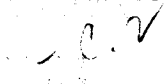


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INTERRELATED PRODUCTS AND THE ELASTICITY OF
EXPORT SUPPLY IN DEVELOPING COUNTRIES

by 

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INTERRELATED PRODUCTS AND THE ELASTICITY OF

EXPORT SUPPLY IN DEVELOPING COUNTRIES

Romeo M. Bautista*

1. Introduction

Although primary products, i.e., from the agricultural and extractive sectors, comprise a large portion of merchandise exports of most developing countries (or "less developed countries", LDCs for short), it is frequently the case that commodities of varying degrees of processing based principally on these primary products are also being exported.¹ Examples of export commodities so related come easily to mind: logs, lumber, plywood and other wood products; metallic ores and concentrates, ingots and various metal products; raw and refined cane sugar; rubber and rubber products; copra, coconut oil, and other coconut-based commodities. The interdependence among such products is generally ignored or assumed away in most existing empirical studies on LDC export behavior.² Thus export supply functions are usually estimated and analyzed in reference to highly aggregative commodity classes or to individual export commodities considered independently of one another. This is clearly unsatisfactory in a situation where the cross-substitution effects among related products are significant. The estimated export supply elasticities may not then reflect the actual responsiveness of exports to past changes in the price and activity variables or be relevant in the quantitative assessment of the probable effect on exports of policy changes or external disturbances affecting these variables.

The objective of this paper is to examine the interrelations among production, prices and exports in the markets for two related export commodities --

one being a primary product and the other a processed commodity which uses in production the primary product as principal material input. A "small country" model is presented that specifies, in addition to the two export supply functions, a domestic demand equation for the manufactured commodity, a fixed coefficient technological relation, a price equation linking the domestic prices of relevant commodities, and certain identities. Some comparative static properties of the model are examined, bringing out the negative indirect effects (resulting from the interactions among the endogenous variables) of changes in the exchange rate and foreign currency prices on export response and identifying the parameters that determine the magnitude of the upward bias of export supply elasticities based on single equation models. Under certain conditions it is shown that a currency devaluation would favor an increase in exports of the processed commodity relative to the primary product. In such a case the well-known tendency of LDCs to overvalue their currencies has the effect of discriminating against exports of processed commodities among related export products. In application to Philippine exports of copra and coconut oil, the behavioral equations of the model are estimated using annual data in the postwar period. Comparison of the direct price effects reflected in the estimates of the structural coefficients with the total effects, as indicated by the corresponding reduced form coefficients, shows evidence of strong interaction effect. In the case of copra export supply, which is found to be own-price inelastic, the substantial cross-substitution effect renders negative the net effect of an exchange rate change. A corollary finding is that the net response of coconut oil exports to a currency devaluation is substantially positive, implying that the widely observed overvaluation of the Philippine peso during the post

period has unduly favored the exporting of copra (the primary product) relative to coconut oil (the processed commodity).

2. The Model

Commodity A is a primary product that can be exported directly or processed domestically into commodity B for home use (either in final consumption or as an intermediate product) or for export. Assuming no barriers to export trade, the export supply functions may be represented by

$$X_A = f(R \cdot P_A^*, P_{hA}, Y_A) \quad (1)$$

$$X_B = g(R \cdot P_B^*, P_{hB}, Y_B) \quad (2)$$

where, in reference to either A or B,

X = quantity of export flow

P_A^* = foreign currency export price

R = exchange rate, in units of domestic currency per unit of foreign currency

P_h = home price of the commodity, in domestic currency

Y = domestic output

and the signs of the partial derivatives are given by

$$f_1 (= \partial f / \partial R \cdot P_A^*) > 0, \quad f_2 (= \partial f / \partial P_{hA}) < 0, \quad f_3 (= \partial f / \partial Y_A) > 0,$$

$$g_1 > 0, \quad g_2 < 0 \quad \text{and} \quad g_3 > 0.$$

The basic assumption underlying equations (1) and (2) is that, from the point of view of the producers of either commodity, the domestic and foreign markets are not perfectly substitutable (Bautista, forthcoming). For any given output of each commodity, the amount exported is determined by the levels of the export price in domestic currency and the domestic price, which proxy

for the profitability of exporting relative to domestic sale. A more restrictive formulation would be that the share of exports to total production X/Y of each commodity depends solely on the relative price $R \cdot P_x^*/P_h$; this is the case of the homogenous export supply function. For the small country, which is our concern here, P_x^* is exogenously determined.

The domestic market demand for the processed good B is given by

$$H_B = j(P_{hB}, P_C, E) \quad (3)$$

where

H_B = amount of home consumption of commodity B

P_C = price of competing consumer products (or a general price index)

E = expenditure or income variable

and $j_1 < 0$, $j_2 > 0$ and $j_3 > 0$. If B is an intermediate good, equation (3) would represent a derived demand function.

Considering the low level of processing that typically characterizes LDC manufactured exports, it seems reasonable for present purposes to make the simple assumption that B's production technology is of the fixed proportion type:

$$Y_B = u \cdot H_A \quad (4)$$

where u is the yield per unit of the input A and H_A is the amount of home consumption of commodity A.

Assuming zero imports and changes in stocks for either commodity, domestic consumption plus the amount exported equals total production:

$$Y_A = H_A + X_A \quad (5)$$

$$Y_B = H_B + X_B \quad (6)$$

To close the system, a price equation is postulated linking the domestic price of commodity A to the average revenue from the production of B and any by-products Z:

$$P_{hA} = u \cdot P_{hB} + s \cdot PZ - MM \quad (7)$$

where PZ is the price of by-products, s is the yield of Z per unit of input A and MM stands for the marketing margin and production costs other than P_{hA} .

Equations (1) - (7) contain seven endogenous variables, namely, X_A , X_B , P_{hA} , P_{hB} , H_A , H_B , and Y_B . Domestic output of the primary product A is assumed predetermined (as are the remaining variables of the model), which allows for the following possibilities: (1) existence of governmental restrictions on domestic production, e.g. logs in some Southeast Asian countries (motivated in this case by environmental concerns and the need to promote exports of wood manufactures); (2) long gestation period characterizing the production of some LDC primary exports, especially the perennial crops and mining products; and (3) other reasons for the widely observed inelastic supply response of primary products (at least in the short run) as discussed, for example, in Cooper (1971). Such assumption would not be justified if Y_A can be explained endogenously in an essential way, i.e., involving other variables of the model.⁴ The system is static in that full adjustment of the behavioral equations and clearing of markets are attained in each time period considered.

3. Some Comparative Statics

In examining now some comparative static properties of the model, our main interest is in the export response to changes in the exchange rate and foreign currency export prices. Consider first an increase in P_{xA}^* , the rest of the exogenous variables assumed to remain constant. The direct effect will

be an increase in the quantity exported of commodity A; this in turn will reduce the amount available for the domestic production of commodity B, which is part of an adjustment process producing a secondary or indirect effect on X_A and additionally a cross-substitution effect on X_B , among other interaction effects.

The total effect of a change in A's foreign currency export price on the amount of A exports is given by⁵

$$\frac{dX_A/X_A}{dP_A^*/P_A^*} = n_{XA} \cdot \frac{1}{1 + \alpha} \quad (8)$$

where

$$\alpha = \frac{n_{hA}}{e_{hB}H_B + n_{hB}X_B} \cdot \frac{X_A}{H_A} (Y_B - n_{yB}X_B) \quad (8a)$$

and $n_{XA} (= f_1 R \cdot P_A^* / X_A)$ = A's export supply elasticity with respect to its export price

$n_{hA} (= f_2 P_A / X_A)$ = A's export supply elasticity with respect to its domestic price

$n_{xB} (= g_1 R \cdot P_A^* / X_B)$ = B's export supply elasticity with respect to its export price

$n_{hB} (= g_2 P_B / X_B)$ = B's export supply elasticity with respect to its domestic price

$n_{yB} (= g_3 Y_B / X_B)$ = B's export supply elasticity with respect to domestic output

$e_{hB} (= j_1 P_B / H_B)$ = B's own-price elasticity of domestic demand.

The term $1/1+\alpha$ is an adjustment factor that should be multiplied to the partial elasticity n_{XA} to obtain the total effect on X_A of a given change in

P_A^* . The necessary and sufficient condition for $\alpha > 0$ is that $Y_B - n_{yB}X_B > 0$,

which is likely to be met in practice.⁶ This will be assumed from hereon,

in which case the adjustment factor is less than one. The indirect effect

is negative and n_{xA} (representing the direct effect) will overstate the "true" export response given in equation (8). This upward bias is larger the higher is the (absolute) value of n_{hA} , the lower B's domestic demand and export supply elasticities with respect to its domestic price, and the higher the proportion of A output being exported.

The effect on X_B can be shown to be as follows:

$$\frac{dX_B/X_B}{dP_A^*/P_A^*} = \frac{-n_{xA} X_A}{K H_B} (e_{hB} n_{yB} + n_{hB} Y_B/H_B) \quad (9)$$

where

$$K = e_{hB} + n_{hB} \frac{X_B}{H_B} + n_{hA} \frac{X_A}{H_B} \left(\frac{Y_B}{H_B} - n_{yB} \frac{X_B}{H_B} \right) \quad (9a)$$

With $n_{yB} X_B < Y_B$ again, $K < 0$ and the effect on the amount exported of commodity B is negative. Thus an increase in the export price of A will have an unfavorable influence on X_B which, from equation (9), is in part determined by the magnitude of A's export supply elasticity n_{xA} .

Considering now an increase in the foreign currency export price of commodity B (the other exogenous variables of the model remaining unchanged), the cross-substitution effect on X_A is given by

$$\frac{dX_A/X_A}{dP_B^*/P_B^*} = \frac{-n_{xB} n_{hA} X_B}{K H_B} \quad (10)$$

which is negative, recalling that $K < 0$.

The total effect on the amount exported of commodity B is

$$\frac{dX_B/X_B}{dP_B^*/P_B^*} = n_{xB} \frac{1}{1 + \beta} \quad (11)$$

where

$$\beta = \frac{X_B}{H_B} \cdot (n_{hB} - n_{yB} n_{hA} \frac{X_A}{H_A}) / (e_{hB} + n_{hA} \frac{X_A}{H_A} \frac{Y_B}{H_B}) \geq 0 \quad (11a)$$

depending on the relative values of the elasticities n_{hA} , n_{hB} and n_{yB} , and export share in the domestic output of A. The "adjustment factor" $1/(1+\beta)$ in equation (11) can be less than or greater than one, and hence the direction of the indirect effect on B's export response is ambiguous.

While changes in foreign currency prices represent an external influence on exports of a small country, variations in the exchange rate, which also affect export supply through the induced change in local currency export prices, are in the domain of domestic policy. Within the framework of our model, an exchange rate change is analytically equivalent to a simultaneous proportionate change in the foreign currency export prices of A and B. From equations (8) - (11), it is clear that, depending on the relative magnitudes of the own-price and cross-substitution effects, export supply of either commodity may respond positively or negatively to a change in the exchange rate. One cannot rule out therefore a perversely negative export response to a currency devaluation in a small country with interrelated export products.

Under the assumption of homogeneous export supply functions, $n_{xA} = -n_{hA}$, $n_{xB} = -n_{hB}$ and $n_{yB} = 1$, in which case

$$\frac{dX_A/X_A}{dR/R} = n_{xA} \cdot \frac{1}{1 - \left(\frac{n_{xA} X_A}{e_{hB} H_A} + \frac{n_{xB} X_B}{e_{hB} H_B} \right)} \quad (12)$$

$$\frac{dX_B/X_B}{dR/R} = \frac{n_{xB} - n_{xA} H_A/X_A}{1 - \left(\frac{n_{xA} X_A}{e_{hB} H_A} + \frac{n_{xB} X_B}{e_{hB} H_B} \right)} \quad (13)$$

As might be expected, the net effect of an exchange rate change on the amount exported of either commodity is lower than what the partial elasticities would indicate. The magnitude of this upward bias is related directly to the export shares in the domestic production of A and B, and inversely to the own-price elasticity of demand for commodity B. From equation (13), B's export response is also seen to be affected negatively by the induced change in X_A ; this result is not surprising since any increase in the amount exported of the primary product A (due to say, a devaluation of the domestic currency) implies, under the assumptions of the model, a commensurate reduction in the output of the processed commodity B. These considerations would seem to warrant the conclusion that the effectiveness of currency devaluation in improving the trade balance of developing countries is reduced by the interrelated nature of some of their principal export products.

From equations (12) and (13), the relative export responsiveness of commodities A and B to an exchange rate change is given by

$$\frac{\frac{dX_A/X_A}{dR/R}}{\frac{dX_B/X_B}{dR/R}} = \frac{1}{n_{xB}/n_{xA} - X_A/H_A} \quad (14)$$

which may be positive or negative according as n_{xB}/n_{xA} is greater or less than X_A/H_A . From a development policy viewpoint, it is also of interest to see whether

$$n_{xB}/n_{xA} - X_A/H_A \geq 1, \text{ or equivalently} \quad (15)$$

$$n_{xB}/n_{xA} \geq Y_A/X_A.$$

If n_{XB}/n_{XA} is greater than Y_A/H_A , which is not unlikely considering the greater price responsiveness of LDC entrepreneurs in activities involving higher degrees of processing, then currency devaluation would favor an increase in the amount exported of the processed commodity B relative to the primary product A. In such a case currency overvaluation, which is prevalent among developing countries (cf. Little, Scitovsky and Scott, 1970), effectively discriminates against the exporting of processed commodities among related export products. This exchange rate policy would then be contrary to LDC policy efforts to lessen primary product exports in favor of manufactured goods.

4. Application to Philippine Exports of Copra and Coconut oil

The postwar experience of the Philippines with respect to copra (dried coconut meat) and coconut oil (which is extracted from copra) provides an interesting case study by which to illustrate empirically and give quantitative expression to the interrelations among production, home consumption, exports and prices of the primary product and processed commodity described in the above model. Copra and coconut oil have long been major contributors to the country's export earnings, accounting for about 30 per cent of the annual revenue from merchandise exports throughout most of the postwar period.⁷ The local market is also a significant outlet for these commodities, absorbing more than one-third of total production.

Although roughly 60 per cent of world exports of indigenous coconut products originate from the Philippines, coconut oil constitutes only about

14 per cent of world trade in fats and oils. Because of the strong substitutability of coconut oil in the international market with other vegetable oils and perhaps also with petrochemical products used in the manufacture of synthetic detergents (Librero, 1971), the volume of Philippine copra and coconut oil exports can not be considered a major determinant of the international prices of these commodities. In oil equivalent terms United States imports of Philippine copra and coconut oil represent less than 10 per cent of the domestic consumption of soybean, cottonseed and groundnut oils. Similarly, Philippine exports of copra and coconut oil to Western Europe constitute a relatively small component (about 15 per cent) of the latter's annual consumption of vegetable oils (including palm kernel, groundnut and soybean oils). In applying the model to Philippine exports of copra and coconut oil, three behavioral relationships need to be estimated, namely, the export supply functions for copra and coconut oil and the domestic demand function for coconut oil. The assumed exogeneity of copra output is suggested by the following considerations: (i) coconut is a perennial crop, requiring six to eight years from the time of planting for the tree to bear fruit; (ii) the yield of coconut trees has in the past not been influenced by copra price, the significant determinants of yield (expressed in nuts per bearing tree) having been found to be the level of rainfall and occurrence of typhoons (Nyberg, 1968; pp. 97-102); and (iii) copra accounts for about 95 per cent of domestic coconut production. The following values to be assigned to the technological parameters of the model are based on the average coconut oil and

copra meal yields per unit quantity (metric ton) of copra crushed: $u = 1.640$ and $s = 350$.

Table 1 presents the estimated equations, which are all in linear form, using ordinary least squares (OLS) and two-stage least squares (TSLS) on annual data for the sample period 1952-1973. The variables appearing in the estimated equations and elsewhere in the model are described in Table 2, and the data sources are given in Appendix 2. In view of an earlier finding (Bautista, forthcoming) that the price effects on export supply of copra and coconut oil extend to the succeeding year in a linear fashion (based on the regression results of alternative specifications on lagged responses to price changes using Almon's (1965) estimation technique), all price variables have been expressed as weighted averages of current and preceding-year values with weights .667 and .333, respectively. Serial correlation of the error terms appeared significant in the initial regressions for each equation and hence the Cochrane-Orcutt (1949) iteration technique was used, the initial value of the autoregressive coefficient determined from a six-point grid search.

The estimated coefficients from the OLS and TSLS results are not markedly different generally, suggesting that the simultaneous equation bias is not very substantial. Although a few of the estimates are only marginally significant, the signs of the coefficients are as expected and the implied elasticities (at the mean values over the sample period) seem credible.

Information on the price effects on the supply of copra and coconut oil is presented in Table 3.

On the other hand, the price effects on the demand for copra and coconut oil are presented in Table 4.

Table 1

Estimation Results

$$(i) \quad QXA = 79.6 + 3.093 RPXA^* - 3.469 PHA + .541 QYA \quad (i)$$

(2.18)	(1.41)	(-2.04)	(6.05)
	.213	-.238	.926

$$\bar{R}^2 = .690 \quad D.W. = 2.10 \quad \rho = .492$$

Estimation technique: OLSCO

$$QXA = 67.8 + 3.253 RPXA^* - 3.367 PHA + .539 QYA \quad (i')$$

(2.01)	(1.48)	(-1.99)	(6.08)
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estimated coefficient of .224 on RPXA* and -.231 on PHA, and .923 on QYA.

The adjusted R-squared is .681, the Durbin-Watson statistic is 2.03, and the rho statistic is .631.

These results are based on the following model:

$$\bar{R}^2 = .681 \quad D.W. = 2.03 \quad \rho = .631$$

Estimation technique: TSLSCO

$$QXB = -54.3 + 3.883 RPXB^* - 2.399 PHB + .400 QYB \quad (ii)$$

(-2.69)	(3.24)	(-2.98)	(4.69)
	1.721	-1.190	.753

$$\bar{R}^2 = .924 \quad D.W. = 2.02 \quad \rho = .214$$

Estimation technique: OLSCO

$$QXB = -43.9 + 3.432 RPXB^* - 2.398 PHB + .481 OYB \quad (ii')$$

(-1.88)	(2.76)	(-2.88)	(4.94)
	1.521	-1.189	.906

$$\bar{R}^2 = .895 \quad D.W. = 1.98 \quad \rho = .355$$

Estimation technique: TSLSCO

$$QHB = 76.1 - .760 PHB + .551 PHC + 1.195 CE \quad (iii)$$

(.80)	(-1.62)	(2.02)	(4.42)
	-.427	.324	.652

$$\bar{R}^2 = .651 \quad D.W. = 1.73 \quad \rho = .368$$

Estimation technique: OLSCO

(continued)

Table 1 (concluded)

$$(iii) \quad QHB = 83.2 - .779 PHB + .504 PHC + 1.189 CE$$

(.90)	(-1.78)	(1.69)	(3.90)
	-.438	.296	.649

$$\bar{R}^2 = .597 \quad D.W. = 1.68 \quad \rho = .436$$

Estimation technique: TSLSCO

Notes: Numbers in parentheses are t-values of regression coefficients. Elasticities at the means are shown underneath the t-values. OLSCO and TSLSCO are, respectively, ordinary least squares and two-stage least squares, with Cochrane-Orcutt iterations.

Table 2

Definition of Variables

Endogenous variables

QXA = quantity of Philippine exports of copra, in million kilograms

QXB = quantity of Philippine exports of coconut oil, in million kilograms

PHA = domestic wholesale price of copra, in pesos per hundred kilograms

PHB = domestic wholesale price of coconut oil, in pesos per hundred kilograms

QHA = home consumption of copra, in million kilograms

QHB = home consumption of coconut oil, in million kilograms

QYB = domestic production of coconut oil, in million kilograms

Exogenous variables

RPXA* = effective exchange rate multiplied by the unit value (U.S. dollars, f.o.b.) of copra exports, in pesos per hundred kilograms

RPXB* = effective exchange rate multiplied by the unit value (U.S. dollars, f.o.b.) of coconut oil exports, in pesos per hundred kilograms

PHC = consumer price index in Manila (1965 = 100)

QYA = domestic production of copra, in million kilograms

CE = index of real personal consumption expenditures (1965 = 100)

PZ = domestic wholesale price of copra meal, in pesos per hundred kilograms

MM = marketing margin and processing cost per hundred kilograms of copra pressed

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Table 3

Reduced Form Coefficients (TSLS Results)

Endogenous Variables	RPXA*	RPXB*	Exogenous Variables				
			PHC	QYA	CE	PZ	MM
QXA	2.524 (.174)	-2.149 (-.227)	-.305 (-.038)	.625 (1.070)	-.662 (-.076)	-.962 (-.030)	2.748 (.049)
QXB	-1.410 (-.408)	2.153 (.954)	-.246 (-.128)	.209 (1.503)	-.532 (-.526)	.537 (.069)	-1.535 (-.114)
PHA	.169 (.170)	.638 (.982)	.091 (.164)	-.025 (-.624)	.196 (.328)	.286 (.128)	-.816 (-.211)
PHB	.264 (.154)	.997 (.891)	.142 (.148)	-.039 (-.565)	.307 (.293)	-.101 (-.026)	.287 (.043)
QHA	-2.524 (-.244)	2.149 (.319)	.305 (.053)	.375 (.902)	.662 (.107)	.962 (.042)	-2.748 (-.069)
QHB	-.206 (-.068)	-.777 (-.390)	.441 (.259)	.031 (.252)	.956 (.522)	.078 (.011)	-.224 (-.019)
QYB	-1.616 (-.248)	1.376 (.324)	.195 (.054)	.240 (.916)	.423 (.108)	.616 (.042)	-1.759 (-.070)

Note: Corresponding elasticities at the mean values are in parentheses.

obtained above. In addition, exports of coconut oil will be reduced (by 4.08 per cent), again as indicated in the earlier comparative static analysis. The other interaction effects consist of increases in the domestic prices of both copra and coconut oil (by 1.70 and 1.54 per cent, respectively) and reductions in the home consumption of the two commodities and the domestic output of coconut oil. Notice finally that the induced rise in the domestic price of copra has a negative feedback on copra exports, which explains the observed direction of the indirect effect.

A 10 per cent increase in the export price of coconut oil, with the other exogenous variables remaining constant, would eventually raise coconut oil exports by 9.54 per cent, which is substantially lower than the direct effect of a 15.21 per cent increase implied by the partial elasticity. Moreover, exports of copra will decrease by 2.27 per cent via the cross-substitution effect. As might be expected, the domestic prices of the two commodities will increase (quite significantly at that -- by nearly 10 per cent) while home consumption of coconut oil will decrease (by 3.9 per cent).

Consider finally a 10 per cent devaluation of the domestic currency. As suggested above, the effects would be identical to that of a simultaneous 10 per cent increase in the foreign currency export prices of the two commodities. Thus the direct effect on export supply consists of increases of 2.24 per cent for copra and 15.21 per cent for coconut oil; the total effect, on the other hand, is seen from Table 3 to consist of a reduction in copra exports by .53 ($= 2.27 - 1.74$) per cent and an increase in coconut oil exports by 5.46 ($= 9.54 - 4.08$) per cent. The large discrepancy between the direct and total effects reflects the significance of the interaction effects of an exchange rate change on Philippine exports

of coconut products. The negative net response of copra exports illustrates the possibility indicated earlier that the negative cross-substitution effect of a currency devaluation could outweigh the positive direct effect on certain export commodities of a small country. From these results one may infer that the overvaluation of the Philippine peso throughout most of the postwar period (Baldwin, 1975), has favored the exporting of copra at the expense of coconut oil exports.

For chronically foreign exchange-constrained LDCs like the Philippines, perhaps the important policy question has to do not so much with the export response of individual commodities to an exchange rate change but with the effect on total export earnings. With constant foreign currency export prices of copra and coconut oil, the effect on export revenue (in foreign currency) from these two commodities is equal to the (value-share) weighted average of the proportionate changes in export quantities. Based on the mean values over the sample period, the calculated elasticity of export earnings from copra and coconut oil with respect to the exchange rate is .108, which is much lower than either of the estimated own-price elasticities for the two export-commodities (.224 for copra and 1.521 for coconut oil, from Table 1). Thus failure to include interaction effects could result in a substantial overestimation of the effect of exchange rate changes on Philippine export revenue from copra and coconut oil.

FOOTNOTES

* Associate Professor of Economics, University of the Philippines and Visiting Research Fellow, National Bureau of Economic Research, Inc. (New York) during academic year 1975-76. Use of the TROLL econometric system has facilitated the computations made in this study. The author wishes to acknowledge also the helpful comments and suggestions of Douglas Adkins and Donald Keesing, and the research assistance of Lisa Horowitz. Preliminary versions of this paper were presented at the Yale Economic Growth Center and the 1976 Econometric Society Meeting at Atlantic City.

¹ LDCs at relatively higher levels of industrial development would presumably have larger shares of manufactured exports; cf. Chenery and Taylor (1968).

² The distinction between direct (primary), indirect (secondary) and total effects as used in the trade literature, e.g., Meade (1951) and Scott (1957), stems from the recognition of interdependence in foreign trade. Most of the relevant studies, however, have been concerned with import demand or demand for a country's exports (assuming infinite elasticity of export supply) as reflected, for instance, in a recent survey by Magee (1975). While there has been some empirical work on export supply functions for developing countries, e.g., Stern (1965), Sheahan and Clark (1967), Bautista and Encarnacion (1972) and Krueger (1974), no systematic analysis of interrelated export commodities is provided in these studies.

³ This would be implied, for example, by a constant elasticity of substitution between exports and domestic sale of each commodity. An analogous result for import demand distinguished by source of supply has been demonstrated by Armington (1969).

⁴The same holds true for the other predetermined variables of the model as specified above for which the exogeneity assumption may not apply.

For instance, P might plausibly be influenced by P_{HB} .

⁵See Appendix 1 for the derivation of equation (8) and succeeding equations presented in this section.

⁶For the homogeneous export supply function, $\alpha_{yb} = 1$ and the condition is satisfied.

⁷Desiccated coconut and copra meal (a by-product of oil extraction) are two other important coconut product exports, but their contributions to Philippine export earnings have been relatively small (less than 4 and 2 per cent, respectively).

⁸See Librero (1971).

⁹The structural relations in the two studies cited are formulated differently from those of the present study in that homogeneous export supply function for copra is assumed and Librero's domestic demand function has as arguments coconut oil prices expressed in U.S. dollars, real national income (in pesos) and a dummy variable to allow for a shift of the function in the 1961 de facto peso devaluation.

¹⁰These empirical results may of course reflect differences in the measures of the price variables used more than the presence of "money illusion."

¹¹The reduced form coefficients from the OLS results correspond very closely to the coefficient values given in Table 3.

¹²One important assumption underlying each model simulation considered in this paper is that, in keeping with the exogeneity of the Y_A variable, domestic production of copra remains constant. With changing domestic price of copra, such assumption cannot be true over a long period of time. Now copra output is determined by the stock of fruit bearing coconut trees. Since it takes at least six years after planting for coconut trees to bear fruit, the induced changes in the endogenous variables (including the interaction effects) should be completed before six years for the simulation results on the total effects to be valid. That this condition is likely to be fulfilled is suggested by the empirical finding of only a two-year lag length for the price effects on export supply.

APPENDIX 1: Notes on the derivation of the effects of export price and exchange rate changes (cf. Section 3)

Taking total differentials in equations (1), (2) and (3) and setting

dY_A , dP_C and dE equal to zero, we obtain

$$\begin{aligned} dX_A/X_A &= n_{xA} d(R \cdot P_{xA}^*)/R \cdot P_{xA}^* + n_{hA} dP_{hA}/P_{hA} \\ dX_B/X_B &= n_{xB} d(R \cdot P_{xB}^*)/R \cdot P_{xB}^* + n_{hB} dP_{hB}/P_{hB} + n_{yB} dY_B/Y_B \end{aligned} \quad (A1)$$

$$dH_B/H_B = e_{hB} dP_{hB}/P_{hB}$$

where n_{xA} , n_{hA} , n_{xB} , n_{hB} , n_{yB} and e_{hB} are the elasticities defined in the text.

From equations (4) - (7), holding Y_A , P_Z and MM constant,

$$\begin{aligned} -dX_A/X_A &= H_A/X_A \cdot dH_A/H_A \\ dY_B/Y_B &= X_B/Y_B \cdot dX_B/X_B + H_B/Y_B \cdot dH_B/H_B \end{aligned} \quad (A2)$$

$$dY_B/Y_B = dH_A/H_A \quad dP_{hB}/P_{hB} = dP_{hA}/P_{hA}$$

Eliminating dH_A/H_A , dH_B/H_B , dY_B/Y_B and dP_{hB}/P_{hB} in (A1) and A2)

gives the following system of equations in matrix form:

$$\begin{bmatrix} 1 & 0 & -n_{hA} \\ n_{yB} X_A/H_A & 1 & -n_{hB} \\ \frac{X_A}{H_A} - \frac{Y_B}{H_B} & \frac{X_B}{H_B} & e_{hB} \end{bmatrix} \begin{bmatrix} dX_A/X_A \\ dX_B/X_B \\ dP_{hA}/P_{hA} \end{bmatrix} = \begin{bmatrix} n_{xA} d(R \cdot P_{xA}^*)/R \cdot P_{xA}^* \\ n_{xB} d(R \cdot P_{xB}^*)/R \cdot P_{xB}^* \\ 0 \end{bmatrix} \quad (A3)$$

Effects on X_A and X_B of a change in A's export price (in foreign currency):

Setting $d(R \cdot P_{xB}^*) = 0$ and $d(R \cdot P_{xA}^*) = R dP_{xA}^*$ in (A3), and using Cramer's rule, we have

$$\frac{dX_A/X_A}{dP_{xA}^*/P_{xA}^*} = \frac{n_{xA}}{K} (e_{hB} + n_{hB}) \quad (A4)$$

where K is the determinant of the coefficient matrix in (A3). The expression for K is given in equation (9a) in the text, which upon substitution in (A4) yields equation (8).

Solving for $\frac{dX_B/X_B}{dP_{xA}^*/P_{xA}^*}$ in (A3) by Cramer's rule gives equation (9) directly.

Effects on X_A and X_B of a change in B's export price (in foreign currency):

Set $d(R \cdot P_{xA}^*) = 0$ and $d(R \cdot P_{xB}^*) = R dP_{xB}^*$ in (A3). By applying Cramer's rule to solve for $\frac{dX_A/X_A}{dP_{xB}^*/P_{xB}^*}$ and $\frac{dX_B/X_B}{dP_{xB}^*/P_{xB}^*}$, equations (10) and (11) are obtained.

Effects on X_A and X_B of a change in the exchange rate:

Setting $d(R \cdot P_{xA}^*) = P_{xA}^* dR$ and $d(R \cdot P_{xB}^*) = P_{xB}^* dR$ in (A3) and using Cramer's rule, we have

$$\begin{aligned} \frac{dX_A/X_A}{dR/R} &= \frac{1}{K} [n_{xA} (e_{hB} + n_{hB} X_B/H_B) - n_{xB} n_{hA} X_B/H_B] \\ \frac{dX_B/X_B}{dR/R} &= \frac{1}{K} [-n_{xA} \frac{X_A}{H_A} (e_{hB} n_{yB} + n_{hB} Y_B/H_B) + n_{xB} (e_{hB} + n_{hA} \frac{X_A}{H_A} \cdot \frac{Y_B}{H_B})] \end{aligned} \quad (A5)$$

from which, assuming homogeneous export supply functions, equations (12) and (13) in the text are obtained.

APPENDIX 2: Sources of data

International Standard Industrial Classification (SIC) (1968)

Basic data used in constructing the time series for most of the variables appearing in the regression equations were obtained from the December 1974 issue of the Statistical Bulletin, a publication of the Central Bank of the Philippines. The personal consumption expenditures index (CE) was derived from the National Income Accounts of the National Economic and Development Authority. Baldwin's (1975, pp. 86-87) estimates of effective exchange rates for traditional exports (R) were extended to 1973 for the desired time series. Because Philippine recorded data on copra exports were rendered unreliable by significant overshipment (actual exports exceed the amount indicated on the shipping papers) during years of substantial overvaluation of the domestic currency and occasional under-shipment (notably in 1963 and 1964), partner country data on copra imports from the Philippines were used to represent QXA with adjustments for copra afloat (over year end), following Nyberg (1968, pp. 33-35). There are no significant discrepancies between recorded and actual coconut oil exports (which are shipped not by chartered vessels as for copra but by conference lines), and hence Central Bank published export data were used for QXB. Data for the domestic consumption variable QHB were obtained residually, subtracting coconut oil exports from domestic output.

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