THE APPLICATION OF A. MAIZELS' EX POST FORMULATION OF THE CHENERY-STROUT GROWTH MODEL TO PERU

by

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CHAPTER I

INTRODUCTION

Economic theory has produced many dynamic models of economic growth and development, some of which take into account the export-import sector and balance of payments problem so vital to underdeveloped countries. These models are either product-market oriented, money-market oriented, or some combination of both. Those that are product-market oriented generally take the import sector as exogenously determined or changing at some specific, usually constant, rate and then analyze the export sector with respect to it; suggesting that in accordance with the theory of comparative advantage, an underdeveloped country should expand its production of export good or goods in which it possesses a comparative advantage, as a means of improving its balance of payments position and moving towards sustained economic growth.

Some of these dynamic theoretical models have not been tested with actual data from underdeveloped nations, largely due to the problem of obtaining reliable data from these countries. Those that have been tested, have used, for the most part, data that ranged over only a short period of time, due to the problem stated above. Several of the more important contributions are summarized in the following section.

REVIEW OF LITERATURE

R. F. Emery tested the hypothesis that a rise in exports is the primary stimulant in economic growth rather than economic growth being the primary stimulant of a rise in exports.[1] He collected data on fifty countries for the period 1953-1963; and through the use of least square regression equations and multiple correlation analysis he found, with a high degree of statistical reliability, that for every 2½ percent rise in exports, gross national product rose by 1 percent. He concluded that high rates of economic growth are associated with high rates of export growth; and that countries that desire to increase their respective rates of growth of gross national product should adopt an economic policy that will stimulate export growth.

Perry A. Patrick, in a study of the first development program for economic expansion in Ireland (1959-1963), found that the rise of gross national product from 1 percent to 4 percent per year during this period was based on rising exports, primarily in the manufacturing industries.[2]

A. J. Robinson made a study of the Australian Economy during the period of 1860-1961.[3] In examining both the Australian agricultural and manufacturing sectors during this period, he concluded that the

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[1]R. F. Emery, "The Relation of Exports and Economic Growth," Kyklos, 1967, pp. 470-484.

[2]Perry A. Patrick, "Development Programs in Ireland," International Monetary Fund Staff Papers, Vol. XII, No. 1 (March, 1965), pp. 119-162.

[3]A. J. Robinson, "Exports and Economic Development," Quarterly Review of Economics and Business, Autumn, 1966, pp. 63-74.

principal stimulus to the growth of the Australian Economy was foreign demand for Australian exports.

C. W. Hultzman set out four narrowly defined types of models to attack the problem of defining the relationship of exports to economic growth: 1) Foreign trade multiplier and growth models, in which autonomous domestic investment is assumed to be the causal factor of economic growth; 2) Leading sector models, in which exports may, but need not be the catalyst for economic growth; 3) Development stage models, in which exports are either ignored or considered a possibility at the last stage of development; 4) Staple- and export-base models, in which economic growth is based on the activity of the export sector.[4] Through these models he pointed out that even though trade theory and export models suggest that there are benefits to be gained from foreign trade, under certain conditions, exports may do little to stimulate economic growth, even if these exports constitute a large share of the country's output. The nature of the commodity, the relationship of the export sector to the related domestic industries, or conditions in the non-export sector may be such that the economy remains static and traditional, even with expansion of the export sector.

E. J. Chambers and D. F. Gordon constructed a model of the Canadian economy (1900-1910) in which the increase in income was caused by the expansion of primary products.[5] Exports were measured by rents paid to

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[4] C. W. Hultzman, "Exports and Economic Growth: A Survey," Land Economics, May, 1967, pp. 148-157.

[5] E. J. Chambers and D. F. Gordon, "Primary Products and Economic Growth: An Empirical Measurement," Journal of Political Economy, August, 1966, pp. 315-332.

natural resources essential to the production of those exports. They suggested, from their study, that when successful exporting economies simultaneously experience a rise in per capita income, most of it may be due to other factors. They further suggested that it would be careless to expect any substantial rise in per capita income, for most underdeveloped economies, through even a large scale expansion of the exports of primary products.

N. H. Leff, in analyzing the downturn in the Brazilian economy in 1962, discussed the effects of import structure on economic development.[6] If the supply of necessary intermediate product imports is inelastic, the ability of domestic producers to meet additional demands for their output may be hindered. He attributed the downturn in the Brazilian economy to the operation of a Chenery-Strout type trade gap. He further stated that export promotion and import substitution are complementary, rather than alternative patterns of economic growth and recommended that for Brazil to resume sustained rapid growth, it is a necessary condition that she foster an income-elastic supply of imports through expansion of the export sector.

J. Ahmad investigated the influence of demand and trade factors on the growth of domestic output in India, during the period 1950-1966.[7] He used the growth of the Indian manufacturing industry as a

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[6]N. H. Leff, "Import Constraints and Development: Causes of the Recent Decline of Brazilian Economic Growth," Review of Economics and Statistics, November, 1967, pp. 494-501.

[7]J. Ahmad, "Import Substitution and Structural Change in the Indian Manufacturing Industry, 1950-1966," Journal of Development Studies, April, 1968, pp. 352-379.

basis for the above analysis, and by attempting to explain the sources of growth of industry, he attempted to explain the sources of growth of domestic output. He attributed the change in domestic output to three independent sources: 1) The change in domestic demand, assuming a constant proportion of the total supply is imported; 2) The change in foreign demand for exports; 3) The change in the import-total supply ratio, a measure of growth due to import substitution. The sources of the growth of output were estimated for manufacturing industries (thirty-three), consumer goods, and intermediate products and capital goods, given constant prices. He showed that the effect of import substitution on the growth of domestic output was significant only during the first five years of this period, and that the effect of exports, which was insignificant to begin with, exhibited a secular decline over the total fifteen years.

Nassau A. Adams compared cross-section and time series data on imports and their relation to economic growth.[8] In his cross section study of forty-eight countries, from 1955-1958, imports of intermediate products had a positive association with the degree of economic development. An increase in income generated an increase in the demand for goods, and imports of intermediate products were a significant factor in meeting this demand. The influence of imported capital goods was not as strong, but rather depended on the size of the country and whether or not it was in the early stages of development and relied

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[8] Nassau A. Adams, "Import Structure and Economic Growth: A Comparison of Cross-Section and Time Series Data," Economic Development and Cultural Change, January, 1967, pp. 143-162.

heavily on imported capital goods. His time series study, based on five countries, from the 1870's to 1930, found similar results for intermediate products, but some differences in trend for the capital goods sector.

Harry G. Johnson, in International Trade and Economic Growth, pointed out through a model of a constant price, two country, two good world (manufactured goods assumed to be luxury goods and foodstuffs necessary goods), that expansion of a country's economy can be "pro-trade biased", "neutral", or "anti-trade biased" with respect to consumption, depended on whether the output elasticity of demand for import goods is greater than, equal to, or less than unity.[9] This expansion with respect to production may fall in the same catagories, depending on whether the output elasticity of supply for imported goods is less than, equal to, or greater than unity.

Romulo A. Ferrero, in a study of Peru, discussed the factors which both helped and hindered the growth of the Peruvian gross national product.[10] Using data from 1950 to 1965, he found the hindrances to the growth of gross national product to be the high illiteracy rate, mountainous terrain, poor climate, scattered population, lack of expenditures for public works and agricultural development, and belief in "erroneous economic doctrines." The most

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[9]Harry G. Johnson, International Trade and Economic Growth, Harvard University Press, Cambridge, 1961, p. 65, 76-77.

[10]Romulo A. Ferrero, "Peru: Dilemma of Development," Reprinted in Readings in Economics, 2nd edition, Edited by Heinz Kohler, Holt, Rinehart, and Winston, Inc., New York, 1968, pp. 692-704.

important factor behind economic growth was exports. He stated that when exports had increased rapidly, gross national product had done the same. Further, when exports stagnated or diminished, the growth of gross national product stopped or even turned down.

R. J. Ball developed a theoretical economic growth model as an extension of the Harrod-Domar growth model,[11] adding an external debt-accelerator. The basic equations of his model are:[12]

1) $Y = C + I + X - M - rd$

2) $X - M = rd - \Delta D$

3) $C = (1 - s) Y \qquad 0 < s < 1$

4) $\Delta Y = \sigma I$

5) $\Delta D = \lambda \Delta Y \qquad \lambda > 0$

9) $\frac{\Delta Y}{Y} = \sigma s = \frac{\Delta D}{D}$

10) $M = mY \qquad m > 0$

11) $\frac{\Delta Y}{Y} = \frac{s\sigma}{1-\sigma m} - \frac{\Delta X}{Y} \cdot \frac{\sigma}{1-\sigma m}$

where Y is real national income; C is real consumption; I is net real investment; X is real exports; M is real imports; (X-M) is the balance of trade; D is outstanding real debt; r is the average yield on that debt; rd is income paid to foreigners; s is the average propensity to

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[11] R. F. Harrod, "An Essay in Dynamic Theory," Economic Journal March, 1939, pp. 14-33; and Towards a Dynamic Economics, N. Y., 1956. Evsey Domar, Essays in the Theory of Economic Growth, N. Y., 1957.

[12] R. J. Ball, "Capital Imports and Economic Development: Paradoxy or Orthodoxy?," Kyklos, Vol. XV, 1962, pp. 610-623.

save; σ is similar to the Domar output/capital coefficient; λ is the coefficient of the foreign investment accelerator; and m is the import coefficient. His purpose was to examine the effects of exports and of capital imports on an economy's rate of economic growth. He showed that capital imports result in an accelerated rate of economic growth; but that an incremental increase in exports might possibly lower this rate of growth, as shown by his equation 11 above. His reason for this latter possibility was that he viewed exports and domestic investment as competitors for available saving.

Brenton F. Massell took Ball to task for the assumptions and resulting conclusions of Ball's model.[13] He argued that Ball confused national income and domestic product (which differ by net factor payments abroad, a positive quantity in most underdeveloped countries, so that domestic product is usually greater than national income). Massell regarded output as related to a country's resource endowment and income as related to its expenditure pattern. With respect to Ball's growth-export equation 11, Massell argued that this equation cannot be derived from Ball's equation 2, 9, and 10. Equation 2 must be rewritten as $\Delta D = \Delta M - \Delta X$, stating that capital imports adjust not to current balance but to the change in the current balance. Thus, "to continue to attract foreign capital, a country would have to maintain an increasingly unfavorable balance on current account -- clearly an unrealistic assumption."[14] He added that Ball has been misled by his

[13]Brenton Massell, "Exports, Capital Imports, and Economic Growth," Kyklos, 1964, pp. 627-635.

[14]Ibid. p. 634.

own assumptions. "If capital imports are assumed to adjust to the deficit in the current balance, it naturally follows that a rise in exports will result in a decline in the income rate of growth."[15] This is not Ball's reason of exports and domestic investment being competitors for saving. Through Ball's equation 9, savings are invested regardless of the level of exports. In Ball's equation 2, exports do affect capital imports, the rate of investment, and the rate of growth; but equation 2 is inadmissible for determining the value of capital imports, for the growth rate is raised both by reducing (eliminating) exports and increasing the propensity to consume, regardless of whether imports are solely luxury goods or not. Except for their effects on capital imports, both exports and imports are essentially "outside the model," since they affect neither savings nor consumption. Therefore, Massell claimed that it is unrealistic to examine the effects of a change either in exports or imports on the rate of growth in Ball's model.

Hollis B. Chenery and Alan M. Strout constructed a growth and development model for fifty countries, using data for the period 1957-1962.[16] They distinguished three phases of economic development characterized by skill limitation, savings constraints, and trade constraints, and divided the countries into categories according to the

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[15]Ibid. p. 634

[16]Hollis B. Chenery and Alan M. Strout, "Foreign Assistance and Economic Development," American Economic Review, Vol. 56, September, 1966, pp. 678-733.

number of these constraints that the countries have or may overcome. Based on data of the above period, they aggregated the countries by world sector, and projected the parameters of each sector to the year 1975, also projecting high and low planned values and upper limit values for these projected parameters. In addition, they provided a thorough test for all phases for the country of Pakistan.

PURPOSE

A. Maizels reformulated the Chenery-Strout model (described above) and tested it for some 13 nations.[17] Although Chenery and Strout tested their model for the country of Peru using data for the period 1957-1962, Maizels did not.

It is the purpose of this thesis to apply Maizels' ex post model to Peru, using data for the period 1950-1967; to compare the parameters and values which Maizels' ex post model yields to those found by Chenery and Strout for Peru during 1957-1962; and to test the hypothesis that Maizels' ex post yields meaningful results for Peru, especially with respect to the role of the exporting sector and its effect upon the economic growth of the country, and hence could be used as a valuable tool for making policy decisions in that country.

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[17] A. Maizels, Exports and Economic Growth of Developing Countries, Cambridge University Press, London, 1968, Chapters 2-3, pp. 50-104.

CHAPTER II

MAIZELS' EX POST MODEL

Formulation

Maizels' *ex post* growth model is based on four accounting identities and five structural equations of the Chenery-Strout *ex ante* growth model.[18] The identities are:

$$Y + M \equiv C + I + X, \quad (1)$$

$$C + S \equiv Y, \quad (2)$$

$$I \equiv S + F, \quad (3)$$

$$X + F \equiv M, \quad (4)$$

where the symbols have the following meaning:

Y = gross national product,
C = consumption,
S = gross domestic savings,
I = gross domestic investment,
X = exports of goods and services,
F = balance of payments on current account.

All variables are measured in real terms. Three of these four identities are independent; the fourth is determinate given the other three. The government sector is not directly considered; nor is money given any role at all. This serious ommission will be discussed later.

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[18] Maizels, *op. cit.*, pp. 66-67.

The five structural equations require some explanation.[19] Gross national product (Y) in the target year of the plan (t) is equal to Y in the starting year of the plan (year zero), multiplied by the compound rate of growth of Y, $(1+r^*)^t$,

$$Y_t^* = Y_0(1+r^*)^t. \tag{5}$$

Planned gross investment in the target year is equal to the incremental capital-output ratio (σ) multiplied by the product of the target rate of growth of Y and planned Y in the target year of the plan,

$$I_t^* = \sigma r^* Y_t^* . \tag{6}$$

Exports in the target year are equal to exports in the starting year multiplied by the compound rate of growth of exports $(1+\epsilon)^t$, where (ϵ) is assumed to be exogenously determined by the development of the world market,

$$X_t = X_0(1+\epsilon)^t. \tag{7}$$

Gross domestic savings in the target year are a linear function of gross national product in the target year and are equal to a constant, plus the ex ante marginal propensity to save (s_1^*) multiplied by Y in the target year,

$$S_t^* = s_0 + s_1^* Y_t^* . \tag{8}$$

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[19] The asterisks in these equations distinguish target or planned values of parameters and variables from ex post values.

Imports in the target year are, again, a linear function of Y_t^* and are equal to a constant plus the *ex ante* marginal propensity to import multiplied by Y in the target year,

$$M_t^* = m_0 + m_1^* Y_t^* . \qquad (9)$$

Maizels describes M_t^* as the "*minimum* level of imports necessary to sustain the planned level of real national product."[20] He then regards (m_1^*) as the "marginal 'necessity' to import".[21]

These five structural equations are applicable to the model in basically two phases of growth--savings constrained growth (investment is limited by the supply of domestic savings and net foreign capital available for borrowing) and trade-constrained growth (imports are limited by export revenue and net foreign capital available for borrowing), though only four of these equations are operative in any one given growth phase. These two growth phases are characterized by the *ex ante* savings gap (I^*-S^*) and the *ex ante* trade gap (M^*-X), respectively. These gaps are necessarily equal in the *ex post* situation (identities 3 and 4, page 11), but in the *ex ante* situation, one gap is normally expected to exceed the other. If the savings gap is the larger, the model is considered to be in a savings-constrained growth phase, and equation (8) is operative while equation (9) is not; if the trade gap is the larger, the model is considered to be in a trade-constrained growth phase, and equation (9) is operative while equation

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[20] Maizels, *op. cit.*, p. 67.

[21] *Ibid.*, p. 67.

(8) is not.

Chenery and Strout also distinguish a third phase of growth in which an upper limit to the target rate of growth becomes effective because of a limit on the available supply of skill.[22] In this phase, two sub-phases are distinguished according to the larger of the two ex ante gaps. Maizels, however, does not apply this phase of the model statistically because he feels that there is ambiguity in what is meant by "skill" limitation. He further feels that for the thirteen Sterling countries he investigated, savings or trade constraints would limit growth before the skill limit would become operative and place a ceiling on the possible rate of growth. The same assumption will be made for Peru.

Maizels proceeds to define gross national product as:[23]

$$Y = Q - iD, \tag{10}$$

where:

Q = gross domestic product
D = net total of foreign debt
i = the mean rate of interest or divident payable on this debt.

Investment can now be rewritten in terms of gross domestic product, (Q) as:

$$I_t = \sigma \bar{r}^* Q_t^*, \tag{6a}$$

where $\bar{r}^*$ is the planned growth rate of Q.

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[22] Ibid., p. 67.

[23] Ibid., p. 69.

Imports and exports are now redefined to exclude net factor payments abroad so that

$$X_t' = X_0'(1+\epsilon)^t, \text{ and} \quad (7a)$$

$$M_t' = m_0' + m_1'Y_t^*. \quad (9a)$$

We can now proceed to derive Maizels' ex post model based on the above information, keeping in mind that parameters and variables without the asterisk refer to ex post values.

This model assumes the following:

1) Fixed capital investment is the dynamic element in economic growth.

2) In primary exporting countries, the level of investment is largely determined by the capacity to import.

3) Imports of capital goods are assumed to depend on the capacity to import.

4) The level of investment in fixed capital is dependent on the volume of capital goods imported.

5) Exports and net capital inflow are exogenously determined and together determine the level of imports.

6) Investment and gross domestic product are related via an incremental capital-output ratio, and gross domestic product can be regarded as the dependent variable.

7) Domestic savings is a function of income generated in the export sector and income generated by the non-export sector; and both sectors make contributions to domestic savings which differ in magnitude.

8) The economy has been and will remain in a phase of trade constrained growth.

9) That simple growth rate formulas are good approximations for compound growth rate formulas; that is, formulas of the form $(1+rt)$ are used by Maizels instead of $(1+r)^t$ in order for him to simplify the algebra of his model.

Using the relation of gross domestic product, gross domestic investment, the incremental capital-output ratio and the growth rate of gross domestic product (equation 6a and assumption 6), Q in year "t" is equal to the incremental capital-output ratio multiplied by the growth rate of Q and divided into domestic investment,[24]

$$Q_t = I_t / \sigma r \qquad (11)$$

From the fact that exports and net capital inflow are assumed to determine the level of imports (identity 4 and assumption 5), imports in year "t" are equal to the sum of exports and net capital inflow in year "t",[25]

$$M_t = X_t + F_t, \qquad (12)$$

where this sum is called the capacity to import, and net factor payments and receipts are included in import and export totals respectively. Changes in the terms of trade are not taken into account here.

Since imports of capital goods are assumed to depend on the capacity to import (assumption 3) and by use of equation (12) above (assuming a one year lag), imports of capital goods in year (t) are a

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[24]The equations of the <u>ex post</u> model are set out in Maizels, <u>op. cit</u>., pp. 71-72.

[25]It is extremely important here to note Maizels' definition of net capital inflow as can be seen in equation (25) on the following page: $F_t = M_t - X_t$. That is, a positive inflow implies that $M > X$, usually defined as an outflow. However, I shall keep his terminology to be consistent with his model.

linear function of the capacity to import in the previous year,[26]

$$M_t^I = a_1 + b_1(X_{t-1}+F_{t-1}). \tag{13}$$

Imports of consumer goods are determined as a residual,[27]

$$M_t^C = M_t - M_t^I , \tag{14}$$

which can also be written as

$$M_t^C = (X_t+F_t) - b_1(X_{t-1}+F_{t-1}) - a_1, \tag{15}$$

by substituting the right-hand sides of equations (12) and (13) above for M_t and M_t^I respectively.

Domestic investment in fixed capital in year "t" is some linear function of the volume of imports of capital goods in year "t" (from assumption 4)

$$I_t = a_2 + b_2M_t^I. \tag{16}$$

Substituting the right hand side of equation (13) for capital imports,

$$I_t = a_2 + b_2(a_1+b_1(X_{t-1}+F_{t-1}))$$

$$I_t = (a_2+a_1b_2) + b_1b_2(X_{t-1}+F_{t-1}) \tag{17}$$

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[26] Here imports of capital goods include intermediate products for the capital goods industry.

[27] Here, imports of consumer goods include intermediate products for the consumer goods industries.

We now substitute this value for domestic investment into equation (11) to yield:

$$Q_t = I_t/\sigma r \tag{11}$$

$$Q_t = \frac{1}{\sigma r} \cdot \left[(a_2+a_1b_2) + b_1b_2(X_{t-1}+F_{t-1})\right] \tag{18}$$

We now proceed to derive the relationship between the growth rate of gross domestic product (r) and that of exports ( ). We rewrite equation (5):

$$Y_t^* = Y_0(1+r)^t, \text{ as} \tag{5}$$

$$Q_t = Q_0(1+r)^t, \tag{5a}$$

and using the simple growth rate formulation (assumption 9), rewrite equation (5a) as

$$Q_t = Q_0(1+rt), \tag{5a'}$$

and equation (7)

$$X_t = X_0(1+\epsilon)^t \tag{7}$$

as,

$$X_t = X_0(1+\epsilon t). \tag{7'}$$

We substitute these values of X_t and Q_t into equation (18)

$$Q_t = \frac{1}{\sigma r} \cdot \left[(a_2+a_1b_2) + b_1b_2(X_{t-1}+F_{t-1})\right] \tag{18}$$

yielding,

$$Q_0(1+rt) = \frac{1}{\sigma r} \cdot \left[(a_2+a_1b_2) + b_1b_2(F_{t-1}+X_0(1+ \epsilon(t-1)) \right] \qquad (18.1)$$

Dividing both sides of this equation by Q_0 and multiplying both sides by r,

$$r(1+rt) = \frac{1}{\sigma Q_0} \cdot \left[(a_2+a_1b_2) + b_1b_2(F_{t-1}+X_0(1+ \epsilon(t-1)) \right], \qquad (18.2)$$

and by rearranging the terms on the right hand side,

$$r(1+rt) = \frac{1}{\sigma Q_0} \cdot \left[(a_2+a_1b_2) + b_1b_2(F_{t-1}+b_1b_2X_0(1+ \epsilon (t-1)) \right],$$

$$= \frac{1}{\sigma Q_0} \cdot \left[(a_2+a_1b_2) + b_1b_2F_{t-1}+b_1b_2X_0+b_1b_2X_0\ \epsilon(t-1) \right],$$

$$= \frac{1}{\sigma Q_0} \cdot \left[(b_1b_2(t-1)X_0)\epsilon + (a_2+a_1b_2+b_1b_2(X_0+F_{t-1})) \right],$$

$$r(t+rt) = \left[\frac{b_1b_2(t-1)}{\sigma} \cdot \frac{X_0}{Q_0} \right] \epsilon + \left[\frac{a_2+a_1b_2+b_1b_2(X_0+F_{t-1})}{\sigma\ Q_0} \right], \qquad (19)$$

which is Maizels' equation (2.28) for the relationship of the growth rate of GDP to that of the growth rate of exports.[28]

Ex post savings is found by using identity (3) and rewriting equation (11),

$$I = S + F; \qquad S_t = I_t - F_t \qquad (3')$$

$$Q_t = I_t/\sigma r; \qquad I_t = Q_t \sigma r. \qquad (11')$$

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[28] Maizels, *op. cit.*, p. 71.

We now substitute the right hand side of equation (11') for domestic investment into equation (3') yielding,

$$S_t = Q_t \sigma r - F_t \,. \tag{3.11}$$

Substituting the right hand side of equation (5a')

$$Q_t = Q_0(1+rt) \tag{5a'}$$

for Q_t into equation (3.11),

$$S_t = Q_0(1+rt)\sigma r - F_t$$

$$= Q_0 \sigma r + Q_0 rt\sigma r - F_t$$

$$S_t = (\sigma t Q_0)r^2 + (\sigma Q_0)r - F_t \tag{20}$$

If the hypothesized relationship between savings, income generated in the export sector, and income generated in the non-export sector is assumed to hold for the future, <u>ex ante</u> savings in year "t" is expressed as,

$$S_t^* = s_0^* + s_1^*(Q_t - X_t) + s_2^* X_t \,,$$

or,

$$S_t^* = s_0^* + s_1^* Q_t + (s_2^* - s_1^*) X_t \,, \tag{21}$$

which is a modified form of the previously shown <u>ex ante</u> savings equation (8). Here, s_1^* represents the <u>ex ante</u> marginal propensity to save for income arising out of the non-export sector, while s_2^* represents the <u>ex ante</u> marginal propensity to save out of income arising from the export sector.

Maizels also wrote this ex ante savings expression so as to vary with net capital inflow (F_t). The procedure for the derivation for this expression is as follows:

We begin with equation (11'),

$$I_t = Q_t \sigma r; \tag{11'}$$

using equation (5a')

$$Q_t = Q_0(1+rt) \tag{5a'}$$

we substitute this value for Q_t into equation (11'),

$$I_t = Q_0 \sigma (1+rt)r, \tag{22}$$

and multiplying the right hand side and rearranging terms,

$$I_t = Q_0 \sigma t)r^2 + (Q_0 \sigma)r. \tag{23}$$

We next take equation (17)

$$I_t = (a_2+a_1b_2) + b_1b_2(X_{t-1}+F_{t-1}), \tag{17}$$

and solve it for X_{t-1} ,

$$\frac{I_t - (a_2+a_1b_2)}{b_1b_2} = X_{t-1}+F_{t-1} ,$$

$$X_{t-1} = \frac{I_t - (a_2+a_1b_2)}{b_1b_2} - F_{t-1} \tag{24}$$

We substitute the right hand side of equation (23) into (24) for I_t, so that

$$X_{t-1} = \frac{(Q_0\sigma t)r^2 + (Q_0\sigma)r - (a_2+a_1b_2)}{b_1b_2} - F_{t-1} \tag{25}$$

which can be rewritten as,

$$X_t = \frac{(Q_0\sigma(t+1))r^2 + (Q_0\sigma)r - (a_2+a_1b_2)}{b_1b_2} - F_t \tag{25a}$$

We now substitute the right-hand side of equation (25a) for X_t into equation (21):

$$S_t^* = s_0^* + s_1^*Q_t + (s_2^*-s_1^*)X_t \tag{21}$$

$$S_t^* = s_0^*+s_1^*Q_t+(s_2^*-s_1^*) \cdot \left[\frac{(Q_0\sigma(t+1))r^2 + (Q_0\sigma)r - (a_2+a_1b_2)}{b_1b_2} - F_t\right]$$

Using the simple growth rate formula for expressing the value of Q_t (equation 5a'),

$$S_t^* = s_0^*+s_1^*Q_0(1+rt)+(s_2^*-s_1^*) \cdot \left[\frac{(Q_0\sigma(t+1))r^2+(Q_0\sigma)r-(a_2+a_1b_2)}{b_1b_2} - F_t\right]$$

Rearranging terms,[29]

$$S_t^* = \left[Q_0(s_2^*-s_1^*)\,\frac{\sigma(t-1)}{b_1b_2}\right]r^2 + \left[Q_0\left[s_1^*t+(s_2^*-s_1^*)\,\frac{\sigma t}{b_1b_2}\right]\right]r - \left[(s_2^*-s_1^*)\left[F_t+\frac{a_2+a_1b_2}{b_1b_2}\right] - (s_1^*Q_0+s_0^*)\right] \qquad (26)$$

Through equation (26) we can see that savings will increase at an increasing rate as r increases; however, whether or not ex ante savings (S_t^*) will rise faster than future ex post savings (S_t), given that past relationships between savings, and income from the export and non-export sector holds for the future, depends primarily on whether $(s_2^*-s_1^*)$ is greater than (b_1b_2). If it is not, the coefficients of corresponding terms of S_t^* would be lower than those of S_t, and hence S_t^* would rise at a slower rate. In this case, the required level of savings (S_t) would exceed the forthcoming future savings, and the model would enter the savings-constrained phase of the Chenery-Strout ex ante model. If the reverse position is true and S_t^* exceeds S_t, there would be some frustrated savings.[30]

Maizels' ex post model also presents an equation to show the required net capital inflow necessary to sustain a given target rate

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[29] Equation (26) should be Maizels' equation (2.30), op. cit., p. 72; however, the first term of Maizels' equation contains (t) rather than (t+1). Since I_t is a function of $X_{t-1}+F_{t-1}$, this author feels that Maizels is in error, and the above equation (26) is correct.

[30] Maizels, op. cit., p. 72.

of growth of GDP ($\bar{r}^*$). It may be derived as follows:[31]

We begin with equation (18'),

$$Q_t = \frac{1}{\sigma \bar{r}^*} \left[(a_2+a_1 b_2) + b_1 b_2 (X_{t-1}+F_{t-1}) \right] \qquad (18')$$

or,

$$Q_{t+1} = \frac{1}{\sigma \bar{r}^*} \left[(a_2+a_1 b_2) + b_1 b_2 (X_t+F_t) \right]$$

Using the simple growth rate formula for Q_t,

$$Q_0(1+\bar{r}^*(t+1)) = \frac{1}{\sigma \bar{r}^*} \left[(a_2+a_1 b_2) + b_1 b_2 (X_t+F_t) \right]$$

Multiplying both sides of this equation by $\sigma \bar{r}^*$ and transposing one term to the left hand side,

$$\sigma Q_0(1+\bar{r}^*(t+1))\bar{r}^* - (a_2+a_1 b_2) = b_1 b_2 (X_t+F_t)$$

Regrouping terms on the left hand side only,

$$\begin{aligned} \sigma Q_0(1+\bar{r}^*(t+1))\bar{r}^* &= Q_0\sigma\bar{r}^* + Q_0\sigma\bar{r}^*\bar{r}^* t + Q_0\bar{r}^*\sigma\bar{r}^*, \\ &= \bar{r}^{*2}(Q_0\sigma t + Q_0\sigma) + Q_0\sigma\bar{r}^*, \\ &= \bar{r}^{*2} Q_0\sigma(t+1) + Q_0\sigma\bar{r}^*, \end{aligned}$$

so that

$$\bar{r}^{*2} Q_0 \sigma (t+1) + Q_0\sigma\bar{r}^* - (a_2+a_1 b_2) = b_1 b_2 (X_t+F_t)$$

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[31] See footnote 1, *ibid.*, p. 72.

Dividing both sides of this equation by b_1b_2 and transposing X_t,

$$F_t = \left[\frac{\bar{r}^{*2}Q_0\ (t+1) + Q_0\ \bar{r}^{*} - (a_2+a_1b_2)}{b_1b_2}\right] - X_t$$

or,

$$F_t = \left[\frac{Q_0\,\sigma(t+1)}{b_1b_2}\right]\bar{r}^{*2} + \left[\frac{\sigma Q_0}{b_1b_2}\right]\bar{r}^{*} - \left[X_t + \frac{a_2+a_1b_2}{b_1b_2}\right] \qquad (27)$$

In addition, Maizels set out an equation for the calculation of (σ), the incremental capital-output ratio. Gross domestic product in year (t) is equal to a constant plus the inverse of the incremental capital output ratio multiplied by sum of domestic investment (lagged by one year). The sum of domestic investment to the year (t-1) is taken as available capital in year (t).[32]

$$Q_t = A + \frac{1}{\sigma}\cdot\sum_{0}^{t-1} I_t \qquad (28)$$

[32]Maizels, op. cit., footnote 1, p. 79. He treats I_t as gross domestic fixed capital formation. The incremental capital-output ratio, then, is a gross figure.

Methodology and Testing

In the preceeding section Maizels' ex post growth model was set out. I will repeat the equations of his model here for convenience.

$$Q_t = I_t/\sigma r \quad ; \qquad Q_t = A + \frac{1}{\sigma} \sum_{0}^{t-1} I_t \tag{11, 28}$$

$$M_t = X_t + F_t \tag{12}$$

$$M_t^I = a_1 + b_1(X_{t-1} + F_{t-1}) \tag{13}$$

$$M_t^C = (X_t + F_t) - b_1(X_{t-1} + F_{t-1}) - a_1 \tag{15}$$

$$I_t = a_2 + b_2 M_t^I \tag{16}$$

$$Q_t = \frac{1}{\sigma r}(a_2 + a_1 b_2) + b_1 b_2 (X_{t-1} + F_{t-1}) \tag{18}$$

$$r(1+rt) = \left[\frac{b_1 b_2 (t-1)}{} \frac{X_0}{Q_0}\right] \cdot \epsilon + \left[\frac{a_2 + a_1 b_2 + b_1 b_2 (X_0 + F_{t-1})}{Q_0}\right] \tag{19}$$

$$S_t = (\sigma\, tQ_0) r^2 + (\sigma Q_0) r - F_t \tag{20}$$

$$S_t^* = s_0^* + s_1^* Q_t + (s_2^* - s_1^*) X_t \tag{21}$$

$$S_t^* = \left[Q_0 (s_2^* - s_1^*) \frac{\sigma t}{b_1 b_2}\right] r^2 + \left[Q_0 \left[s_1^* t + (s_2^* - s_1^*) \frac{\sigma}{b_1 b_2}\right]\right] r - \left[(s_2^* - s_1^*)\left[F_t + \frac{a_2 + a_1 b_2}{b_1 b_2}\right] - (s_1^* Q_0 + s_0^*)\right] \tag{26}$$

$$F_t = \left[\frac{\sigma Q_0 (t+1)}{b_1 b_2}\right] \bar{r}^{*2} + \left[\frac{\sigma Q_0}{b_1 b_2}\right] \bar{r}^{*} - \left[\frac{X + a_2 + a_1 b_2}{b_1 b_2}\right] \tag{27}$$

$$M_t^* = m_0^* + m_1^* Q_t \tag{9'}$$

The symbols have the following meaning:

Q_t = gross domestic product in year (t)

I_t = domestic investment (fixed capital) in year (t)

M_t = <u>ex post</u> imports in year (t)

M_t^* = <u>ex ante</u> imports in year (t)

M_t^I = imports of capital goods in year (t) (including intermediate products for the capital goods industries)

M_t^c = imports of consumer goods in year (t) (including intermediate products for the consumer goods industries)

X_t = exports in year (t)

F_t = net capital inflow in year (t)

$(X_{t-1}+F_{t-1})$ = capacity to import

S_t = <u>ex post</u> savings in year (t)

S_t^* = <u>ex ante</u> savings in year (t), assuming the past observed relationships between savings, income from the export sector, and income from the non export sector hold for the future

σ = incremental capital-output ratio

ϵ = rate of growth of exports

r = rate of growth of GDP

$\bar{r}^*$ = target rate of growth of GDP

A = a constant

a_1 = a constant

a_2 = a constant

s_0^* = a constant

m_0^* = a constant

b_1 = marginal propensity to import capital goods out of the capacity to import

b_2 = the investment multiplier of imported capital goods.

s_1^* = <u>ex ante</u> marginal propensity to save out of income generated in the non-export sector.

s_2^* = <u>ex ante</u> marginal propensity to save out of income

m_1^* = <u>ex ante</u> marginal propensity to import out of gross domestic product.

The test of this model consisted of computing the parameters and variables specified by it for Peru, for the period 1950 to 1967, and making projections of certain variables (where required) to the year 1980. The procedure was to treat gross domestic product (Q_t), net capital inflow (F_t), capital imports (M_t^I), fixed capital investment (Maizels used this as gross domestic investment) (I_t), and total imports (used in order to project future imports) (M_t) as exogenous variables.[33] All data used were in millions of constant soles, 1963 prices (43.50 soles = $1.00 U. S.).

Maizels, in defining his model in terms of gross domestic product (from the gross national product version of Chenery-Strout) stated that imports and exports had to be redefined so as to exclude net factor payments abroad;[34] however, as he developed his <u>ex post</u>

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[33]Data used for variables (Q_t, X_t, M_t), F_t, and S_t' (actual savings) came from Peru, Instituto Nacional de Planification, <u>Indice Anexo Estadistico</u>, Oct. 9, 1968, Cap. 1-1A, Cap. 1-2A, and Cap. 3-1A, respectively. Data for variables M_t^I, and I_t came from Manuel Romero Caro, <u>El Sector y su Incidencia en la Economia Peruana Durante el Periodo 1950-1967</u>, 1969, Cuadro No. 3-a. This data, however, was originally taken from the same Peruvian Government source.

[34]Maizels, <u>op. cit.</u>, p. 70.

model, he included net factor payments and receipts in import and export totals, while continuing to base his model on gross domestic product.[35] This author feels that this is inconsistent and that due to his original gross domestic product definition of imports and exports, net factor payments should be excluded. Therefore, in the test of Maizels' ex post model, net factor payments were excluded from import and export totals.

In addition, for the test of this model, imports of capital goods were redefined to include only imports of capital goods; imports of consumer goods were redefined to include imports of consumer durables and non-durables, combustibles, primary materials, and intermediate products.[36] In this manner, imports of capital goods plus imports of consumer goods equal total imports.

In order to calculate the necessary parameters, the least squares regression technique was employed. For the determination of the past relationship between imports and GDP (so that future imports could be projected), equation (9) was modified to regress actual ex post imports against actual ex post GDP. In addition, actual savings (S'_t) were regressed against income generated in the export and non-export sectors to determine the ex post relationship of these three variables (equation 21). On the following page is presented a summary of

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[35] Ibid., p. 71.

[36] Data for variable M^c_t (imports of consumer goods) came from, Instituto Nacional de Planification, Indice Anexo Estadistico, November 13, 1968, Cuadro No. 16.

the equations used to determine the necessary parameters by the least square regression technique and the results of the regressions performed.

Equations used to Determine Parameters
and Subsequent Regression Results

$$Q_t = A + \frac{1}{\sigma} \sum_{0}^{t-1} I_t \qquad R^2 \qquad (28)$$

$$\underset{(2040.65)}{Q_t = 43174.30} + \underset{(0.0072)}{0.271} \sum_{0}^{t-1} I_t \qquad .9896^{a} \qquad (28)$$

$$M_t^I = a_1 + b_1(X_{t-1} + F_{t-1}) \qquad R^2 \qquad (13)$$

$$M_t^I = 788.58 + \underset{(0.038)}{0.34}(X_{t-1} + F_{t-1}) \qquad .9178^{b}$$

(815.05)

$$I_t = a_2 + b_2 M_t^I \qquad R^2 \qquad (16)$$

$$I_t = 1888.46 + \underset{(0.16)}{2.38} M_t^I \qquad .9300^{c}$$

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[a] The parameter $\frac{1}{\sigma}$ was significant at the .00025 level. The F-test showed significance to the .01 level. (σ) was found to have a value of 3.68.

[b] Parameter b_1 was significant at the .00025 level. The F-test showed significance to the .01 level.

[c] Parameter b_2 was significant at the .002 level. The F-test showed significance to the .01 level.

(1373.17)

$$M_t = m_0 + m_1 Q_t \qquad R^2 \qquad (9')$$

$$M_t = -6458.14 + \underset{(0.0199)}{0.297} Q_t \qquad .9660^d$$

(1638.60)

$$Q_t = \frac{a_2+a_1b_2}{\sigma r} + \frac{b_1b_2}{\sigma r}(X_{t-1}+F_{t-1}) \qquad R^2 \qquad (18')$$

$$Q_t = 2461.43 + \underset{(0.31)}{3.45}(X_{t-1}+F_{t-1}) \qquad .8918^e$$

(6593.66)

$$r(1+rt)\,Q_0 = \text{const.} + \epsilon(V_1) + b_1b_2F_{t-1} \qquad R^2 \qquad (19')$$

$$r(1+rt)\,Q_0 = 11017.13 + \underset{(0.00023)}{0.143}(V_1) + \underset{(0.002)}{(0.00)}F_{t-1} \qquad .9999^f$$

(21.54)

$$S'_t = s_0 + s_1Q_t + (s_2-s_1)X_t \qquad R^2 \qquad (12')$$

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[d] Parameter m_1 was significant at the .00025 level. The F-test showed significance at the .01 level.

[e] The coefficient of the capacity to import was significant at the .00025 level. The F-test showed significance to the .01 level.

[f] In the above equation, (const.) is equal to $(a_2+a_1b_2+b_1b_2X_0)$; (V_1) is equal to $(b_1b_2(t-1)X_0)$. The value of was found significant at the .00025 level. The coefficient of F_{t-1} was not significant. The F-test yielded significance at the .01 level.

$$S'_t = 979.80 + 0.102\,Q_t + 0.528\,X_t \qquad .9209^{g}$$
$$\qquad (0.058) \qquad (0.237)$$
$$(1419.48)$$

From equation (18') above, the coefficient of the capacity to import was solved for the growth rate of Q (r). It was found to be 0.063. The constant term was not used to solved for (r) as it was not judged as statistically significant. Equations (18') and (19') contain the same parameters as equations (18) and (19) respectively. The terms of these equations were only rearranged to permit the use of the least squares regression technique to determine (r) and (ϵ).

Once the values of these parameters were determined, they were substituted into relevant equations to determine the values of necessary variables in this model. Equation (18'') was used to calculate yearly values of (r) and these yearly values were substituted into equation (19''), though these yearly values were not called for in Maizels' ex post model per se. Equations (5a') and (7') were used to project gross domestic product and exports, treating 1967 as the base year. These values were used to project (S_t), ex post savings, (S^*_t), ex ante savings, and (F'_t), the required net capital inflow necessary to sustain the rate of growth of gross domestic product of 6.38 percent per year (assuming that the rate of growth of gross domestic product for the 1950-1967 period, 6.38 percent, continues in

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[g] The parameter s_1 was significant at the .025 level; (s_2-s_1), at the .013 level. The F-test showed significance at the .01 level.

the future). The projections were made for the period 1968-1980. In addition, projected (Q_t) was used with equation (9) to project imports; these values were used in conjunction with projected exports (X_t) to determine forthcoming net capital inflow (equation 12). Below is presented the number of the table at the end of Chapter III in which the equations used to determine the values of the necessary variables and the values themselves are presented.

Equations used to Determine Variables

Table	Equation	
I	$M_t^c = (X_t+F_t) - b_1(X_{t-1}+F_{t-1}) - a_1$	(15)
II	$r_t = \frac{1}{\sigma Q_t}\left[(a_2+a_1b_2) + b_1b_2(X_{t-1}+F_{t-1})\right]$	(18'')
II	$\epsilon_t = \frac{1}{b_1b_2(t-1)X_0}\left[Q_0\sigma r_t(1+r_tt)-(a_2+a_1b_2(X_0F_{t-1}))\right]$	(19'')
III	$S_t = (\sigma tQ_0)r^2 + (\sigma Q_0)r - F_t$	(20)
V	$S_t^* = s_0^* + s_1^*Q_t + (s_2^*-s_1^*)X_t$	(21)
IV	$X_t = X_{1967}(1+\epsilon t)$	(7')
IV	$Q_t = Q_{1967}(1+rt)$	(5a')
IV	$M_t = m_0 + m_1Q_t$	(9)
VI	$F_t = M_t - X_t$	(12)
VI	$F_t' = \left[\frac{\sigma Q_{1967}(t+1)}{b_1b_2}\right]\bar{r}^{*2} + \left[\frac{\sigma Q_{1967}}{b_1b_2}\right]\bar{r}^{*2} - \left[X_t + \frac{a_2+a_1b_2}{b_1b_2}\right]$	(27)

In addition, actual savings and calculated <u>ex post</u> savings were compared (Table III); projected ex post and ex ante savings were compared (Table V); and projected forthcoming and required net capital inflow were compared (Table VI).

Chapter III

RESULTS AND CONCLUSIONS

Maizels' ex post model included three parameters that were calculated by Chenery-Strout for Peru for the period 1957-1962. The values of these parameters are:

Parameter	Value (Maizels' Model) 1951-1967	Value[37] (Chenery-Strout) 1957-1962
Gross Incremental Output-Capital Ratio (σ)	3.68	3.10
Growth Rate of Exports (ϵ)	14.3%	14.3%
Growth Rate of GDP (r);	6.38%	not calculated
GNP (r)	not calculated	7.3%

Although the two rates of growth of exports compare favorably, the two incremental output-capital ratios and rates of growth of GDP and GNP do not. Some of the differences may be due to my use of better data over a longer period of time. Also, one must remember equation (10): the fact that GDP is equal to GNP plus the cost of net total foreign debt. If net total foreign debt was increasing at an increasing rate over this period, GDP would grow at a slower rate than

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[37] Chenery-Strout, op. cit., p. 706.

GNP.

Maizels hypothesized that capital imports were determined by the capacity to import--the sum of net capital inflow and exports in the previous period. This capacity to import, by equation (12), is nothing more than total imports in the previous period. What Maizels has actually done, then, is to hypothesize that capital imports are determined by total imports in the previous period. This hypothesis tended to be supported by empirical testing, as the least squares regression performed showed that imports in the previous period explained 91 percent of the variation of capital imports in the following period (F-test significant at the 99 percent confidence level). The marginal propensity to import out of the previous year's imports was highly significant and found to be .34.

The incremental output-capital ratio was found by regressing fixed capital investment (lagged one year) against gross domestic product. It was found that fixed capital investment explained 98 percent of the variation of gross domestic product in the following period. The incremental output-capital ratio, found to be 3.68 was highly significant.

Imports of consumer goods were taken as the difference of total imports and capital imports. These calculated values of imports of consumer goods compared somewhat favorably with the actual values (Table I).

Maizels' assumption that domestic investment is determined by the volume of imports of capital goods held up well under testing. It was found that capital imports explained 93 percent of the variation in gross domestic investment (fixed capital investment, F-test significant at the 99 percent confidence level). The investment multiplier of imported capital goods was found to be 2.38.

Maizels' assumption that domestic investment and GDP are related via the incremental output-capital ratio proved relatively strong. When domestic investment was solved for internally in the model (in terms of the capacity to import) and regressed against GDP, it was found that it explained 89 percent of the variation in GDP (F-test significant at the 99 percent confidence level). From the coefficient of the capacity to import, the rate of growth of GDP was found to be 6.38 percent.

The equation used to determine the rate of growth of exports made the rate of growth of GDP a function of time and net capital inflow. This regression yielded an extremely high R^2 (.9999, F-test significant at the 99 percent confidence level), but this is what one would expect, since time series data were used in the regression analysis. The rate of growth of exports was found to be 14.3 percent. It is worth noting that the coefficient of net capital inflow was not significant and its value (0.00) was not equal to the product of b_1 and b_2 (determined in previous regressions) as it should have been.

The models' determination of <u>ex post</u> savings yielded interesting results when compared to actual savings for the period 1950-1967. Maizels' <u>ex post</u> savings equation assumes that savings adjust to the difference of investment and net capital inflow (assuming that GDP grows at a fixed rate for the period). We can then view the computed <u>ex post</u> savings as the necessary savings to meet investment demand. We then can treat actual observed savings for the period as the amount of savings that were forthcoming. If we look at Table III in this light, we find Peru in a savings constrained phase of growth for the years 1950, 1954, 1955, and 1958 through 1962. We find frustrated savings for the years 1951 through 1953 (the Korean War period, when Peru exported large amounts of copper and cotton), 1956, 1957, and 1963 through 1967. Frustrated savings in this latter period are continually increasing, implying that either Peruvian investment has fallen, or much of Peruvian savings have been held out of the system or have been invested abroad. However, one must remember that GDP is assumed to be growing at 6.38 percent for this period, a rather strong assumption, if one looks at the yearly growth rates of GDP in Table II. Using yearly growth rates of GDP would change the value of computed ex post savings, but Maizels' model is based on overall growth rates, instead of yearly rates.

The regression of actual savings as a function of income derived from the export and non export sector produced an R^2 of .9209 (F-test significant at the 99 percent confidence level). The marginal propensities to save out of each sector were found to be .629 and .102 respectively and seem to be reasonable if one considers the export sector the dynamic sector of the Peruvian economy.

The projection of ex post (required) savings and ex ante (forthcoming) savings (Table V) shows that forthcoming savings continually exceeds required savings, although the gap continually lessens. This is a continuation of the relationship that was found in looking at ex post and actual savings for the 1950-1967 period, in that frustrated savings are apparent in the Peruvian economy, if it is assumed to grow at 6.38 percent. In order to alleviate the frustrated savings, it appears that Peru should either foster increased domestic investment or reduce imports in order to increase required savings to meet the forthcoming savings.

In an examination of the projected net capital inflow (based on the projected difference of imports and exports, equation 12) and required net capital inflow necessary to sustain a rate of growth of gross domestic product of 6.38 percent (equation 27), seems to imply that Peru is indeed in a trade-constrained growth phase. Projected net capital inflow indicates that Peru's imports are in high excess of her exports (Table IV). Although this gap continually grows smaller, in the year 1980 her imports still exceed her exports by 277.91 million soles (roughly .1 percent of her projected gross domestic product in 1980, equal to about 6.1 million U.S. dollars). However, her required net capital inflow indicates that exports must exceed her imports by a continually larger amount each year if she is to maintain a growth rate of gross domestic product of 6.38 percent per year. In the year 1980, exports must exceed imports by 20637.3 million soles (about 10 percent of her projected gross domestic product in 1980, equal to roughly 449 million U.S. dollars). It appears that to get out of the trade-constrained growth phase, she must drastically cut down on her imports to give her a favorable balance of trade and perhaps slow down her rate of growth of exports somewhat to permit her a lower required net capital inflow to sustain the 6.38 rate of growth of GDP; though this move admittedly could conceivably cause her future rate of growth of GDP to fall.

Although Chenery-Strout base their model on balance of payments, Maizels' model considers only balance of trade. If Peru's continually worsening balance of payments are taken into consideration[38], her net capital inflow problem would be much more acute than Maizels' model actually demonstrates.

In taking an overall view of Maizels' ex post model, it appears that if Peru is to grow and develop in the future, she needs to drastically cut down on her imports and stimulate domestic investment, and perhaps even slow down on her rate of growth of exports until the economy can come to some sort of balance.

Even though Maizels' model appears to be supported empirically, it is still a simple model, and as a simple model it does not consider important factors such as the terms of trade, balance of payments, and money. Though all data used were in real terms, consideration of money directly could alter the results and at the same time, provide a method of alleviating Peru's economic problems. For example, if we should make the implicit price deflator a linear function of the money supply, we would find,

$$\underset{(3.31)}{\text{Imp. Pr. Def.} = 23.84} + \underset{(0.00016)}{.007} \text{ Money Supply,}$$

with the T-test for (.007) significant at the .00025 level and F-test significant at the 1 percent level (R^2 = .9924); if we should make real

[38]Indice Anexo Estadistico, op. cit., Cap. IV-iB

gross domestic product a linear function of the money supply, we would find,

$$\text{Real GDP} = \underset{(2520.49)}{39855.93} + \underset{(0.12)}{3.89}\ \text{Money Supply},$$

with T-test for (3.89) significant at the .00025 level and F-test significant at the 1 percent level (R^2 = .9850); or, if we should make nominal gross domestic product a function of the money supply, we would find,

$$\text{Nom. GDP} = \underset{(63379.38)}{\text{large constant}} + \underset{(0.304)}{9.23}\ \text{Money Supply},$$

with T-test for (9.23) significant at the .00025 level and F-test significant at the 1 percent level (R^2 =.9830); however, this is beyond the scope of Maizels' model, and hence, beyond the scope of this thesis.

In addition, both the import and export sectors should be broken down into subsectors to determine the role of each factor on the Peruvian economy. Furthermore, overall rates of growth, calculated over a wide period of time, may not be extremely desirable for making future projections, or even examing the present. They should be considered on a yearly basis, or if this were not possible from a model-building point of view, at least the data should be weighted, giving emphasis to the most recent years under consideration.

Maizels' ex post model seems to provide a fair picture of what is actually taking place in Peru; one which to some degree follows the actual circumstances of the country; however, the model needs to be highly refined before it can be used as a tool to enable Peru to solve its economic problems.

Table I

A Comparison of Actual and Calculated Imports of Consumer Goods*
1951-1967

Form of the equation

$$M_t^c = (X_t+F_t) - b_1(X_{t-1}+F_{t-1}) - a_1$$

Year	Actual** M_t^c	Calculated** M_t^c	Difference**	Per Cent Difference
1951	4421.60	5410.88	-989.28	-22.37
1952	5030.00	5563.35	-533.35	-10.60
1953	5180.70	6063.38	-882.68	-17.04
1954	5210.00	4544.55	665.45	12.77
1955	7189.20	7456.64	-267.44	-3.72
1956	7292.60	8549.50	-1256.90	-17.23
1957	8244.30	9439.57	-1195.27	-14.50
1958	7358.30	6802.37	555.93	7.55
1959	6909.20	5686.09	1223.11	17.70
1960	8287.60	8472.51	-184.91	-2.23
1961	8980.90	9545.61	-564.71	-6.29
1962	9240.20	10345.43	-1105.23	-11.96
1963	10502.10	10908.08	-405.98	-3.87
1964	11799.50	11735.47	64.03	0.54
1965	15243.70	16098.75	-855.05	-5.60
1966	16135.60	17302.85	-1167.25	-7.23
1967	18473.90	18346.25	127.65	0.69

*Imports of consumer goods include consumer durables and non-durables, combustibles, primary materials, and intermediate products.

**In millions of constant soles, 1963 prices.

Table II

Calculated Per Centage Growth Rates of GDP and Exports
1951-1967

Form of the equations

$$r_t = \frac{a_2 + a_1 b_2 + b_1 b_2 (X_{t-1} + F_{t-1})}{\sigma Q_0}$$

$$e_t = \frac{1}{b_1 b_2 (t-1) X_0} \cdot \left[\sigma Q_0 r(1+rt) - a_2 a_1 b_2 + b_1 b_2 (X_0 + F_{t-1}) \right]$$

Year	Growth Rate GDP	Growth Rate Exports
1951	5.05	5.73
1952	5.77	3.76
1953	5.89	8.63
1954	5.90	9.19
1955	5.20	7.83
1956	5.96	10.33
1957	6.32	11.54
1958	6.82	14.04
1959	5.85	10.17
1960	4.74	7.86
1961	5.11	11.80
1962	5.34	13.74
1963	5.45	13.11
1964	5.39	10.62
1965	5.25	9.93
1966	5.99	9.28
1967	6.25	8.07

Table III

A Comparison of Actual and Calculated Ex Post Savings
1950-1967

Form of the equation

$$S_t = (\sigma t Q_0)r^2 + (\sigma Q_0)r - F_t$$

Year	Actual Savings*	Computed Savings*	Difference*	Per Cent Difference
1950	8687.20	10535.07	-1847.87	-21.27
1951	10567.00	8919.20	1647.80	15.59
1952	10594.00	9603.15	990.85	9.35
1953	11004.50	10136.39	868.11	7.89
1954	11383.40	12555.13	-1171.73	-10.29
1955	9913.30	11278.57	-1365.27	-13.77
1956	11680.00	10888.40	791.60	6.78
1957	11710.00	10367.55	1342.45	11.46
1958	10295.10	13307.38	-3012.28	-29.26
1959	10416.00	17304.92	-6888.92	-66.14
1960	16171.30	18820.96	-2649.66	-16.38
1961	16479.20	19859.20	-3380.00	-20.51
1962	18144.10	19691.64	-1547.54	-8.53
1963	19248.70	18862.28	386.42	2.01
1964	21894.00	19723.22	2170.78	9.91
1965	20322.10	15529.36	4792.74	23.58
1966	21112.80	13218.60	7894.20	37.39
1967	21540.50	12601.84	8938.66	41.50

*In millions of constant soles, 1963 prices.

Table IV

Projected Exports, Projected Imports, and Projected GDP
1968-1980

Form of the equations

$X_t = X_{1967}(1+.143t)$ $M_t = m_0 + m_1 Q_t$ $Q_t = Q_{1967}(1+.0638t)$

Year	Exports*	Imports*	GDP*
1968	21108.91	28162.21	116331.81
1969	23749.83	30238.50	123308.63
1970	26390.75	32314.82	130285.50
1971	29031.69	34391.12	137262.31
1972	31672.60	36467.42	144239.13
1973	34313.52	38543.74	151216.00
1974	36954.46	40620.04	158192.81
1975	39595.38	42696.38	165169.75
1976	42236.29	44772.67	172146.56
1977	44877.23	46848.99	179123.44
1978	47518.14	48925.29	186100.25
1979	50159.06	51001.59	193077.06
1980	52800.00	53077.91	200053.94

*In millions of constant soles, 1963 prices.

Table V

A Comparison of Ex Post and Ex Ante Savings Projectional[1]
1968-1980

Form of the equations

ex post $S_t = (\sigma tQ_{1967})r^2 + (\sigma Q_{1967})r - F_t$

ex ante $S_t^* = s_0^* + s_1^*(Q_t - X_t) + s_2^* X_t$

Year	Ex Post Savings**	Ex Ante Savings**	Difference**
1968	20259.55	23931.95	-3672.41
1969	22462.22	26033.62	-3571.40
1970	24664.86	28135.29	-3470.43
1971	26867.55	30236.97	-3369.41
1972	29070.22	32338.63	-3268.41
1973	31272.87	34440.29	-3167.43
1974	33475.56	36541.97	-3066.41
1975	35678.19	38643.65	-2965.46
1976	37880.86	40745.31	-2864.45
1977	40083.53	4346.99	-2763.46
1978	42286.20	44948.65	-2662.45
1979	44488.87	47050.32	-2561.45
1980	46691.54	49152.00	-2460.46

[1] Values of Q_t, X_t, and F_t are projected values: see Tables 4 and 6 respectively.

**In millions of constant soles, 1963 prices.

Table VI

A Comparison of Required and Projected Net Capital Inflow[1]
Based on a Future Growth Rate of GDP of 6.38% Per Year
1968-1980

Form of the equations

Required $$F'_t = \left[\frac{\sigma Q_{1967}(t+1)}{b_1 b_2}\right]\bar{r}^{*2} + \left[\frac{\sigma Q_{1967}}{b_1 b_2}\right]\bar{r}^{*} - \left[X_t + \frac{a_2 + a_1 b_2}{b_1 b_2}\right]$$

Projected $F_t = M_t - X_t$

Year	Projected** F_t	Required** F'_t	Difference**
1968	7053.29	-1192.62	8245.91
1969	6488.67	-2813.01	9301.68
1970	5924.07	-4433.39	10357.46
1971	5359.43	-6053.80	11413.23
1972	4794.82	-7674.18	12469.00
1973	4230.22	-9294.57	13524.79
1974	3665.58	-10914.97	14580.55
1975	3101.00	-12535.36	15636.36
1976	2536.38	-14155.74	16692.12
1977	1971.77	-15776.14	17747.91
1978	1407.14	-17396.53	18803.67
1979	842.53	-19016.91	19859.44
1980	277.91	-20637.31	20915.22

[1] Values of M_t and X_t are projected values; see Table 4. Maizels' definition of net capital inflow is $F_t = M_t - X_t$ so that a positive net capital inflow implies that imports exceed exports, and a negative, vice versa. The author is aware that the usual terminology would be net capital outflow; however, he has kept Maizels' expression to be consistent with the original model.

**In millions of constant soles, 1963 prices.

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THE APPLICATION OF A. MAIZELS' *EX POST* FORMULATION OF THE CHENERY-STROUT GROWTH MODEL TO PERU

by

Arnold B. Baker

ABSTRACT

Maizels' *ex post* growth model is a reformulation of the Chenery-Strout growth model. Though Chenery-Strout tested their model for Peru for the period 1957-1962, Maizels did not. It is the purpose of this thesis to apply Maizels' model to Peru for the period 1950-1967, compare those parameters and variables that his model yields with those of Chenery-Strout, and attempt to find whether or not Maizels' model yields meaningful results for this country and hence, can be useful for policy-making decisions in the same.

Maizels' model was tested using data from the Peruvian Government. The least squares regression technique was applied where necessary.

The results showed that Maizels' model was statistically relevant to Peru; that Peru needed to take corrective action in the areas of domestic investment and imports to enable her to maintain a reasonable growth rate of gross domestic product; but that due to variables not considered in the model, modification of the model would be necessary before its usefulness as a policy-making tool could be completely determined.