row')          =10000;
   df.up('broilers','US')       =5000;
   df.up('broilers','Jap')      =1000;
   df.up('broilers','Row')      =5000;
   di.up('corn','US')           =1000;
   di.up('corn','Jap')          =100;
   di.up('corn','Row')          =1000;
   di.up('meal','US')           =1000;
   di.up('meal','Jap')          =500;
   di.up('meal','Row')          =1000;
   pf.up('beef','US')           =1000;
   pf.up('pork','US')           =1000;
   pf.up('broilers','US')       =1000;
   pi.up('corn','US')           =100;
   pi.up('meal','US')           =100;
   pf.up('beef','JAP')          =2000;
   pf.up('pork','JAP')          =1000;
   pf.up('broilers','JAP')      =1000;
   pi.up('corn','JAP')          =600;
   pi.up('meal','JAP')          =1000;
   pf.up('beef','ROW')          =1000;
   pf.up('pork','ROW')          =1000;
   pf.up('broilers','ROW')      =1000;
   pi.up('corn','ROW')          =100;
   pi.up('meal','ROW')          =100;
MODEL Base /all/;
SOLVE Base using NLP minimizing gamma;
```

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