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COMMENT ON "EFFECTS OF AN EXCHANGE RATE CHANGE ON AGRICULTURAL TRADE"

By Maury E. Bredahl and Paul Gallagher¹

Effects of devaluation are examined for a one-commodity, two-region case. A percentage change in price of the commodity will not exceed a percentage change in the quantity traded of the commodity. A change in quantity traded could be large, even under the assumption that underlying supply and demand relations are inelastic.

Keywords: Exchange rate, agricultural trade, exchange rate elasticities.

INTRODUCTION

Increasingly, authors in agricultural economics are focusing on changes in exchange rates and the impacts on agricultural trade. Recently, Kost examined potential price and quantity effects of such changes. He drew implications for agricultural trade, assuming that the underlying supply and demand curves were inelastic (*I*).² He concludes the following:

In summary then, we can only expect a small impact on agricultural trade due to any change in exchange rates. And what effect there is will be primarily a price effect rather than a quantity effect. The maximum change in either price or quantity traded will be equal to the same percentage change as the exchange rate change . . . to the extent that there are conditions that restrict the free flow of goods internationally, the impact on agricultural trade will be substantially less than this maximum.

THE OBJECTIVES

In this article we extend Kost's analysis by developing (1) an alternative graphic approach to exchange rate analysis and (2) quantitative measures of changes in equilibrium price and quantity due to an exchange rate change. Sufficient conditions are developed under which the percentage change in quantity traded exceeds that of equilibrium price. The conditions necessary for the percentage change in quantity traded to exceed the percentage change in the exchange rate are identified. Kost appropriately concludes that the effects of an exchange

rate change depend on the elasticities of the underlying excess demand and supply relationships. However, we believe, contrary to Kost's assumption, that these relationships may be relatively elastic.

AN ALTERNATIVE GRAPHIC APPROACH

The figure shows the effect of an exchange rate change on equilibrium price and quantity using the traditional two country-one commodity closed system of Kost.³ Kost's analysis is modified by the addition of a currency exchange sector. The trade sector is measured in dollars; changes in the export supply (U.S.) and import demand are shown from the U.S. position.

Initially, the value of one dollar is assumed to equal one foreign currency unit; that is, an exchange rate (γ) of one. In this case, the export supply (ES) and import demand (ID) curves, measured in dollars, represent the difference between the domestic supply and demand curves at each price (see the figure).

The devaluation of the dollar (exchange rate down from 1 to 0.5) rotates the import demand curve upward to the right. This rotation around the intercept represents a proportional change in that curve. The construction of the linear import demand curve requires only two price-quantity points. Because currency adjustments do not change the intersection of the curve with the quantity axis, only one additional point is needed. The logical point is the price in foreign currency at which import demand is zero, F_{P_0} . This price in foreign currency units is translated into dollars through the following step. The dotted line originating at the intersection of supply and demand (Kost's isolation equilibrium price) in the foreign country is traced through the currency exchange sector to the 45 degree line (OA), and it is moved perpendicular (up) to the ray representing the appropriate exchange rate (OB). In this manner, the shift in the import demand curve from ID to ID' is determined.

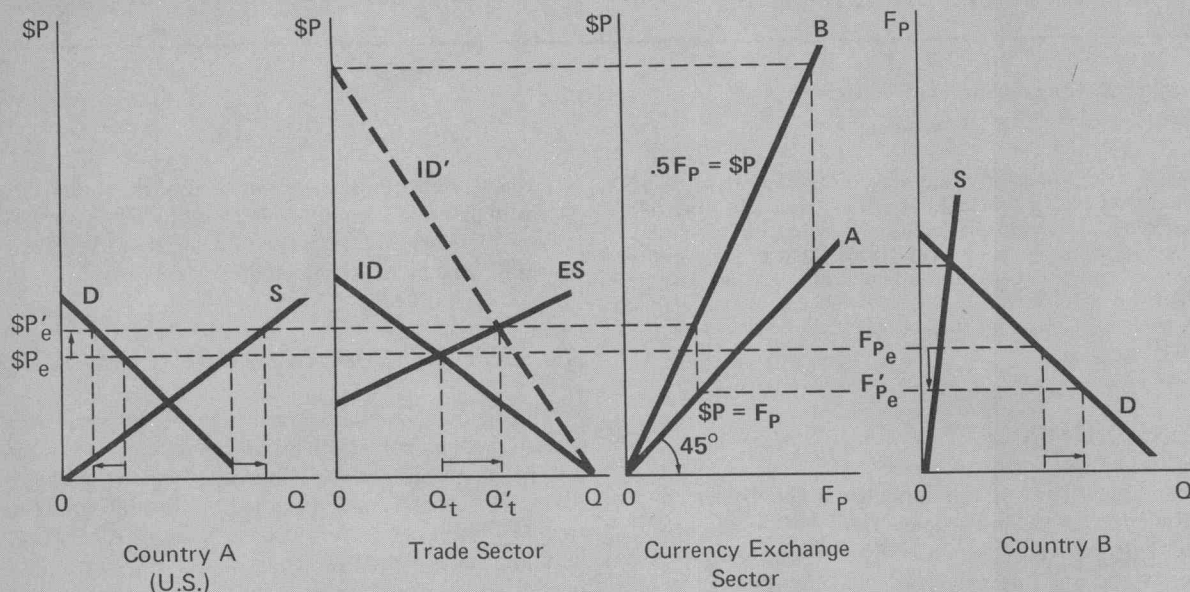
As depicted in the figure, the equilibrium price in the exporting country increases ($\$P_e$ to $\$P'_e$), quantity traded increases (Q_f to Q'_f), and the equilibrium price in the importing country decreases (F_{P_e} to $F_{P'_e}$). (Changes in quantities supplied and demanded in the two countries are indicated by arrows.) This graphical

¹The authors are agricultural economists with the Commodity Economics Division, ERS. They thank Mary Ryan, J. P. Houck, Martin Abel, Abner Womack, and Wayne Boutwell for helpful comments.

²Italicized numbers in parentheses refer to items in References at the end of this article.

³The model assumes zero transportation costs; competitive, unrestricted markets; and a homogeneous commodity. For a more complete discussion, see (2).

Effect of a Currency Readjustment*



* The case depicted holds for a devaluation by the exporting country or a revaluation by the importing country. Arrows indicate the magnitude and direction of changes.

presentation is conceptually more straightforward than Kost's approach of relabeling the price axis and shifting domestic supply and demand curves. The figure permits evaluation of the impacts of either a devaluation of the exporting country's currency or the revaluation of the importing country's currency; they are identical. In a partial equilibrium model, the domestic supply and demand curves are not shifted by a change in the exchange rate. The only curve which shifts is the import demand curve.

A QUANTITATIVE APPROACH

We now provide an algebraic development equivalent to the case depicted in the figure to develop measures of changes in equilibrium values. Translating the importing country's import demand function into the currency units of the exporting country (dollars) entails multiplying the slope of the excess demand curve by the appropriate exchange rate. The trade sector is expressed in dollars; therefore, the appropriate exchange rate (γ) translates foreign currency units to dollars.⁴ The excess demand and supply relationships measured in dollars are

⁴The exchange rate measures the number of foreign currency units which can be purchased by \$1. The value of the exchange rate, expressed in this manner, will decline if the foreign currency is revalued or the dollar devalued.

$$Q_{ed} = a_2 + [\beta_2 \gamma] \$P \quad (\beta_2 \leq 0)$$

$$Q_{es} = a_1 + \beta_1 \$P \quad (\beta_1 \geq 0)$$

$$Q_{ed} = Q_{es}$$

The effect of an exchange rate change is determined by totally differentiating each equation and solving for the appropriate differential. The total differential of the price in dollars is:⁵

$$d\$P = \frac{\beta_2}{\beta_1 - \gamma\beta_2} \$P d\gamma$$

The numerator of this expression is negative, the denominator positive; hence, the resulting quotient must be negative. The devaluation of the exporting country's currency is expressed by a decrease in γ (from $\gamma = 1$ to $\gamma = 0.5$; $d\gamma = -0.5$); therefore, a devaluation must increase the dollar price of the commodity.

The effect may also be expressed as an elasticity. The net or reduced form elasticity of the equilibrium price for the exchange rate is:

⁵When more general excess demand and supply functions are linearized with differentials, the same result holds, except that β_1 and β_2 are replaced by the appropriate partial derivatives. The algebraic expressions that follow them hold for more general demand and supply functions.

$$E_{\$P,\gamma} = \frac{-1}{1 - \frac{\eta_{es}}{\eta_{ed}}}$$

where η_{ed} is the price elasticity of excess demand and η_{es} is the price elasticity of excess supply. This net elasticity is bounded by 0 and -1. Therefore, the percentage change in equilibrium price will, at the most, equal the percentage change in the exchange rate.

The excess supply curve does not shift; therefore, the elasticity of the equilibrium quantity for the exchange rate becomes:

$$E_{q,\gamma} = E_{\$P,\gamma} \cdot \eta_{es}$$

or
$$E_{q,\gamma} = \frac{\eta_{ed} \eta_{es}}{\eta_{es} - \eta_{ed}}$$

Multiplying the net elasticity of the equilibrium price for the exchange rate and the price elasticity of the excess supply function yields the elasticity of the equilibrium quantity for the exchange rate. Logically, this elasticity, which is negative, is bounded on the upper end by zero *but it has no lower bound*. Depending on the elasticities of the excess supply and demand relationships, this net elasticity may be less than -1; the percentage change in equilibrium quantity may exceed the percentage change in the exchange rate.

The net elasticities developed above can be used to examine two of Kost's conclusions: (1) that the price effect will exceed the quantity effect and (2) that trade impacts of an exchange rate change will be relatively small.

The size of the quantity effect relative to the price effect is determined by comparing the net elasticities developed above. The quantity effect will be larger than the price effect if the absolute value of the net elasticity of equilibrium quantity exceeds that of equilibrium price:

$$\left| E_{q,\gamma} \right| > \left| E_{p,\gamma} \right|$$

or
$$\left| \frac{\eta_{ed} \eta_{es}}{\eta_{es} - \eta_{ed}} \right| > \left| \frac{\eta_{ed}}{\eta_{es} - \eta_{ed}} \right|$$

Therefore, the sufficient conditions for the percentage change in quantity traded to exceed that of equilibrium price are that the elasticity of the excess supply relationship be greater than one and the elasticity of the excess demand relationship not be zero.

The question of the absolute size of price and quantity effects is somewhat more difficult to answer. A "large" exchange rate effect occurs when the percentage change in quantity traded exceeds that of the exchange

rate. This definition of a large exchange rate effect requires that the net elasticity of quantity traded with respect to the exchange rate exceed one. The net elasticity of quantity traded will be elastic (net elasticity greater than one) if the product of the absolute values of the excess relationship's elasticity exceeds the sum as shown below.

$$\left| \frac{\eta_{es} \eta_{ed}}{\eta_{es} - \eta_{ed}} \right| > 1$$

$$\left| \eta_{es} \eta_{ed} \right| > \left| \eta_{es} - \eta_{ed} \right|$$

This relationship implies that if the absolute values of the excess elasticities are equal, the absolute value of each must exceed two for the net elasticity to exceed one. If the elasticities are unequal, each must be greater than one. These elasticities must be determined empirically.

The crucial theoretical question in determining the size of price and quantity changes becomes the elasticity of the excess relationships. Kost argues that agricultural commodity supply and demand relationships are inelastic; therefore, the quantity effect of an exchange rate change must be small. However, noting that the underlying domestic supply and demand relationships are inelastic is not sufficient evidence to conclude that excess supply and demand relationships are inelastic. Recalling that the quantity effect will exceed the price effect if the elasticity of the excess supply curve is greater than one, we now develop the elasticity of that relationship. Following Kost, the price elasticity of the excess supply relationship may be written:

$$\eta_{es} = \eta_s \cdot (Q_s/Q_x) - \eta_d(Q_d/Q_x)$$

where η_d and η_s represent the price elasticities of domestic demand and supply, Q_d and Q_s represent domestic quantities supplied and demanded, and Q_x represents the quantity exported. (Note that $Q_s - Q_d$ equals Q_x and that η_d is necessarily negative for downward-sloping demand curves.) The excess supply elasticity may be elastic even if the underlying supply and demand relationships are inelastic. For example, if one assumes the absolute value of both elasticities is 0.5, quantity demanded and supplied are 75 and 150, respectively, the elasticity of the excess supply function will be 1.5. In all cases, the elasticity of the excess supply curve will never be smaller than the elasticity of the domestic supply function. They will be equal if $Q_s = Q_x$. Note also as the percentage of supply exported decreases, the elasticity of the excess supply function increases. A similar type of analysis indicates that excess demand curves may be elastic, which suggests that exchange rate effects on quantity may be large even though domestic supply and demand relationships are inelastic.

Further theoretical justification for the hypothesis that the demand for U.S. exports is elastic is found by analysis of the elasticity of the export demand for U.S. agricultural commodities. Export demand is defined as the difference between the sum of the excess demand of all importing countries and the excess supply of all export demand relationships as shown below:

$$XUS = \sum_i ID_i - \sum_j ES_j$$

(XUS equals export demand for a U.S. commodity, ID_i equals import demand of i th importing country and ES_j equals export supply of j th exporting country.) Substituting linear relationships for all excess relationships,

$$XUS = \sum_i (a_i + b_i \gamma_i P) - \sum_j (a_j + b_j \gamma_j P) \quad (b_i \leq 0; b_j \geq 0)$$

Holding all exchange rates between all countries constant (γ_i, γ_j) and totally differentiating, one obtains:

$$dXUS = \sum_i b_i dP - \sum_j b_j dP$$

Expressing the differential as a net elasticity yields:

$$E_{XUS,P} = \sum_i \eta_{ed_i} \frac{Q_i}{Q_{XUS}} - \sum_j \eta_{es_j} \frac{Q_j}{Q_{XUS}}$$

Q_i/Q_{XUS} and Q_j/Q_{XUS} are the proportion of i th country's total imports from the United States and exports of the j th country as a proportion of U.S. exports, respectively. If one assumes the absolute value of all elasticities is 1.5 and that the United States accounts for half the agricultural trade of the commodity, the elasticity of the U.S. export demand function is -4.5. Therefore, the elasticity of the export demand for U.S. agricultural commodities may be much larger than the elasticities of the underlying excess demand and supply relationships. These, in

turn, may be more elastic than the underlying domestic demand and supply relationships.

CONCLUSIONS

From the algebraic analysis of the free trade model, we can conclude that:

- The percentage change in equilibrium price and quantity depend on the elasticities of the excess supply and demand relationships. The percentage change in equilibrium price will not exceed the percentage change in the exchange rate; the percentage change in equilibrium quantity traded may or may not exceed the percentage change in the exchange rate.
- The percentage change in quantity traded will exceed that of the price change if the elasticity of the excess supply function exceeds one.
- The elasticities of excess supply and demand relationships may be elastic even if the underlying domestic supply and demand relationships are inelastic.
- Given elastic import demand and export supply relationships, the percentage change in quantity traded due to an exchange rate change may be quite large.

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