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Pitfalls in The Measurement of Real Exchange Rate Effects on Agriculture

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ABSTRACT

Studies of the effects of real exchange rates on agriculture commonly assume that these effects can be identified as those which pertain to traded goods in the standard Australian model of an open economy. Further, it is common to assume that the indirect effects of changes in the real exchange rate have the same impact on the various production activities within agriculture. This paper discusses the extent to which these stylized facts reflect reality, focusing in particular on: (1) the determinants of tradability in agricultural markets (2) the irrelevance of results based on "free trade" equilibria to policy analyses (3) the importance of the characteristics of crop production functions in estimating the effects of real exchange rate changes. Ignoring these considerations can cause errors in the measurement of policy effects on agricultural incentives.

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Introduction

Much of the recent debate on the effects of economy wide policies on agriculture in developing countries has focused on the real exchange rate, and the extent to which sectoral policies or programs can ameliorate these macro effects. This is appropriate - it is clear that wide swings in the real exchange rate can reduce capital formation and output both in the agricultural sector and in the economy as a whole.[1] However, much of this debate in the literature on the effects of macro policy seems to take for granted several stylized facts which upon closer inspection are subject to some important caveats.

One problem shared by all studies, whether focusing on agriculture or not, is the fact that measurement of real exchange rate bias requires the choice of a benchmark nominal exchange rate representing the analysts' view of the "equilibrium" or "fundamental" level. Given the unobservable nature of this variable and Edwards' (89) argument that the equilibrium value fluctuates substantially over time, it is inevitable that the choice of benchmark is arbitrary.[2]

A common generalization in studies of real exchange rate bias and agriculture is that all agricultural goods are traded and that the effects on the sector can be identified as those which are presumed to affect traded goods. This is an assumption which is often true, but which is inaccurate for a substantial percentage of agricultural production. Allowance for differences in "tradedness" between agricultural commodities gives rise to a much more complex view of the effects of macro policies and one in which results of given policy initiatives cannot be determined independently of the structure of production. One purpose of this paper is to discuss the determinants of tradedness for agricultural commodities and to generate predictions as to which agricultural commodities are likely to be traded.

Critical to an analysis of the effects of real exchange rate movements on agriculture is some allowance for differing input requirements for different crops. For example, a recent study assumes that all agricultural output is affected similarly by changes in the relative prices of inputs induced by real exchange rate movements. Consider the following quote:

> " ... by definition, those policies which indirectly affect agriculture have the same net impact on import competing as on exportable commodities, and the listing of indirect protection ... is therefore identical"[3]

A second purpose of this paper is to show that this assumption can be misleading and that an evaluation of the structure of inputs for different crops is important in an evaluation of the effects of macro policy on agricultural incentives. These considerations support the conclusion that indirect policies do <u>not</u> have the same impact on exportables as compared to importables, nor is this necessarily true even between different crops within these two categories.

One important motivation for this analysis is the fact that differential responses to macro policies may divide along lines of income class or region, since these differences will hinge upon demand propensities for those who consume certain crops and the structure of production for particular groups of producers. In addition, it is important to consider the time required for resource flows and reallocations when using results based on free trade or other equilibria to guide policy. A typical horizon for policy analysis is 5 to 10 years, a period clearly too short to allow for full adjustment of long standing cultural practices or development of supporting infrastructure for production. Thus, many goods which might be considered traded in a free trade equilibrium will in fact exhibit behavior characteristics of a non-traded good over periods of interest to policymakers.

The next section of this paper discusses the determinants of tradedness of agricultural goods. This is followed by a section analyzing the effects of input structure on the response to changes in the real exchange rate. The fourth section discusses the relevance of these considerations for economic reform programs in developing countries.

Traded Goods, Tradeable Goods and Contestable Markets

The effects of real exchange rate changes on agricultural markets depend on the degree to which agricultural goods are traded. In this discussion a distinction is made between "traded" and "tradeable". In general, the fact that a commodity is tradeable in principle does not mean that it can be regarded as a traded good for the purposes of policy analysis with a medium term perspective. Several factors affect the degree of tradedness any given commodity will exhibit.

(1) **"Natural" Nontradedness** This refers to structural impediments to trade which render a good non-traded at any conceivable price. In some cases, structural impediments may be alleviated by policy over time or may erode as the economy becomes increasingly developed.

The most obvious source of natural nontradedness is transport costs. Following Dornbusch (80) we can classify goods as traded or non-traded depending upon the relationship between transport costs and the price differential between home production and the world market. Figure 1 shows this relationship graphically, with per unit transport costs of ϕ. For a given world price P^*, the presence of fixed costs and per unit transport costs allow us to distinguish between three possible situations: Zone I in which the good is exported, Zone II in which it is non-traded, and Zone III in which it is imported.

There are two characteristics of this relationship which are important to the analysis. First, it is clear that the classification of goods as traded or non-traded is endogenous, depending both on changes in prices and on changes in transport costs. Second, the range over which a good is non-traded depends on transportation costs as compared to the price differential between world and domestic production.

For labor intensive services such as haircuts, the prohibitive level of these costs seems obvious. For agricultural commodities, transport costs are low compared to the prices of the commodities and these price differentials are correspondingly small.

However, consider the effects on this relationship of the presence of fixed costs in transportation. These per unit fixed costs can be quite substantial in a situation where necessary infrastructure, both institutional and physical, is lacking. This implies substantial variation in the degree of "tradedness" of agricultural commodities in different regions of a country depending on the location of consumption and/or production. Those living far from roads in an area where there is little in the way of necessary storage or warehouse space or where the marketing margin is substantial are more likely to be producing or consuming under conditions approximating nontradedness than are people living in a port city. Even in the latter case, physical limitations on import or export capacity can further widen the range over which a good is nontraded. These factors are present to some degree in all countries but are especially important in developing countries. Antle (83) presents evidence that infrastructure development is an important determinant of agricultural productivity, a finding consistent with this argument.

For example, in various West African countries (e.g. Nigeria), the north/south road network is poorly developed, rendering the northern areas more likely to exhibit markets approaching the non-traded category than would southern ones. The costs of providing the necessary transport services is quite large in these cases, meaning that price differentials would have to become quite large for trade to occur.[4]

In Southern Africa, landlocked countries may face extremely high transport costs for extended periods. Zimbabwe, Zambia, Botswana, and Malawi are obvious candidates. Similar observations are applicable to the interiors of large countries such as Zaire, or Sudan.

This discussion is related to the concept of <u>contestable</u> markets which states that a market is contested if, in principle, other entrepreneurs would enter to undercut any attempt to extract excessive profits. Baumol et. al. (82), and comments by Spence (83) and Brock (83) analyze the conditions under which a given market can be considered contested. There are close parallels with the current case since it has been observed that mere absence of visible trade in a commodity does not indicate that it can be considered non-tradable if in fact pricing decisions by the (apparent) domestic monopolist are constrained by the threat of foreign competition. The theory of contestable markets relies heavily on the notion of "hit and run" entry whereby a potential competitor is able to exploit any transient profit opportunity by rapidly entering the market and undercutting prices of the incumbent producers to extract available rents. This threat keeps the existing producers honest in the sense that they must price according to competitive conditions even in the absence of visible competition.

The presence of large fixed costs to production or marketing can cause a market to be noncontested or nontraded. The longer the period over which costs, once incurred, remain sunk (or fixed) in comparison to the time it takes for existing producers to respond by cutting their own prices, the less contested a market will be. Nontradedness is also more likely if the good is not perishable or if production requires a certain amount of time regardless of scale. These caveats are of obvious importance in the production of many agricultural commodities, particularly fruits, vegetables, or meats, all of which require time to produce, are perishable, and for which sunk costs as well as fixed costs may be quite important.[5]

Following this argument, tradeable goods can become traded goods if an importer decides to contest the market due to the existence of excess profits. However, this will not occur if hit-and-run entry of the type described is not feasible. It is worth emphasizing that it is not enough for prices to rise high enough for a market to become contestable <u>in principle</u>. For a good to be considered traded, this must not only be possible, but it must in fact be the case that a trader has a reasonable chance for a profit over a relatively short term since there is likely to be a fairly high degree of riskiness in many markets. For some products with low value/bulk ratios (e.g., cassava) or with high requirements for capital investment (e.g. refrigeration for meats or rapid transit facilities for other perishables), the riskiness of such trade is likely to render many markets uncontested or, in our terminology, nontraded.

To summarize, this discussion implies that agricultural commodities are more likely to exhibit the characteristics of non-traded goods:

- The more poorly developed is supporting transportation infrastructure.
- The more sunk costs and fixed costs such as refrigeration or warehouses are required.
- The higher the ratio of bulk to value.

- The more perishable the commodity.
- The more quickly existing sellers can change prices.

(2) **Structure of demand** - Domestic demand clearly affects the tradedness of commodities since a high level of domestic demand, resulting in a high domestic price, can cause a commodity to be imported while the opposite situation can cause it to be exported. The degree of substitutability between agricultural goods and other traded and non-traded goods has an important effect on the extent to which it behaves as a traded good in response to policy changes. The income elasticity is an important determinant of changes in this status over time.

Given a long enough time period, virtually all food is substitutable, within nutritional constraints. However, this is not the case within the time frame envisioned for policy reform programs in many developing countries. On the production side, structural impediments to trade such as poorly developed road networks are unlikely to change substantially, if at all, over such a period. On the demand side, long standing cultural practices in terms of diet and undeveloped marketing systems can greatly reduce the speed and extent of response to macro policy changes.

In addition, aggregate measures of agricultural production and food consumption can mask the importance of non-traded commodities for large segments of the population. Groups which produce and/or consume such commodities may in fact constitute a large percentage of the agricultural sector yet may be affected by macro policies in ways quite distinct from those derived from stylized models of real exchange rates and agriculture. Evidence for such adverse effects of macro adjustments on nutrition for different groups is presented by Pinstrup-Andersen (89).

For example, a review of agricultural production and food consumption statistics for Sub-Saharan Africa shows that some important root crops such as cassava are non-traded, with the greater part of production being consumed by subsistence farmers who often have little contact with organized markets. Indeed, the required physical and institutional infrastructure are virtually non-existent in many of the areas where this low value to bulk crop constitutes a staple food. Table 1 shows the share of non-traded root crops in total per capita calorie supply in Sub-Saharan Africa. In some countries, e.g., Zaire, cassava and other root crops provide more than half of the available calorie supply, while in many others it represents a very large fraction.[6]

Large though these aggregate figures are, they understate the importance of root crops for some groups, which may rely on these sources for much higher percentages of energy intake than indicated in the table. The importance of non-traded crops in nutrition is even more striking when account is taken of other important non-traded staple crops such as plantains.

(3) **Policy-dependent factors** - "Induced" nontradedness can result from the structure of taxes, subsidies, and quantitative restrictions applying to a given commodity. A recent example of this phenomenon is the decision of Nigeria to ban imports of some important grain crops. This, in effect, rendered all of these crops "nontraded" at least from the point of view of the domestic producer.

While it is common for studies of the indirect protection afforded to agriculture to address the question of how the entire structure of direct trade taxes and restrictions and indirect real exchange rate changes affect incentives, as compared to a hypothetical free trade situation, it is in some ways more interesting to ask how a policy change will affect incentives given the continuation of other interventions. This question relates more closely to the actual situation in developing countries, where reforms are usually pursued one step at a time. Further, it avoids the need to define a hypothetical free trade equilibrium. Given the poor record of international economists in predicting what activities might be in the comparative advantage of a country, we should take estimates of equilibrium values of the current account or exchange rate in a totally free trade situation with more than a few grains of salt.

For the purposes of policy analysis it is often beside the point whether a good would or would not be traded in a hypothetical situation of free trade with no interventions. The more important question is whether or not a good is in fact traded or would become so as a result of the policy change under consideration. To the extent that agricultural markets remain uncontested with respect to a policy shock, it is incorrect to identify the effects on agriculture as those applying to traded goods.

Policy induced non-tradedness can also be an important consideration when identifying where in the marketing chain to measure price responsiveness. For example, a government marketing board for an export crop may be completely exposed to variations in international prices yet at the same time completely insulate domestic producers from the international market. In such a case the crop is clearly traded from a national point of view in that the marginal revenue to the country is determined by the international market. However, if a policy analyst is interested in the effects on production of macro policies such as exchange rate changes, it is mistaken to treat such a crop as traded if the marketing system effectively precludes transmission of border prices.

The Importance of Input Structure - The "Effective Protection" Effects of Real Exchange Rate Bias

The previous section argued that measures of indirect policy effects on agricultural incentives may be incorrect since not all agricultural products are traded, nor could they be even in principle within the time frame normally considered for policy analysis. This section shows that even if agricultural products are traded, aggregate measures of the effects of indirect policies affecting the real exchange rate can be misleading because of the effects of differing input structure. There are several important conclusions which will be analyzed in some detail, but all point to the fact that failing to account for differences in the characteristics of the production functions of different activities can cause large errors in measurement as well as inaccurate predictions of the effects of real exchange rate changes on resource flows and incentives. Accounting for differences in input structure is particularly important in light of the fact that crop-specific interventions vary widely in both level and type.

That measures of bias and effective protection can vary over time is well recognized, and is the basis for many discussions of these issues. Table 2 shows coefficients of variation of real exchange rates for selected countries, illustrating the wide swings that can occur. While many analyses focus on policy dependent internal sources of variation in measures of protection or bias it is important to recognize that external factors in international markets can also be a major source of variation, as can be seen from the coefficients of variation for world commodity prices in Table 3. Another potentially important source of variation which has been ignored in many discussions of real exchange rate bias such as that quoted in the Introduction is the difference in production functions for various activities comprising the agricultural sector. This section examines the degree to which this problem may affect measures of real exchange rate bias.[7]

First, the role of differing factor and input intensities will be analyzed in the fixed coefficient case to show that measures of effective protection depend sensitively on these differences. The overall conclusion is: Differences in the structure of inputs, and in particular differences in the use of traded inputs can result in differences in effective protection which can range from magnification of protection to complete elimination of it.

Next, the effects of traded inputs on measurement of real exchange rate effects on incentives will be extended to the case where input coefficients are flexible. The main conclusions are: First, the presence of substitution possibilities has the effect of <u>overstating</u> the degree to which the nominal tariff structure provides protection. (Alternatively, if the overall effect of the real exchange rate bias is determined to be negative, the presence of substitution possibilities will <u>reduce</u> the measured degree of adverse bias.) Second, the degree to which traded inputs are substitutable for the different primary factors has an important role in determining the extent to which changes in output and input prices cause changes in relative outputs of traded versus nontraded goods.

(1) Intermediate Inputs and Real Exchange Rate Effects[8] The role of intermediate inputs can be illustrated with an extension of the traded/non-traded goods framework which supports the case for real exchange rate policies. The basic approach will be to add a traded input to the standard 2 x 2 model where capital is sector specific in the short-run but can be shifted between sectors in the medium to long-run. This extension makes it apparent that relationships between real exchange rate changes and increased outputs of tradeable goods become less clear cut in the presence of traded inputs. The prices of the three commodities, X_T, X_N, and X_M (traded, nontraded, and imported intermediate goods respectively) are related to input prices via the following zero profit conditions:

$$a_{LT}w + a_{KT}r + a_{MT}P_M = P_T \tag{1}$$

$$a_{LN}w + a_{KN}r = P_N \tag{2}$$

where the a_{ij} coefficients represent input output coefficients, w is the return to labor, r is the return to capital, and it is assumed that changes in the exchange rate affect P_T and P_M equally, but that both prices are also assumed to include policy dependent taxes or subsidies, so that their respective differentials need not be equal in the analysis that follows. This assumption is important in consideration of empirical cases since both real exchange rate bias and explicit tax/subsidy policies are operative in most situations. Letting

p_i denote world prices, e the exchange rate, and t_i the rate of tax or subsidy, we have:

$$P_i = ep_i(1+t_i) \qquad (i = T,M)$$

Full employment conditions for the model are:

$$a_{LT}X_T + a_{LN}X_N = L \tag{3}$$

$$a_{KT}X_T + a_{KN}X_N = K \tag{4}$$

In this context, we can represent a program of trade liberalization or structural adjustment as changes in the relative prices of traded versus non-traded goods. To simplify the algebra, we assume that all changes are relative to changes in P_N so that $dP_N = 0$. Letting a "*" denote relative changes (dx/x), differentiation of (1) and (2) yields:

$$\theta_{LT}w^* + \theta_{KT}r^* = P_T^* - \theta_{MT}P_M^* \tag{5}$$

$$\theta_{LN}w^* + \theta_{KN}r^* = 0 \tag{6}$$

It is immediately apparent from equation (5) that the extent to which a macro policy such as devaluation affects value added is dependent upon the parameter θ_{MT} and the rate of change of the price of the traded input. The change in value added is equal to the sum of the changes in returns to capital and labor. At one extreme, if $\theta_{MT} = 1$ and $P_M^* = P_T^*$, then value added will not change at all. At the other extreme, if either $\theta_{MT} = 0$ or $P_M^* = 0$, then value added will change to the full extent of the percentage change in the output price. Note that the distribution of this change is ambiguous, but the normal presumption is that if, e.g., traded goods are labor intensive, then the returns to labor will rise and the returns to capital will fall. Solving (5) and (6) for the changes in wages and rentals yields:

$$w^* = (\theta_{KN}/\Theta)(P_T^* - \theta_{MT}P_M^*) \tag{7}$$

$$r^* = -(\theta_{LN}/\Theta)(P_T^* - \theta_{MT}P_M^*) \tag{8}$$

where Θ is the determinant of the coefficient matrix of (5) and (6), and is positive if traded goods are labor intensive relative to nontraded goods. It is important to note that the definition of "labor intensive" must be modified from the usual definition of $\theta_{LT} > \theta_{LN}$ because of the presence of an intermediate input. Here we define labor intensive as $\theta_{LT}/(1 - \theta_{MT}) > \theta_{LN}$.[9]

Figure 2 shows the effects of changes in prices on factor returns and labor allocation. In the top panel, the value added marginal product (VMP_L) of labor in the traded goods is measured from the left, and that in the non-traded goods from the right. Equilibrium is at W_o and L_o, with the wage bill represented by the area O_t, W_o, e_o, L_o and the returns to capital by the area below the VMP_L curve and above W_o. An increase in the price of traded goods raises the VMP_L curve by the amount of the price increase. If there were no intermediate inputs, wages would rise to W_1 and labor allocation would shift to L_1 on the new equilibrium. However, if the price of traded inputs rises, also, the curve will shift back, with the new equilibrium occurring at W_2 and L_2. The bottom panel illustrates the effects of differing elasticities of labor demand, drawn to represent more elastic demand for labor in the traded goods sector. Note that the shift back in the VMP_L caused by the increased price of imported intermediates can in some cases dominate the original movement.

So far, the analysis has followed closely the standard analysis of effective protection, but in the context of the traded-non-traded goods model. It is apparent from the above discussion that the degree of "effective" change in incentives for a given activity resulting from a change in the overall real exchange rate can be quite different for different activities, depending upon the structure of input use. First, the direct effect of a change in the real exchange rate will be mitigated to the extent that traded inputs represent a significant proportion of costs in the traded goods sector. Second, the factor intensity of the activity of interest relative to that of the rest of the economy will play an important role in the division of the value added between capital and labor.

It is also important to note in passing that it is even possible for a program designed to depreciate the real exchange rate and eliminate subsidies for imported inputs to <u>decrease</u> incentives to produce traded goods if P_M* is large enough (for a given θ_{MT}) compared to P_T*. All of these considerations indicate that the use of sectoral averages for the above parameters can produce results that may be very misleading if applied to a particular activity whose input structure is significantly different from the average.

Table 4 presents estimates of the share of tradable inputs θ_{MT} in crop production for selected countries of Latin America and Africa. The figures show that this share varies considerably from crop to crop both within and across countries. In addition, the figures for wheat in Mexico show that there can be considerable variation between different locations in the same country for the same crop.

Table 5 shows that input prices have in many cases risen faster than output prices though it is clear that experience has varied across countries. The effects of input scarcity and pricing reforms are consistent with the evidence in Figure 3, where it can been seen that by 1987 levels of fertilizer consumption had declined to levels approximately those reached at the beginning of the 1980's. Overall, the importance of traded inputs in production, the marked variation in relative prices of inputs and outputs, and evidence of stagnation in input use indicate that the considerations discussed in the section have the potential to be important in practice.

(2) The Importance of Substitution Effects Changes in relative prices of inputs will in most cases result in changes in the mix of inputs used. Which inputs are substituted for those with higher prices depends on the characteristics of the technology used in production. These technologically determined substitution possibilities together with relative abundance of required inputs (or more generally, factor supply conditions) affect the extent and pace of adjustment to real exchange rate changes.

The possibility of substitution among inputs in response to changing factor and output prices will in most cases increase the apparent effective change in incentives over that which would occur in the case of fixed coefficients. The intuitive reason for this is that if input coefficients are allowed to vary, the effect is to increase the menu of options available to producers - among these options is the original input mix. So, a producer can either stick with his original situation or, if flexibility allows a lower cost input mix, choose that combination instead. If this results in a smaller input share for a traded input subject to a tariff, apparent effective protection will be greater. In any case the producer will certainly be no worse off and probably better. How will the a_{ij}'s change? The following equation expresses the relationship between relative changes in technical coefficients and input prices:[8]

$$a_{iT}^* = \theta_{LT}\sigma_{iLT}w^* + \theta_{KT}\sigma_{iKT}r^* + \theta_{MT}\sigma_{iMT}P_M^* \tag{9}$$

$$a_{iN}^* = \theta_{LN}\sigma_{iLN}w^* + \theta_{KN}\sigma_{iKN}r^* \tag{10}$$

where σ_{ij}^k denotes the partial elasticity of substitution between inputs i and j in sector k. Since changing all input prices by the same percent will not change the optimal mix:

$$\theta_{LT}\sigma_{iLT} + \theta_{KT}\sigma_{iKT} + \theta_{MT}\sigma_{iMT} = 0 \tag{11}$$

$$\theta_{LN}\sigma_{iLN} + \theta_{KN}\sigma_{iKN} = 0 \tag{12}$$

Since all own-partial elasticities are negative, at most one other elasticity in equation (11) can be negative. A negative cross-partial indicates complementarity of inputs, while a positive value indicates substitutability.

In order to see the effects of substitution possibilities on production, we need to totally differentiate the full employment conditions, (3) and (4):

$$\lambda_{LT}X_T* + \lambda_{LN}X_N* = -(\lambda_{LT}a_{LT}* + \lambda_{LN}a_{LN}*) \tag{13}$$

$$\lambda_{KT}X_T* + \lambda_{KN}X_N* = -(\lambda_{KT}a_{KT}* + \lambda_{KN}a_{KN}*) \tag{14}$$

where λ_{ij} represents the fraction of the i^{th} factor employed in the j^{th} sector. Subtract (14) from (13) to get:

$$\Lambda(X_T* - X_N*) = (\lambda_{KT}a_{KT}* + \lambda_{KN}a_{KN}*) - (\lambda_{LT}a_{LT}* + \lambda_{LN}a_{LN}*) \tag{15}$$

where Λ is the determinant of the coefficient matrix of (13) and (14) and is positive if the traded goods sector is labor intensive. Substituting (9) and (10) into this expression,

$$\Lambda(X_T* - X_N*) =$$

$$\{(\lambda_{KT}\theta_{LT}\sigma_{LK}{}^{T} + \lambda_{KN}\theta_{LN}\sigma_{LK}{}^{N}) - (\lambda_{LT}\theta_{LT}\sigma_{LL}{}^{T} + \lambda_{LN}\theta_{LN}\sigma_{LL}{}^{N})\}\ w*$$

$$+ \{(\lambda_{KT}\theta_{KT}\sigma_{KK}{}^{T} + \lambda_{KN}\theta_{KN}\sigma_{KK}{}^{N}) - (\lambda_{LT}\theta_{KT}\sigma_{KL}{}^{T} + \lambda_{LN}\theta_{KN}\sigma_{KL}{}^{N})\}\ r*$$

$$+ \{(\lambda_{KT}\theta_{MT}\sigma_{MK}{}^{T} - \lambda_{LT}\theta_{MT}\sigma_{ML}{}^{T})\}\ P_m^* \tag{16}$$

The sum of the quantities in brackets must sum to zero since, as noted above, equal changes in all input prices will not change the input mix. Also, since all own partials are negative, it follows that the coefficient of w* is positive and that of r* is negative, assuming that all factors are substitutes. Since the case being analyzed is that of an increase in price for the labor intensive traded sector, it follows that the sum of the first two expressions is positive, since $w^* > 0$ and $r^* < 0$. Nevertheless, it is clear that the larger (in absolute value) the own-elasticities, and the smaller the cross elasticities, the less the change in outputs. The coefficient of $\overset{*}{P}_m$ is negative unless elasticities of substitution in the traded sector are biased in a particular way. Inequality in the values of these two elasticities will tend to mitigate or reinforce the initial impact on production.

To get an expression for the response of outputs to changes in P_T and P_M, let the expressions in brackets in equation (16) be β_L, β_K, and β_M respectively and substitute (7) and (8) into (16) to get:

$$\Lambda(X_T^* - X_N^*) = \frac{1}{\theta} (\theta_{KN}\beta_L - \theta_{LN}\beta_K)(P_T^* - \theta_{MT}P_M^*) + \beta_M P_M^* \tag{17}$$

Jones (71) has analyzed, within a standard 2 x 2 trade model, the cases under which perverse output results can occur from changes in protection of outputs and inputs. His argument can be applied to the present case, where the issue is the degree of "protection" afforded by a given change in the real exchange rate, with the added possibility that $P_T^* \neq P_M^*$ due to changes in taxes or subsidies on the imported input. While Jones concentrates on the conditions economic characteristics which make this result possible illuminate the factors which are important in causing incentive effects of real exchange rate changes to differ across commodities. If there is no change at all in P_M, perhaps due to a fixed input price with the gap between this and the border price being absorbed by the government, then equation (17) reduces to the standard 2 x 2 model, where all inputs are primary factors.

What about increasing the price of imported inputs while holding other prices constant? This can only cause a perverse increase in output of traded goods relative to non-traded if the last expression in equation (17) outweighs the effects of the first two, which following the argument above, we know to be negative in this case. Thus, a necessary condition is[10]

$$\frac{\sigma_{MK}{}^{T}}{\sigma_{ML}{}^{T}} > \frac{\lambda_{LT}}{\lambda_{KT}} \tag{18}$$

The role of biased substitution effects is clear from this inequality. Since traded goods are here assumed labor intensive, we know that $\lambda_{LT} > \lambda_{KT}$. Thus, perverse results are more likely (or put another way, the results obtained without allowing for differing input structures are mitigated) if the imported intermediate good is a closer substitute for capital than for labor.

The reason for this result is that an increase in the price of the imported input should cause the traded good sector to contract, so that there is a release of resources from the traded sector. Since the price of the traded input has gone up, there will be a tendency to substitute other factors for the now more expensive traded input. However, if capital is a better substitute for this input than is labor, there will be a tendency for the traded sector to raise its K/L ratio and use more capital. If this effect is strong enough, there can be a decrease in the amount of capital remaining for the rest of the economy. Since, by assumption, the rest of the economy is capital intensive, this decrease in capital will result in a contraction of the non-traded sector.

This response to substitution induced relative capital scarcity is simply an application of the Rybczinsky theorem, and will be more pronounced the more widely divergent are the relative factor ratios employed by the two sectors. This is because the proportions of factors released by the contracting sector will correspond less to those demanded by the expanding sector the more the factor ratios differ.

It should be emphasized that "perverse" results are not necessary to support the conclusion that biased substitution effects can distort predictions of output and resource responses to real exchange rate and/or subsidy changes. All that is necessary is that $\sigma_{MK}{}^{T} \neq \sigma_{ML}{}^{T}$. In other words, if there is no substitution bias toward either capital or labor, then changes in P_M are analogous to Hicks neutral technical change in the sense that the K/L ratio will depend only on the wage rental ratio, and the intermediate input price will determine the level, but not the ratio, of returns to the primary factors.

Figure 4 illustrates the effects of a real exchange rate with representative iso-price curves. The increase in output price causes a shift outward of the curve for the traded good resulting in a lower r and higher w. To the extent that the good uses intermediate inputs also subject to price increases, this curve is shifted back toward the origin again, mitigating the initial impact on r and w. The size of these shifts in interest and wage rates will depend on the shapes of the curves for traded and non-traded goods. This depends on the substitution elasticities in each sector; high substitution values result in more pronounced curvature while complementary relationships result in relatively flat curves.

Figure 5 shows a single iso-price curve and isolates the effects of a rise in the price of the intermediate input. A rise in P_M which leaves K/L unchanged causes a homothetic shift in toward the origin since with a higher P_M and given P_T, w and/or r must be lower. Biased substitution effects would result in a new equilibrium either above the ray representing "neutral" effects if $\sigma_{MK}^T > \sigma_{ML}^T$ or below this ray if the inequality is reversed.

Either case represents a situation in which it is inappropriate to use existing technical coefficients to predict the response of capital and labor allocations to policy changes. Various studies have indicated that biased substitution effects do in fact exist in some activities in the case of oil. See, for example, Burgess (74), Griffin & Gregory (76), Laumas & Williams (81), and Oztalay et. al. (79). Antle (88) shows that road density, which contributes to tradedness, increases the demands for traded inputs, particularly fertilizer and tractors.

Tables 6 and 7 present estimates for elasticities of substitution in the agricultural sector for Colombia, the U.S. and Japan. All show that the elasticities of substitution between traded inputs and primary factors differ considerably. In Colombia, machinery was found to be a relatively good substitute for labor in all crops, with estimated elasticities between 1 and 2. In contrast, machinery was found to have very low or even negative elasticities of substitution for land.

Table 7 presents elasticities of substitution for the U.S. and Japan for two periods, one representing a time when both could be considered to be developing countries and the second representing modern times. Here it is again apparent that elasticities of substitution between primary factors and traded inputs are quite divergent, both between different inputs and across countries, a conclusion supported by Brown and Christensen (81) and Binswanger (74), who confirm these results in U.S. agriculture since 1947.

To summarize, substitution effects can either reinforce or mitigate the resource and output effects of price changes. The effects of input price changes will cause the "normal" effects to be mitigated or reversed (reinforced) if the imported input is a sufficiently good (poor) substitute for the factor in which the traded sector is <u>not</u> intensive. These effects are more likely to be important the larger are the changes in input prices as compared to output prices.

The presence of these substitution effects indicate that it is not possible even in theory to predict the effects of removal of real exchange rate bias and subsidies on agricultural incentives and outputs without reference to the conditions of production. In addition, it is impossible to say which direction the bias will go without empirical investigation, though the results presented above are suggestive.

However, it should be noted that studies which take input coefficients from data pertaining to a situation with interventions and with a history of sustained real exchange rate bias are likely to overstate the degree of the bias since producers will have adjusted to this situation by substituting away from expensive inputs and toward cheaper ones. Estimation of the results of removal of interventions and biases cannot be accurately done on the basis of these coefficients, since outputs and resource movements cannot be assumed to respond according to a ranking of activities on the basis of a measure of the degree of bias affecting their cum-intervention input structure.

As a final observation, note that the analysis above can be extended from the two good - two sector case above to n goods.[12] The important considerations for any given sector or subsector are four: First, the degree of tradedness of its output; second, the importance of traded inputs in production; third, the values of the substitution parameters; fourth, the extent to which factor ratios in the sector diverge from those of the rest of the economy.[13]

Implications for Economic Reform Packages

The analysis above suggests that the effects of reform packages designed to eliminate subsidies and depreciate the real exchange rate may have impacts that vary widely across different sectors or crops. In particular, packages that include a strong element of devaluation together with elimination of subsidies on traded inputs such as fertilizer are candidates for some of the adverse effects outlined in the section above.

To be specific, the following set of conditions would tend to militate against a strong output effect in agriculture from reforms intended to depreciate the real exchange rate and eliminate subsidies:

1. A significant proportion of non-traded agricultural output

2. Factor proportions different from the rest of the economy

3. Removal of large subsidies on traded inputs such as fertilizer which may represent a large fraction of input costs

4. Low degree of pass-through of devaluation to producer prices

5. Strong substitutability of traded input for factor not intensively used for given crop or sector

For example, suppose that traded agricultural products in a particular country are produced with relatively more labor and traded inputs than are other crops or commodities. Further, as suggested by the elasticity estimates in Tables 6 and 7 assume that fertilizer is a relatively good substitute for land but a relatively poor substitute for labor and that the reform program includes removal of a large subsidy on its use. This sort of situation can result in dampened (or in extreme cases, negative) output response.

The negative effects are likely to be more pronounced following the adoption of a reform package, insofar as traded inputs representing a very large fraction of short-run variable costs, are sharply increased in price or limited in availability. These inputs are precisely those which can be most readily increased to provide a short-run supply response. Even in the absence of legitimate fertility maintenance or other reasons to promote fertilizer use, a relatively cautious pace of reform may well be the best way to promote needed supply increases over the short to medium term.

More generally, the heterogeneity of the agricultural sector both in terms of the structure of production and the response to policy reforms demonstrates that though real exchange rate adjustments are a necessary condition for improved performance they are not a substitute for an agricultural development strategy. Policies and investments tailored to the specific conditions of production are a necessary condition as well, both in the agricultural sector and in the formulation of overall development strategies.

NOTES

1. Edwards, 1988.

2. Most estimates rely on purchasing power parity arguments in some form and so are open to criticisms familiar from this literature (See, for example, Officer (90) for a discussion). Another approach is to estimate a rate which would result in a zero trade balance or current account. While not directly based on PPP concepts, this is equally arbitrary in its choice of a zero balance as an equilibrium level at any particular point in time. In practice, the exchange rate that would generate this outcome can be difficult to estimate with a high degree of confidence. In any case, these considerations cause problems for estimates of levels but not of changes in real exchange rate bias.

3. Krueger, A, M. Schiff & A. Valdes, 1988, p. 264.

4. Note that this argument does not refer to the fixed costs of building roads, since that is a cost to be borne by the government, if at all. Rather, the cost refers to the fixed costs of setting up a marketing network both in terms of needed organizations and physical infrastructure for transport and storage. Two observations are pertinent. First, these are once and for all costs, which nevertheless will not be incurred until agents are confident a wide price differential will remain in place for an extended period (the riskiness of the investment must be within reasonable bounds) and the volume that can be sold must be sufficient to justify the expense of the fixed investment. Second, insofar as a poor road network remains a fact of life for those who would engage in the export/import business, it will act to increase the fixed cost associated with any given quantity of goods.

5. According to this argument the presence of fixed costs are not necessarily a barrier to entry in a contestable market because a competitor can produce at efficient scale for short periods and then gradually sell off inventory as it is demanded. For example, if minimum efficient scale is 1000 units per month, but the market is only able to absorb 100 units per month then the producer can produce for one month out of ten without incurring excess costs. By shortening the interval between bursts of production, inventory carrying costs can be reduced as well. That this argument seems somewhat unrealistic in many developing countries strengthens the case for non-tradedness of some commodities.

6. This table was calculated on the basis of a standard which required that there be <u>no</u> recorded trade in the specified crops. Thus, it may be the case that some countries reported as having a zero value in the table may in fact consume some of the indicated crops but could not be cited as examples of nontradeness due to the existence of some recorded trade (e.g., Malawi). In various cases, it is likely that there is some cross-border trade in frontier areas but this fact does not vitiate the argument that large areas, especially in large landlocked countries such as Sudan or Zaire, will exhibit characteristics of non-traded markets.

7. While this discussion concentrates on the problems inherent in sector-wide aggregation across various crops and production activities, it is also important to recognize that there can be substantial variation within activities as well. McIntire and Delgado (1985) show that the variation across farms in the structure of input use for the same crop renders standard measures of effective protection and domestic resource costs insignificantly different from zero at conventional confidence levels.

8. This discussion draws on arguments developed in different contexts by Corden (71), Burgess (80), and for the discussion on substitution effects, Jones (71).

9. This leaves open the possibility that the distributive share of labor in the traded goods sector is less that its share in non-traded goods. The key here is that the sum of the θ's for each sector must equal one.

10. For the last expression in equation (17) to dominate we must have:

$$\beta_M > \frac{\theta_{MT}}{\Theta} (\theta_{KN}\beta_L - \theta_{LN}\beta_K)$$

So, it is clear that β_M must be positive and sufficiently large for this result to occur. From equation (16) we see that β_M is positive if

$$\lambda_{KT}\theta_{MT}\sigma_{MK}{}^T > \lambda_{LT}\theta_{MT}\sigma_{ML}{}^T$$

The result in the text follows.

11. Allen, R. G. D, 1938, p. 504.

12. See Mussa (74) for such an extension in a related context.

13. This last consideration must be qualified somewhat. For a given activity, the important consideration is the divergence between the factor proportions it needs and those that, on a net basis, are released from all of the other activities in the economy, after taking into account all of the adjustments which occur in response to a given reform package.

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Table 1. Share of Non-traded Roots and Tubers in Total Per Capita Calorie Supply.*

Country	1979-1981 Average
Benin	0.38
Botswana	0.01
Burkina Faso	0.02
Burundi	0.39
Cameroon	0.22
Central African Republic	0.53
Congo	0.48
Gambia	0.01
Ghana	0.37
Guinea	0.20
Ivory Coast	0.28
Kenya	0.09
Lesotho	0.00
Liberia	0.23
Madagascar	0.17
Malawi	0.00
Mali	0.02
Mauritania	0.00
Mozambique	0.40
Niger	0.04
Nigeria	0.26
Rwanda	0.49
Sao Tome and Principe	0.14
Senegal	0.00
Sierra Leone	0.05
Somalia	0.01
Sudan	0.02
Swaziland	0.02
Tanzania	0.31
Togo	0.37
Uganda	0.18
Zaire	0.59
Zambia	0.05
Zimbabwe	0.01

* Includes cassava, yams, sweet potatoes, taro. Total calories excludes alcohol.

Source: FAO Food Balance Sheets, Rome 1984.

Table 2. Coefficients of Variation of Multilateral Real Exchange Rate Index (Quarterly data 1972-1985).

Country	Coefficient of Variation
Bolivia	.20
Brazil	.20
Chile	.28
Colombia	.11
Cyprus	.09
Dominican Republic	.18
Ecuador	.08
El Salvador	.22
Ethiopia	.18
Greece	.04
Guatemala	.08
Guyana	.14
Honduras	.11
India	.12
Israel	.13
Kenya	.06
Korea	.07
Malaysia	.08
Malta	.09
Mauritius	.06
Mexico	.15
Pakistan	.11
Paraguay	.19
Peru	.19
Philippines	.06
Singapore	.07
South Africa	.08
Sri Lanka	.39
Thailand	.06
Tunisia	.09
Turkey	.14
Yugoslavia	.14
Zambia	.18

Source: Edwards, 1989.

Table 3. Coefficient of Variation of World Commodity Prices.

Product	(Quarterly 1967:I–1987:IV)
Cocoa	0.54
Coffee	0.52
Cotton	0.33
Groundnuts	0.58
Maize	0.34
Palm Kernel	0.47
Palm Oil	0.43
Rice	0.36
Rubber	0.40
Sorghum	0.30
Sugar	0.87
Tobacco	0.35

Source: World Bank – International Commodity Markets Division.

Table 4. Share of Tradable Inputs in Value of Production.[a]

Country/Agricultural Products	Percent
Ecuador[b]	
Wheat	18
Barley	35
Potatoes	35
Dairying	24
Mexico[c]	
Wheat(Sonora)	33
Wheat(Tlaxcala)	43
Kenya[d]	
Export Crops	14
Cereals[e]	34
Milling	6
Other Domestic Crops	30
Zimbabwe[f]	
Wheat	31
Maize	31
Soybeans	39
Groundnuts	48
Cotton	22
Tobacco	10

a Includes costs of machinery, fuels, fertilizer, chemicals, and miscellaneous purchased inputs.

b Source: Byerlee, 1985.

c Source: Byerlee and Longmire, 1985.

d Source: Sharpley, 1988. Figures are for imported inputs only used in 1983/84 crop year for production, processing, and transport. Export crops include coffee, tea, tinned pineapples, sisal, pyrethrum, cashew nuts, and wattle extract. Cereals include maize, wheat, barley and rice. Other domestic crops include sugar, oilseeds, tobacco and cotton.

e Production and transport only.

f Source: Morris, 1988. All figures are for irrigated crops.

Table 5. Index Numbers of Prices Received and Paid by Farmers.

	1980	1981	1982	1983	1984	1985	1986	1987
Algeria 1980=100								
Crops	100	100	115	115	143	145		
Fertilizer	100	100	100	128	182	217		
Energy			100	117	150	267		
C. A. R. 1970=100								
Crops	174	183	200	183	230			
Energy	185	218	265	300				
Guinea B. 1976=100								
Crops	89	89	100	100	163			
Fertilizers				100	200			
Kenya 1982=100								
Crops	84	87	100	117	140	171		
Fertilizers	68	93	100	104	105	142		
Energy	70	89	100	109	121	130		
Malawi 1980/81=100								
Crops	97	100	100	116	168	187	218	232
Fertilizers	92	100	105	120	130	141	183	220
Mali 1975/76=100								
Crops	195	239	251					
Fertilizers	276	289	289					
Rwanda 1982=100								
Crops	136	116	100	113	154	186	130	
Fertilizers	100	100	91	93				
Togo 1976=100								
Crops	142	196	217	239	212	181	172	
Fertilizers	100	233	233	267	333	333	333	333
Zimbabwe 1980=100								
Crops	100	138	135	149	166	205		
Fertilizers	100	116	123	130	193	207	251	
Energy	100	103	108	159	160	175	202	

Source: FAO Fertilizer Yearbook, 1988.

Table 6. Estimates of Allen Partial Elasticities in Colombian Agriculture.

Crop	Parameters: Machinery/Labor	Land/Labor	Machinery/Land
Rice	1.4	.79	-.34
Cotton	1.9	-.02	-.13
Corn	1.4	.79	-.66
SSS*	1.3	.55	.13
Wheat and Barley	1.1	.44	.04

* Aggregate of sesame, sorghum and soybean.

Source: Thirsk, 1974 Table 4.

Table 7. Estimates of the Allen Partial Elasticities of Substitution for U.S. and Japanese Agriculture.

Allen partial elasticity of substitution	United States		Japan	
	1880-1925	1930-1980	1880-1940	1955-1980
Labor/machinery	.191	.191	.029	.013
Land/fertilizer	.777	.741	.093	.108
Other*	.191	.191	.239	.239

* Other elasticities, land/labor, labor/fertilizer, land/machinery, machinery/fertilizer, constrained to be equal.

Source: Hayami and Ruttan, 1985, p. 203.

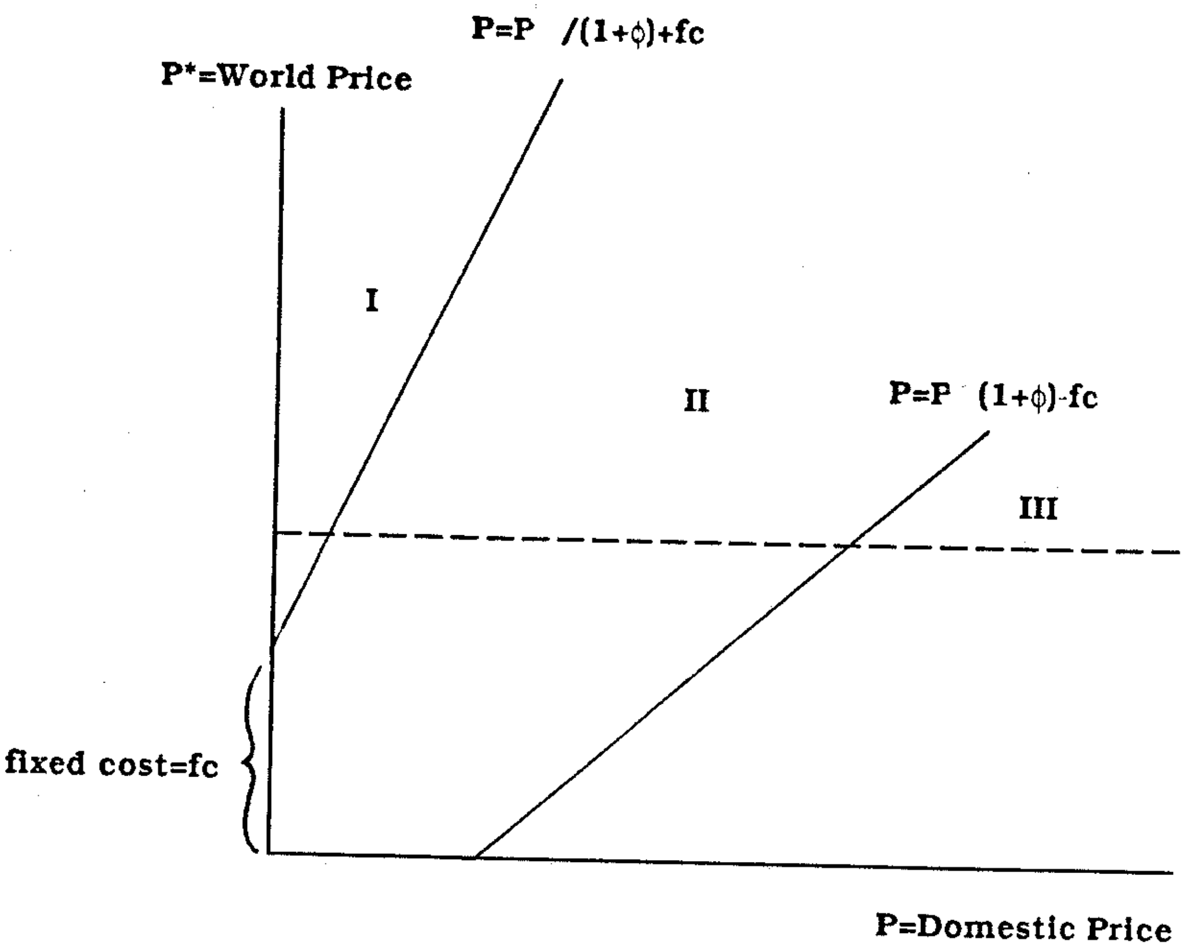
P=P /(1+ϕ)+fc
P*=World Price
I
II
P=P (1+ϕ)-fc
III
fixed cost=fc
P=Domestic Price

Figure 1.

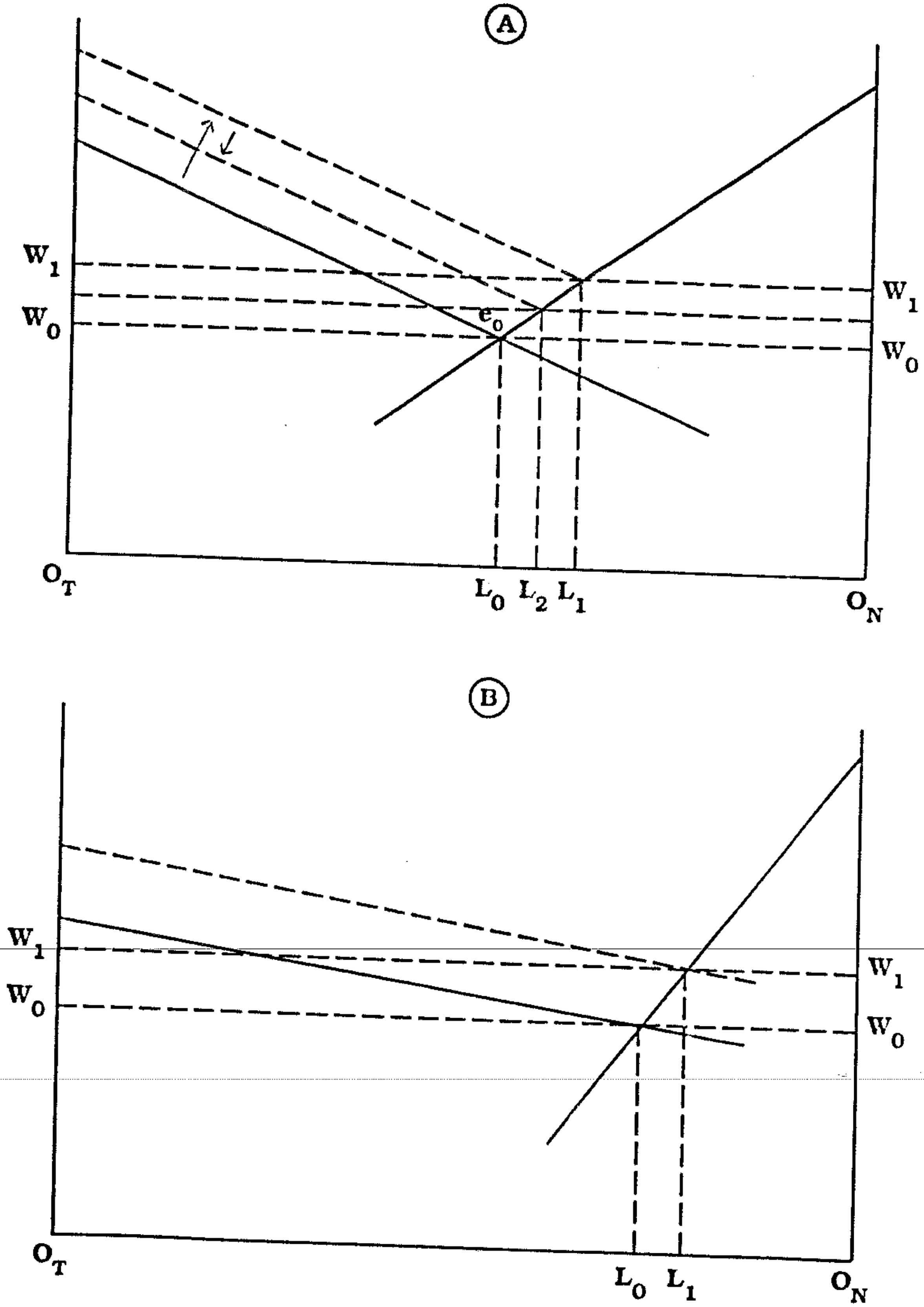

Figure 2

Figure 3

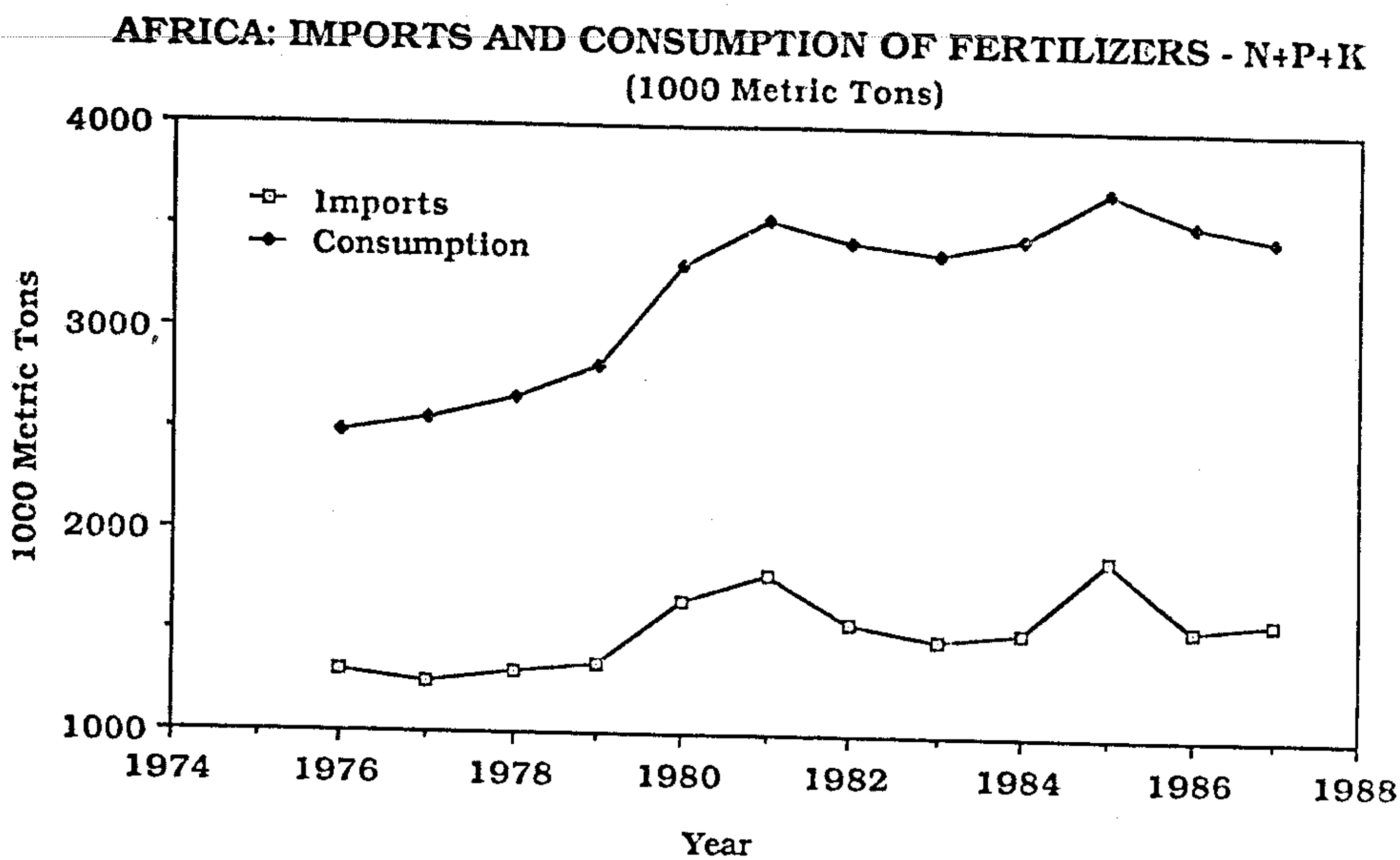
AFRICA: IMPORTS AND CONSUMPTION OF FERTILIZERS - N+P+K
(1000 Metric Tons)
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Figure 4.

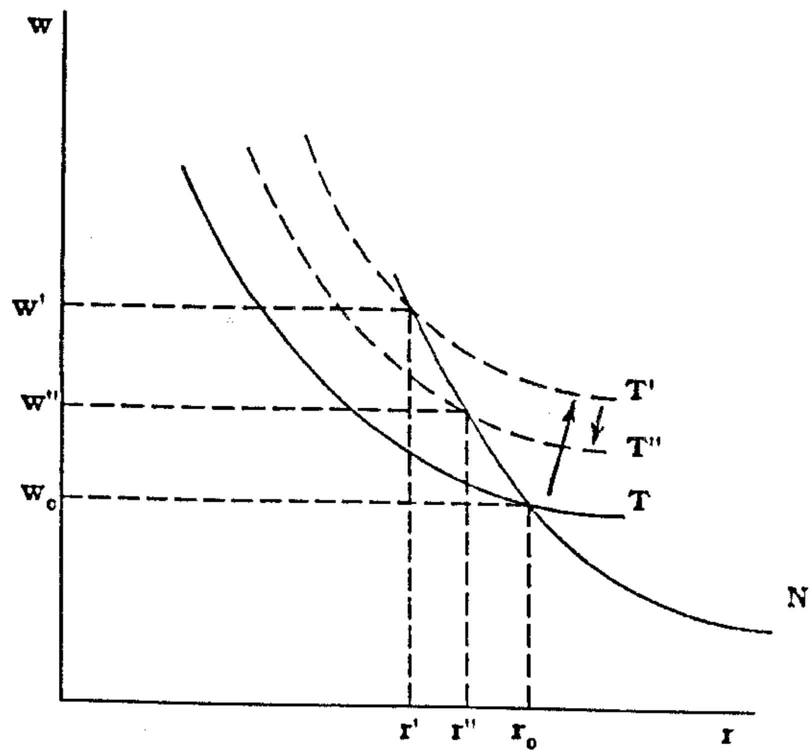
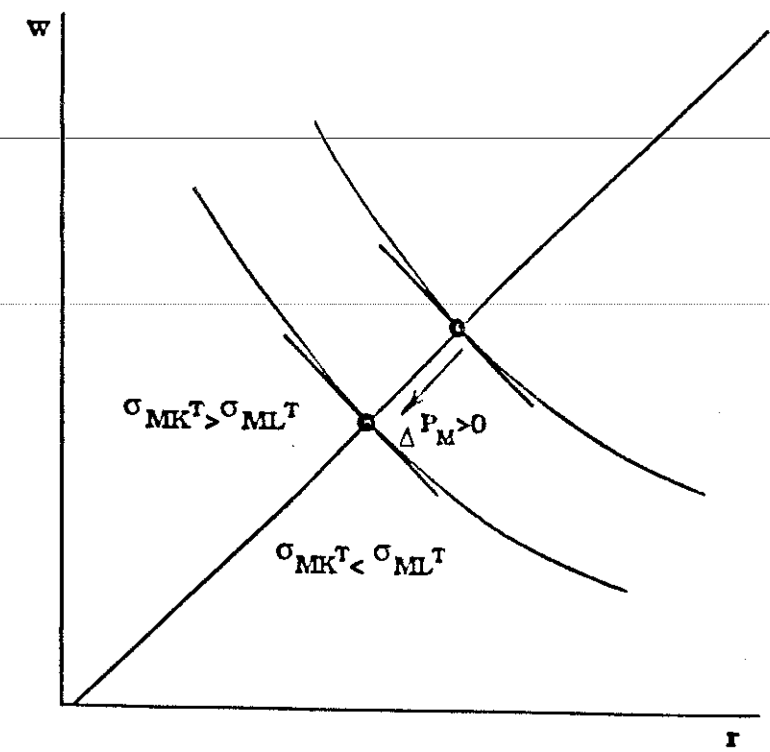


Figure 5.



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