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A MACRO-ECONOMIC MODEL OF JAMAICA, 1959-1966

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1. This paper consists of a descriptive account of an econometric model of the Jamaican economy over the period 1959-66. As such, it belongs to a well-known class of models, the members of which have the common characteristic that they provide a macro-economic structural description of an economy, with statistically-estimated quantitative parameters. These models, the development of which is particularly associated with the name of Professor Lawrence R. Klein,[1/] typically contain about thirty equations, and provide a description of the macro-economic behavior of the economy over an observed period of time. As such they are often used in order to project the future path of an economy, or to show the likely effect of possible economic policies.

2. Originally such models were constructed for the economies of developed countries such as the United States. With the observations and predictions relating to quarterly periods, they have had some measure of success in connection with attempts to assess the impact of government fiscal and monetary policies, and to make conditional predictions of the values of the main macro-economic aggregates.[2/] This success has been limited, however, to periods for which the underlying structure was

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1/ See for example, Kelin, L.R. and Goldberger, A.S., An Econometric Model of the United States, 1929-1952, New York, 1955, Humanities Press.

2/ See for example: National Bureau of Economic Research, Models of Income Determination, Princeton, 1964, pp. 11-57 (the Wharton Model). Also see, Duesenberry, J.S., Eckstein, O. and Fromm, G., A Simulation of the U.S. Economy in Recession, Econometrica 28 (1960), pp. 749-809. For a larger attempt at the same thing see Duesenberry, J.S., Fromm, G., Klein, L.R. and Kuh, E., eds. The Brookings Quarterly Econometric Model of the U.S. Economy, Chicago, Rand-McNally, 1965.

correctly specified. Recently, and in particular since the latter part of 1968, the predictive value of such models of the American economy has not been good. This suggests that the underlying structure of the economy has changed.

3. Very similar models have in many cases been constructed also for developing countries. In such cases the limitations of the data have made it necessary to proceed on an annual rather than a quarterly basis; while a further problem is that the structural relations which the models attempt to determine statistically may be more subject to change than in more complex economic systems. Thus in developing countries the models necessarily rest on much less secure foundations. Despite this, however, they have sometimes been used as a basis for longer term forecasts, for periods of five or ten years ahead, and also as a guide to the choice of economic policies. Thus for example the UNCTAD Secretariat, first in estimating the prospective "resource gap" of the developing world and subsequently in making projections in relation to the Second Development Decade, has made extensive use of this kind of econometric model.[1/]

4. In our view, such extensions and applications of the model are of questionable value. An explanatory system which works reasonably well on a quarterly basis, and for short-term predictions in a developed economy which has good sources of data and is not subject to drastic change, cannot legitimately be used for forecasting several years ahead in a situation where typically the data are extremely bad and rapid structural changes are

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1/ See for example: Trade Projections and Capital Needs of Developing Countries, UNCTAD, New York, 1968.

both expected and desired. There are a number of reasons why this is so, of which the following are perhaps the most significant:[1/]

a. The process of growth in developing countries is often characterized by major structural changes, while a statistically estimated macro-economic model of the kind that we are concerned with here is related only to the structure of a past period.

b. The forecasting error inherent in such models is so large that over the typical planning horizon, which is usually five years but, may sometimes be ten or more, the dispersion of probable outcomes is too wide to allow the forecast to be of any practical use. Educated guesses are in general more reliable, as well as less costly and laborious to make.

c. Data limitations are often very serious, and often dictate the form of the model that can be used. In so doing, however, one runs the risk of creating serious specification errors.

d. Even with better data, the problem of specification may still be a serious one. In particular, the causal relationships that will be important in the future may not have been so in the past.

e. The construction and manipulation of such models is, and will continue to be, demanding in terms both of skilled labor and

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1/ For an extended discussion of this very important issue, the reader is referred to Shourie, A.: The Relevance of Econometric Models for Medium- and Longer-Term Projections and Policy Prescription, IBRD Department of Economics, December 29, 1969.

of machine-time. As such, it is beyond the capacity of the planning departments of many developing countries, and a questionable use of scarce resources in the rest. Only when the models are small, and can be calculated sequentially (as opposed to simultaneously), can they be handled by the typical planning unit.

5. Despite these very serious limitations, such models are often of value even in developing countries. If used with caution and in conjunction with other information, they may help in the task of making short-run projections. The process of constructing them helps considerably to illuminate structural relationships and hence the working of the economy concerned, and it further serves to instil an intimate knowledge of the nature and limitations of the available statistical sources. Moreover, a macro-economic model provides a compact summary of the data, and as such can be used extensively to check the consistency and reliability of economic information. Such are the uses to which the present model of Jamaica has been put.

6. This paper covers the period 1959-66 (in annual observations) and describes, in some 33 equations, the structure of the economy over that period. It has proved very helpful to the author in attempting to understand the economy and it is hoped that it will do the same for the reader. It is not intended, however, that this model serve as any kind of forecasting or predicting device, nor as a vehicle for policy prescription.

7. The economy of Jamaica has been characterized by steady growth, stable prices, and a strong private sector. The pace of economic activity is strongly affected by the export sector of the economy, especially the

aluminum and tourist industries. The political and economic stability of the colonial era has been inherited by the independent nation and as a result there is a strong economy extensively documented by statistics, certainly better than most countries of similar size and income level. For these reasons Jamaica is a good country with which to do research in the field of quantitative models.

8. Jamaica is a country that has been presented as a "showcase" of development, since it has been able to achieve continuous high rates of growth. This impression tends, however, to be based on the experience of the late 1950's. More recent experience shows a marked slump in the early 60's (brought on to some extent by the proximity of Cuba) accompanied by a fall in the outmigration of labor occasioned by restrictions in the U.S. and U.K. Although the economy has recovered since 1964, the economic infrastructure is currently becoming somewhat strained, and there is reason to doubt the ability of the public sector to keep social overhead capital growing in line with the needs of the economy. Thus, there is now some question as to whether Jamaica can continue to grow successfully and provide sufficient growth in employment for a population that is deserting the no longer productive agricultural sector of the economy.

Background to the Model

9. Before presenting the model itself, it is interesting to discuss briefly the major influences on the economy over the period in question (1959-66). The biggest exogenous factor for Jamaica was what was happening in the next island, Cuba. This dominated the climate of economic activity in Jamaica, being particularly pronounced in the years 1961-63. In fact this factor was so strong that it is possible to use it to explain the

movements in investment over the period. It is introduced in the model via the variable "earnings from tourism", as the tourist is apparently an exceptionally good barometer of the general climate of confidence in the island. As tourism is one of the major growth elements of the economy, this argument seems reasonably sound. Also, we have the observation of 1961-63, when frightened by the proximity of Cuba, the tourist stayed away, and the economy stagnated. Another factor which was prominent in the economy was in fact an instrument of policy, namely the net amount of additional credit extended to the private sector. This credit came from the commercial banks, and appears to have been guided by the central bank both in the form of changes in the bank rate and also in "suasion" which accompanied these changes. This credit variable appears to be important in the explanation of investment. The other important exogenous variable is of course exports, but this in the model only plays a role in income determination, being thus on a par with government consumption, as Jamaica, over the period in question, has had no particular need to be overly concerned about the balance of payments.

10. In November 1967, Jamaica followed the lead of Britain and devalued its currency.[1/] This means that in order to use the model for projection purposes one must take account of the role of import prices, particularly as they reflect on imports. In the present model these prices have not been included, and indeed it may be difficult to do so. A detailed analysis

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1/ The official explanation was that such a move was necessary to preserve markets in sugar and bananas, and thus maintain employment, but it is more likely that the Government was caught by surprise and had little choice in the matter.

of Jamaican imports was undertaken with particular attention being given to import price indices in the hope of being able to ascertain the probably shifts in the import functions due to the devaluation. The results, however, have been inconclusive and unusable for this exercise. The effects of devaluation upon exports are not as pronounced, as exports in general are with countries that also devalued or, as in the case of mining, the exports are foreign owned to begin with and Jamaica receives only a fixed royalty.

The Structure of the Model

11. The model presented in this paper is of moderate size detailing in quantitative fashion the macro-economic structure of the economy over the period 1959-66.[1/] The model shows how the economy reacts to exogenous factors, such as exports and tourism, and how the fiscal system relates to the sectors of economic activity. As Jamaica experienced no significant inflation over the period in question, the model is in current prices, the advantage being that more economic series are available in this mode. The equations of the model are presented below, without the accompanying statistics so as not to overload the main body of the paper with numbers. The complete details of each equation are presented in an annex at the end. In general each of the equations presented is of high statistical significance with good "t ratios" for the coefficients and with most Durbin-Watson statistics sufficiently close to 2.0.[2/]

1/ Data does exist for earlier years but there is a break in the series between 1958 and 1959 which prevents the use of anything but the overall aggregates.

2/ The "t" ratio refers to the ratio of a coefficient to its standard error. This ratio is a means whereby one can assess the likelihood that the coefficient is significantly different from zero. In the case of this paper the values of the "t" ratio should be greater than about 2.0 to indicate significance of the coefficient. The Durbin-Watson statistic is a measure of the degree of serial correlation in the unexplained portion of the dependent variable. A value of 2.0 indicates no serial correlation while values less than 1.0 or greater than 3.0 tend to indicate a substantial amount present.

12. The first part of the model is the import sector. As mentioned above a detailed analysis of imports was undertaken, but the results were not encouraging. In general problems arise from the lack of homogeneity in the items that make up any group of trade commodities. These problems can be hidden at an aggregate level, but when looked at in detail the indices tend to jump about from year to year and thus do not present a coherent base upon which to undertake analysis.

13. In this study, in lieu of a detailed breakdown, I have used the classification of the Bank of Jamaica. This is a modification of an ECLA end-use system of treating imports. From it I have taken five major categories, food, other consumer goods, intermediate goods, capital goods and fuel. The last category has been treated as exogenous, as the period in question was one where a refinery was put up in Jamaica and thus the whole structure of fuel imports has changed.

14. Imports of food are related to personal consumption:[1/]

$$M_f = -1.8913 + 0.0935\ C_p \qquad (1)$$

Imports of non-food consumer goods are also related to personal consumption:

$$M_c = -7.1417 + 0.1545\ C_p \qquad (2)$$

15. Thus about 25 percent of marginal personal consumption is spent on imported goods. The implied elasticity of non-food consumer goods is 1.3, about the level that would be expected in the light of findings of studies of consumer behavior in other countries. The elasticity of food imports is,

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1/ The units of this and all other equations, unless otherwise stated, are millions of Jamaican pounds (1) £ = US$2.80 during the model period, subsequently 1£J = US$2.40. Currently 1£J = US$1.20.

however, 1.11 which is considerably higher than in most countries. This lends credence to the assertion that imports of foodstuffs are a significant problem in Jamaica. Of course part of this phenomenon is due to the high (almost 100 percent) import content of tourist food. However, equations using tourism earnings as explanatory variables to explain imports of food and consumer goods were tried and their significance was not particularly high.

16. Imports of capital goods were related to investment in mining and other investment. One expects this equation to be significant a priori, as Jamaica, like many other less developed nations, uses imports of capital goods as one of the sources of data for estimates of investment. The large fluctuations of mining investment make it necessary to separate it from the rest of investment in this equation. The equation is as follows:

$$M_k = -2.828 + 0.4369\ I_o + 0.9901\ I_m \qquad (3)$$

where I_o is gross domestic fixed capital formation outside of mining and I_m is mining investment. As can be seen, on the margin, about one-half of non-mining investment and almost all of the mining investment is in direct imports. The elasticity of non-mining investment imports is 0.90, indicating a slowly falling proportion of imports in capital formation.

17. Finally, the imports of intermediate goods are assumed to be related to output (GDP at factor cost) in the manufacturing sectors:

$$M_i = -0.6685 + 0.4208 \qquad (4)$$

This shows quite a high intensity of imports in manufacturing, but it is quite probable that this coefficient is biased to the high side as manufacturing covers only the sector so-called in the Jamaican national accounts and there are other sectors which use imported inputs. However, the

elasticity is 1.04, indicating that this intensity is increasing. Imports are aggregated in an identity:

$$M = M_f + M_c + M_k + M_i + M_p + MOS + FPO \qquad (23)^{1/}$$

where M_p is fuel imports, FPO the factor out-payments and MOS represents imports of other services. FPO can be related to the value of aluminum industry exports (EAL), both alumina and bauxite (as the aluminum companies are the major foreign interests in Jamaica), while MOS is related to GDP.

$$FPO = 0.1361 + 0.5777\ EAL \qquad (5)$$

$$MOS = -1.0187 + 0.0639\ GDP \qquad (7)$$

18. On the export side, most of the exports of Jamaica can be treated as exogenous variables. The major ones, bauxite and aluminum are determined by the current needs of the mining companies; manufactures (textile particularly) by the quotas of the developed world; and agricultural products by the vagaries of the weather.[2/] Finally, tourism, although more recently a function of industry capacity, was in the period covered by this model determined by confidence in Jamaica and in the Caribbean area. Thus only one part of exports was put into a structural equation, factor payments. These were found to be related to the level of GDP (probably just a time trend). However, the curtailing of the migrant workers program by the U.S. caused a sharp drop in the rate of increase in these payments and an actual absolute decline in 1966. Accordingly, a dummy variable for 1965 and 1966

1/ Equations are numbered consecutively in the annex. Equation 23 is an identity and as such is placed after the structural equations.

2/ For example, the sugar output fell drastically in 1969 as very wet weather substantially lowered the sugar content of the cane.

was used in the equation. This variable, of high significance, shows a drop of almost £4 million per year as the result of the curtailing of the program.

$$FPI = -2.8854 + 0.0444\ GNP - 3.8552\ D_2 \qquad (6)$$

Thus it appears that to a large extent, at any rate given the present status of the mining companies, the rate of increase in exports must be taken as given - i.e., as independent of government policies. A possible exception to this for the future is the tourism industry where there is considerable scope for expansion within the present structure of demand.

19. Moving to consumption, this item is broken down into two parts, private (C_p) and government (C_g). Government consumption is treated as exogenous and private consumption as a function of private disposable income and a dummy variable representing the first significant impact of the introduction of hire purchase in the Jamaican economy (in 1964).

$$C_p = 26.2672 + 0.7979\ Y_{pd} + 16.53\ D_1 \qquad (8)$$

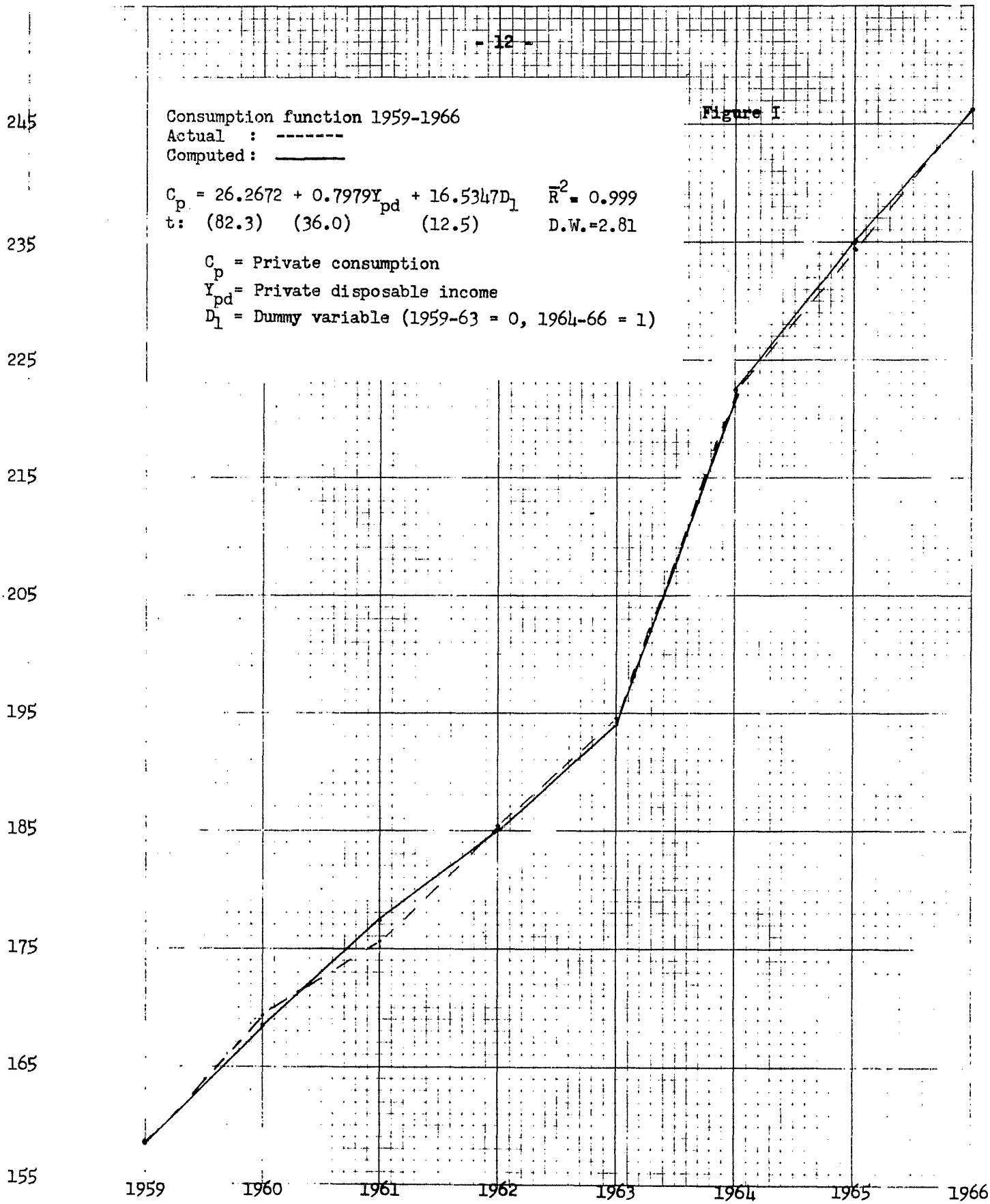
This particular equation presented some problems. Consumption can be related to private disposable income, with a coefficient of determination of 0.97; however, the marginal propensity to consume in that equation is 1.04. Examination of the data showed that the problem lay in the years 1963 and 1964 when the apparent marginal consumption rate was 1.9. During the period the economy underwent a sharp increase (revival) in economic activity and thus it was first reasoned that perhaps the apparent marginal consumption figure might have been caused by changes in income distribution, particularly an increase in the share of wage earners. Examination of the data showed that such an explanation could only have accounted for a small fraction of the jump in consumption. Another possible but unsustainable hypothesis was

Figure I

Consumption function 1959-1966
Actual : -------
Computed : ———

$C_p = 26.2672 + 0.7979Y_{pd} + 16.5347D_1$ $\bar{R}^2 = 0.999$
t: (82.3) (36.0) (12.5) D.W.=2.81

C_p = Private consumption
Y_{pd} = Private disposable income
D_1 = Dummy variable (1959-63 = 0, 1964-66 = 1)



that the jump had been caused by price effects. Next, examination of the banking data for Jamaica showed that in years 1963 and 1964 there was a massive increase in credit extended to the private sector, financed primarily by overseas borrowing of the commercial banks. Inclusion of a variable measuring change in credit extended to the private sector was then tried but the elasticity of consumption with respect to the credit variable was very low, in the order of 0.02. Also, the implied marginal consumption rate, although below 1.0, was still too high to be plausible. Thus we settled instead for a dummy variable with a value of 1.0 from 1964 on. As can be seen the fit is very close, and only misses the intensity of the slowdown in growth in 1961.

20. Non-mining investment is divided into two categories, fixed and inventories. The latter (I_n) proved to be so near random that it was not possible to have a structural equation for it. It was thus left as an exogenous variable, its values being generally in the range of one percent of GNP. Fixed investment presented a very interesting problem.[1/] The first specification tried was to relate investment to the change in income and the previous level of investment. It was immediately evident that the latter variable was completely insignificant while the change in income when fitted alone was only very barely so. Moreover the explained variance was only about 70 percent. Moving then to indirect explanations of investment, it was reasoned that investment would probably be related to the level of confidence in the economy and perhaps also to the amount of funds readily

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1/ A detailed examination of investment functions in Jamaica has been the subject of a further study by this author with Steven Kohlhagen. Results will be forthcoming shortly.

available for investment. As argued above, confidence can be fairly well represented by earnings from tourism. Tourists will only go to a country when they feel safe and this was certainly the case with Jamaica with its close proximity to Cuba and later, to a lesser extent, to the Dominican Republic. Furthermore, it was reasoned that the attitudes of tourists, and thus their lag in activity behind the true climate (which would be known to the more sophisticated businessmen) would just about be balanced by the businessmen's necessary caution in committing large sums of investment funds as well as the inherent delays built into the investment process.

21. There is, of course, no intnetion on our part to claim that investment is caused by tourism, except to the extent that much investment is in hotels and tourist facilities; rather it is felt that the confidence in the economy is reflected directly in both variables, the probable correlation between confidence and tourism being so high as to make the latter a good surrogate for the former.

22. Beyond this several variables measuring available funds were tried and it was found that the credit change variable (which was tried in the consumption relationship) was by far the most significant. The resulting investment equation is as follows:

$$I_o = 27.4685 + 1.0822\ E_t + 0.635\ L \qquad (9)$$

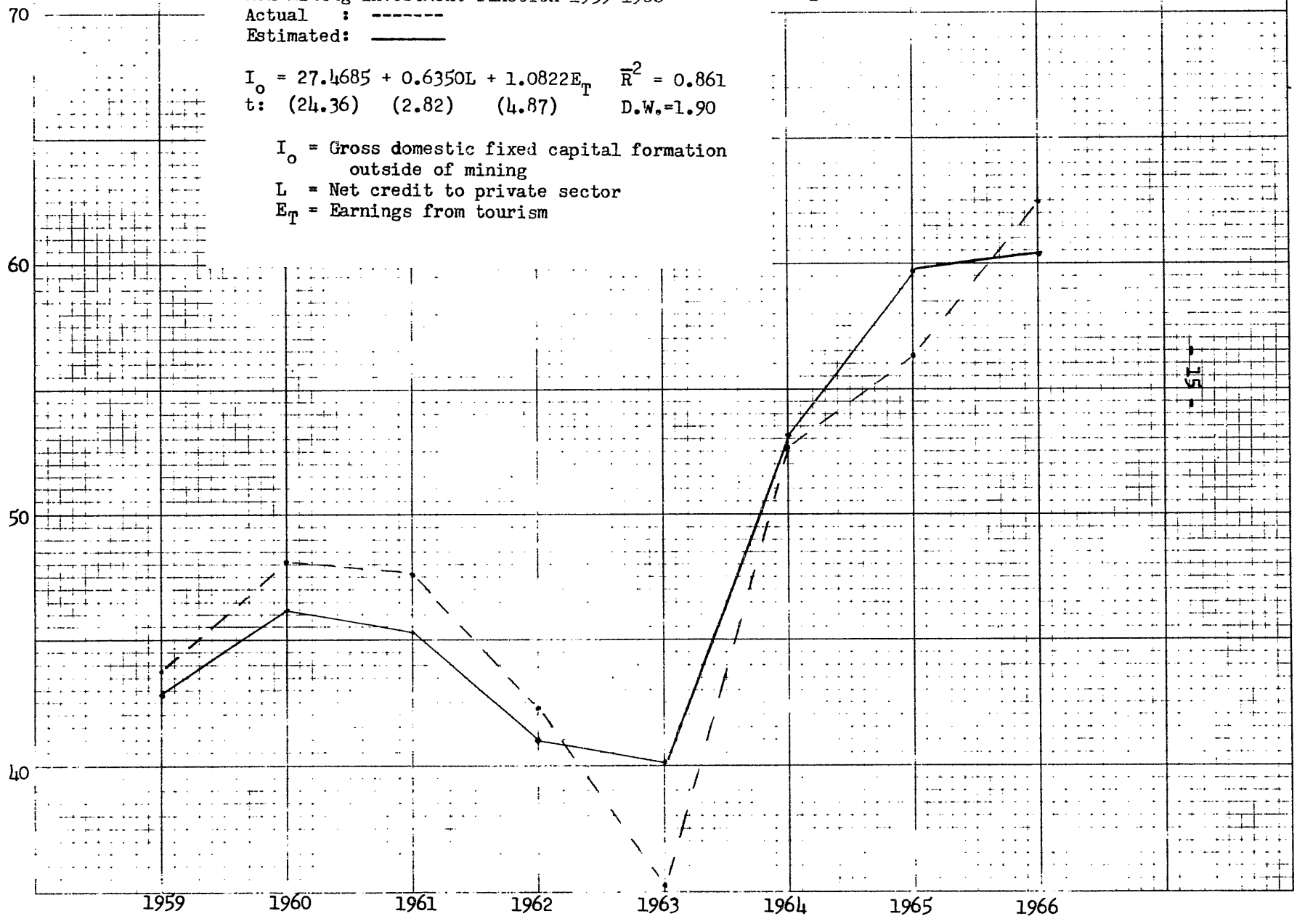
where L is the credit variable and E_t is earnings from tourism. It is recognized that this equation does not conform to any of the generally accepted ideas about investment; it does, however, make sense in the context, and as Figure II shows it provides a reasonable explanation of the behavior of investment over the period 1959-66. It successfully picks up turning points, but does not reflect the full intensity of the swings in the investment cycle.

Figure II

Non-mining investment function 1959-1966
Actual : -------
Estimated: ———

$I_o = 27.4685 + 0.6350L + 1.0822E_T \quad \bar{R}^2 = 0.861$
t: (24.36) (2.82) (4.87) D.W.=1.90

I_o = Gross domestic fixed capital formation outside of mining
L = Net credit to private sector
E_T = Earnings from tourism



23. Mining investment is exogenous and thus total fixed investment is the sum of mining and non-mining.

$$I_k = I_m + I_o \tag{29}$$

24. With the above equations we can complete the GNP identity:

$$GNP = C_p + C_g + I_k + I_n + X + FPI - M + E \tag{24}$$

where X is exogenous exports, and E is the statistical discrepancy between GNP from the product side and GNP from the expenditure side.

25. These 11 equations serve to make up an income determination model of the economy. There are, however, several variables which need to be explained as endogenous variables to the system, particularly Y_{fm} (value added in manufacturing) and Y_{pd} (personal disposable income) so that we need to add more equations.

26. GDP at factor cost in the manufacturing sector was related to income even though it was found that a simple time trend gave a better fit.

$$Y_{fm} = -8.9984 + 0.1659 \text{ GDP} \tag{10}$$

The elasticity of this function is 1.24, indicating the expected increase in the manufacturing share of the economy as income rises.

27. In order to get to personal disposable income one must subtract personal income taxes thus:

$$Y_{pd} = Y_p - T_p \tag{33}$$

where T_p is personal taxes.

28. Moving to personal income (Y_p) one would expect this to be related to national income, but the presence of sizeable and essentially random transfers in the economy somewhat blurs this identity. In the present version of the model we have stated Y_p as follows:

$$Y_p = Y_n - Y_g - PCU - T_\pi + T_{gp} + T_{wp} \tag{25}$$

where Y_n is national income, PCU is corporate undistributed profits, Y_g is government enterprise income, T_π is corporate profits taxes, and T_{gp} and T_{wp} are transfers to persons from government and from the rest of the world.

29. Moving to the elements of equation (25), the first one we treat is income from government enterprises. This is not a particularly well behaved variable, but its size is small and thus a simple regression on GDP is probably adequate for the purposes of the model:

$$Y_g = -0.3251 + 0.0029 \text{ GDP} \qquad (11)$$

The elasticity indicated by this relationship is 1.66 meaning that the public sector involvement in enterprise, although small, is increasing fairly substantially as the economy grows.

30. Taxes on corporations (T_π) presented somewhat of a problem in estimation. In the first place their rate of increase falls sharply after 1964; this, however, is probably explainable by the introduction of investment incentive laws at about that time. These laws contain many provisions for income tax relief for investment in certain industries. Beyond this, however, it was found that the variable recorded as corporate profits in the national income accounts was not at all closely related to the taxes collected. The reason for this is that the national income accounts only record the profits earned by nationally owned firms. In an economy such as the Jamaican one, where there is a substantial proportion of foreign ownership of industry, a lot of domestic corporate profits are recorded only as factor income payments and thus do not appear under corporate profits in the national income accounts. However, the taxes collected on corporate profits, since they accrue to the government, include both the taxes on local and on foreign owned enterprises.

31. Thus it was necessary to reconstruct the series for corporate profits to a domestic basis. This was accomplished by adding the corporate profit component of factor income payments,[1/] to the series in the national income accounts.

$$\Pi_L = \Pi - \Pi_f \qquad (31)$$

where the subscripts L and f refer to the local and foreign components of corporate profits.

32. From this new series for all profits we could estimate the corporate tax function:

$$T_\pi = -4.0711 + 0.3322\pi - 1.4063\ D_1 \qquad (12)$$

where D_1 is a dummy that is zero from 1959-1963 and 1 from 1964 to 1966. Its purpose, as mentioned above, is to take care of the effect of the investment incentive laws on profits taxes.

33. Continuing with the corporate sector, it was found that foreign profits could be treated as a function of total profits:

$$\Pi_f = 3.6986 + 0.2921\Pi \qquad (21)$$

and further that total profits could be expressed as a function of income in the manufacturing sectors of the economy:

$$\Pi = 4.1552 + 0.9943\ Y_{fm} \qquad (20)$$

34. Some notes about these two functions. In the first place the base for profits is much wider than just income in the manufacturing sector, so that the coefficient has no meaning in terms of shares; but the equation is a better explainer of profits than a regression on GDP. The implied elasticity, however, is less than one, which perhaps shows a declining

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1/ This unpublished series was obtained from the Bank of Jamaica.

profit share in the economy. Similarly with the equation for foreign profits, the elasticity implies that the local share of profits is growing faster than the foreign.

35. Undistributed corporate profits (PCU) were found to be a function of profits after taxes. Here again, this function was not significant on a national basis, but gave quite a good statistical explanation (r^2=0.983) when total profits were considered.

$$PCU = -3.2458 + 0.5458(\pi - T_\pi) \qquad (19)$$

Finally, a regression is introduced to explain local dividends. This is not needed for the model, but was added as an auxiliary relationship to try to explain dividend behavior. Here again there is a problem as the series for dividends reflects only those accruing to local people. Thus they are a function of $(\pi - \pi_f - T_\pi) = (\pi_L - T_\pi)$;

$$DIV = -0.0957 + 0.1089\ (\pi_L - T_\pi) \qquad (22)$$

36. The final two items in equation 25, transfers to persons from the government and from the rest of the world are both treated as exogenous in this model.

37. National income is related to GNP via the identity:

$$Y_n = GNP - I_{ts} - S_d \qquad (26)$$

where I_{ts} is indirect taxes less subsidies, and S_d is savings in the form of depreciation (capital consumption allowance). Further, indirect taxes less subsidies can be expressed as an identity:

$$I_{ts} = T_e + T_d + T_{oi} - SUBS$$

where T_e and T_d are excise and import taxes (both excluding petroleum revenues as this was an import substituted industry during the period and the tax shifted from import to excise), and T_{oi} is other indirect taxes. SUBS represents subsidies.

38. Moving to the remainder of the tax equations (corporate taxes were covered in the discussion of corporate profits), we have relationships for excise taxes, customs duties, other indirect taxes, and personal income taxes:

$$T_e = -2.9983 + 0.2591\ Y_{fm} \quad (13)$$

$$T_d = 3.8679 + 0.3336\ M_c \quad (14)$$

$$T_p = -4.5793 + 0.0523\ Y_p \quad (15)$$

$$T_{oi} = -3.8385 + 0.0423\ GDP \quad (16)$$

In each equation the tax has been related to a particular base. These bases were chosen on the basis of plausibility and data availability.1/ The elasticities with respect to the various bases are as follows:

Tax	Base	Elasticity
Excise	Output in Manufacturing	1.45
Import	Consumer Imports	0.67
Personal Income	Personal Income	1.69
Other Indirect	GDP	1.48

The elasticity of excise taxes can be explained by the rapid increase in the imposition of excise taxes by the government during the period while at the same time the low elasticity for import duties reflects import substitution, a phenomenon which also serves to raise the level of excise taxes. Personal

1/ In using output in manufacturing as a base for excise taxes we are perhaps committing a specification error in that the particular items of consumption involved might be more realistic as tax bases. However, output in manufacturing is available and explainable (equation 10), while the use of certain parts of personal consumption would necessitate an extension of the model to explain inter-sectoral consumer choice.

income taxes exhibited a high elasticity possibly because during this period there was a large increase in the sectors of the economy falling under the PAYE system.

39. Subsidies were not very easy to explain. The best relationship was with GNP, and here the r^2 was only 0.8:

$$SUBS = -1.7304 + 0.0136\ GNP \qquad (17)$$

40. Savings from depreciation was related to a series for capital stock. This latter series is artificial as we had no actual stock figures. However, we did have figures for annual investment and depreciation, thus:

$$K_t = K_{t-1} + I_k - S_{d(t-1)};\quad K,\ S_d\ 1958 = 0 \qquad (28)$$

This type of series, although it does not give a good idea of the actual level of capital stock, will, however, give some idea of the rate of depreciation on subsequent capital stock. If the initial level of capital stock is small, or if the amount of depreciation on this capital is a constant figure each year, the coefficient on capital will be essentially unbiased:

$$S_d = 12.75 + 0.0412\ K \qquad (18)$$

In this case one can say that the effective rate of depreciation is about four percent per annum.

41. Finally, two identities are needed to complete the model:

$$GDP = GNP - FIP \qquad (32)$$

$$FIP = FPI - FPO \qquad (27)$$

Solution and Simulation of the Model

42. The preceding equations describe the system as initially estimated. The estimation procedure involved the use of ordinary least squares, a method that is completely appropriate for simple equations considered in

isolation. The present system of equations is, however, fairly interdependent (the values for some of the determining variables are themselves determined in their own equations). Moreover, the system is simultaneous, that is to say that there are certain groups of equations whose members depend on each other and thus cannot be solved except all together. For these reasons, it can be shown that the use of ordinary least squares is not entirely appropriate and other more sophisticated methods should be used to get to the true values of the coefficients of the system. Such an exercise was carried out using the technique of instrumental variables. The appendix contains the results and compares them with those of the equations obtained by ordinary least squares. In general the differences are minor and hardly worth the considerable additional effort required.

43. The next step was the simulation of the model. This is a process whereby one can determine the degree to which the model is able to duplicate the actual events of the past. Of particular interest in this context is the ability (or inability) of the model to follow turning points that is to say, when the economic time series changes direction, a good model should also do so. The model presented in this paper appears to do fairly well in the simulation exercise; this is illustrated in Figures III-VI. In essence the simulation process supplies the system with the values of the exogenous[1/] variables for a given year and then lets the system find a set of completely consistent corresponding values for the endogenous[2/] variables. Since in doing so the determining variables of certain equations are not supplied

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1/ I.e., determined outside the system.

2/ I.e., determined inside the system.

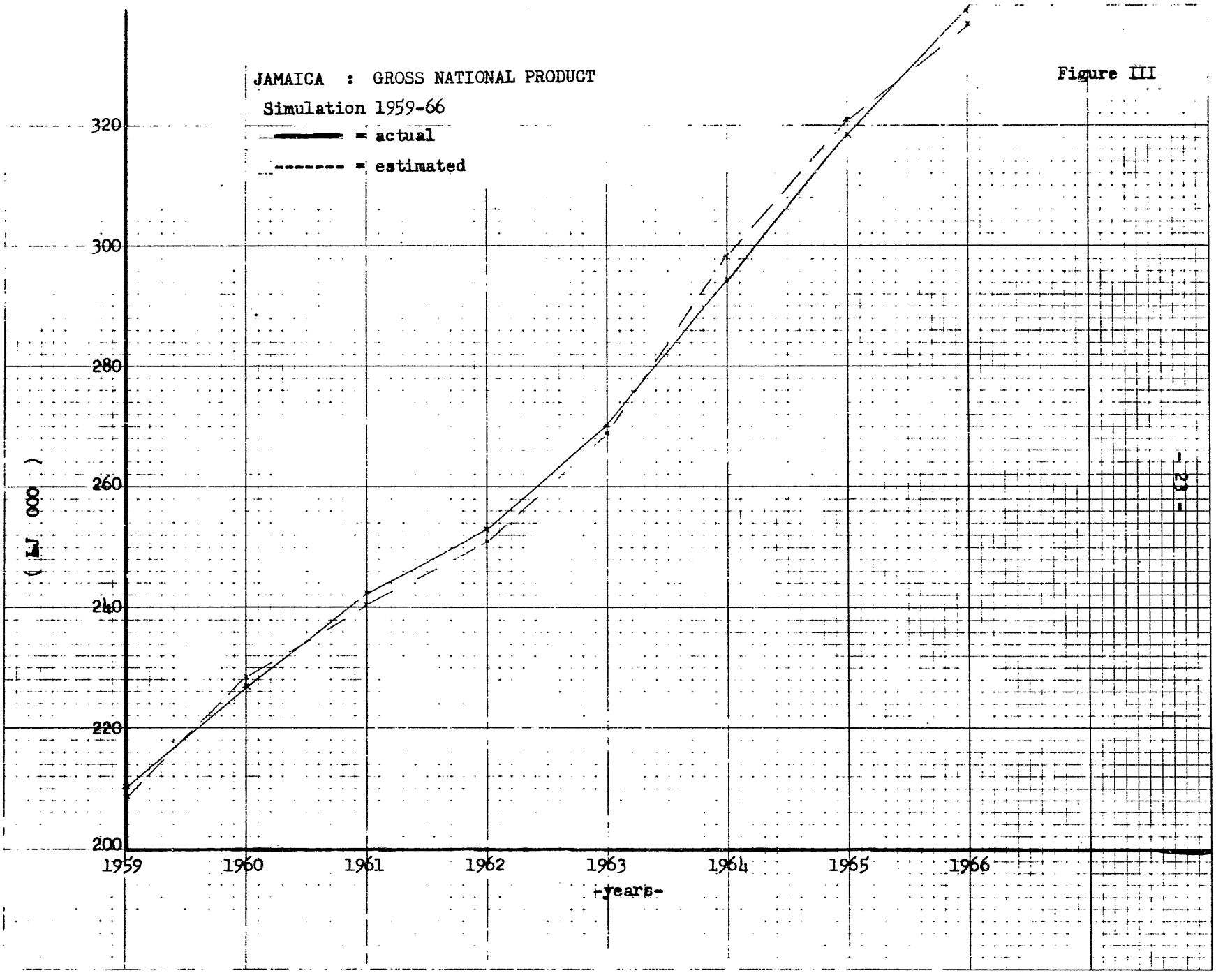
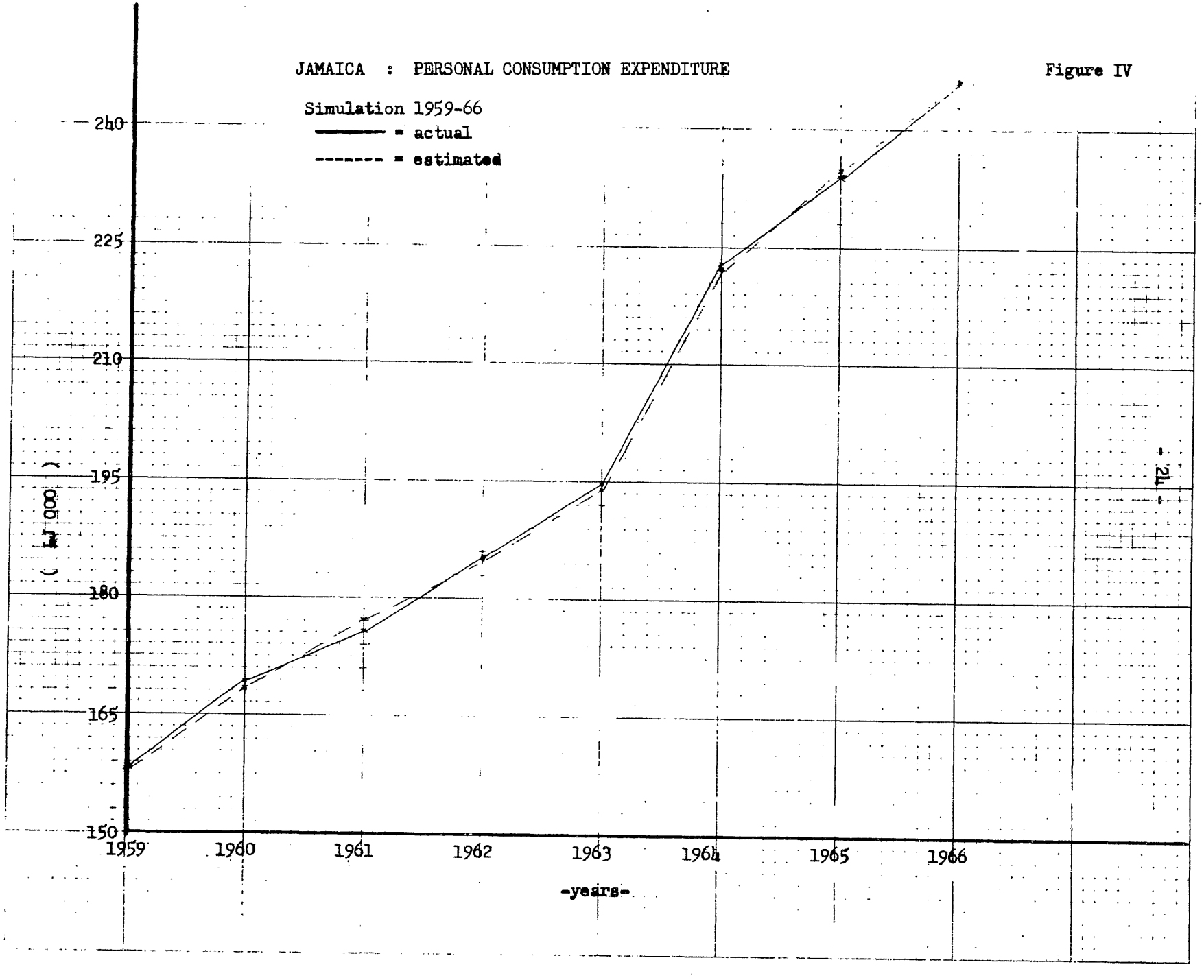

JAMAICA : GROSS NATIONAL PRODUCT
Simulation 1959-66
= actual
= estimated
Figure III
320
300
280
260
240
220
200
(£ 000)
1959
1960
1961
1962
1963
1964
1965
1966
-years-

Figure IV

JAMAICA : PERSONAL CONSUMPTION EXPENDITURE



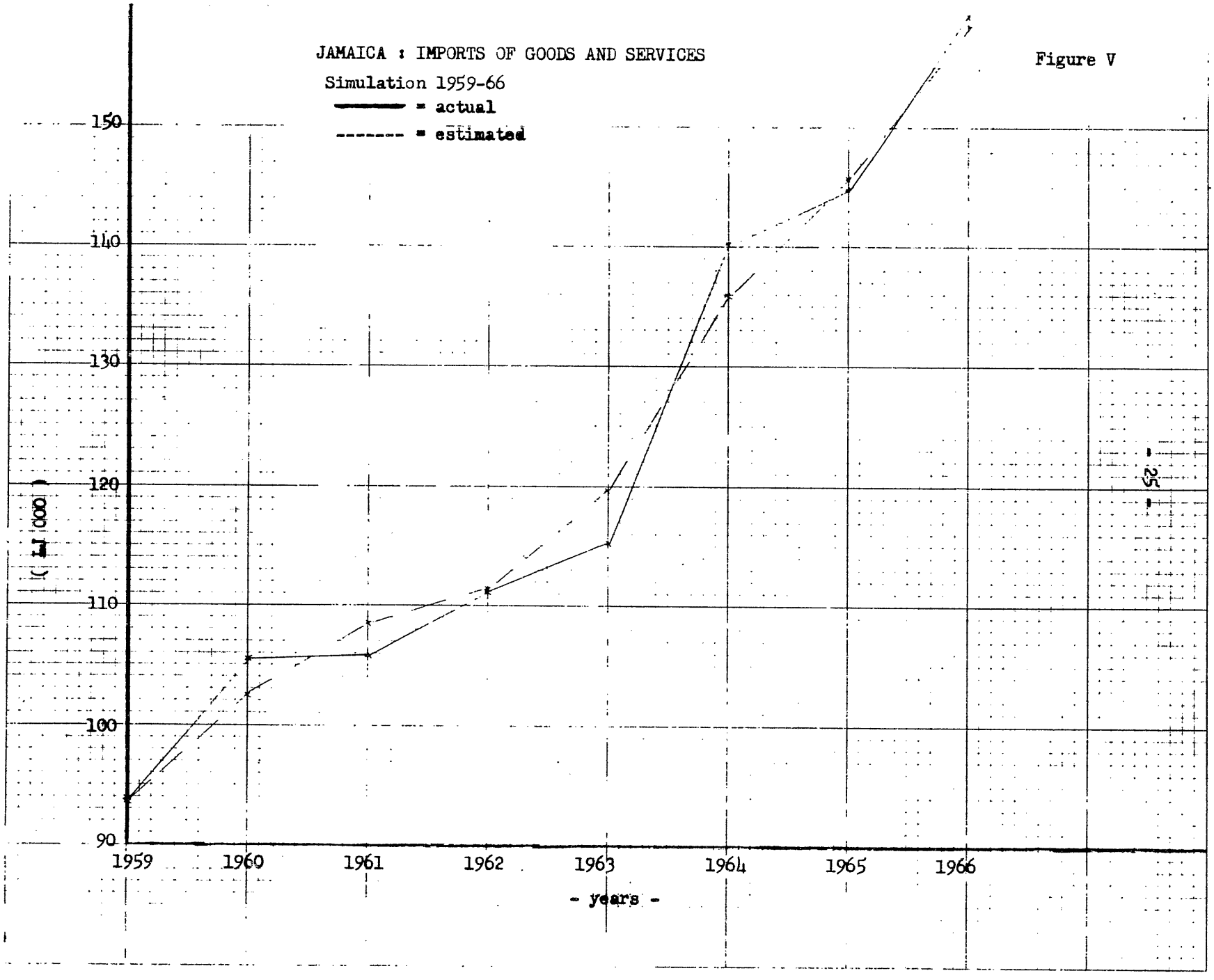

JAMAICA : IMPORTS OF GOODS AND SERVICES
Simulation 1959-66
= actual
= estimated
150
140
130
120
110
100
90
1959
1960
1961
1962
1963
1964
1965
1966
- years -

Figure V

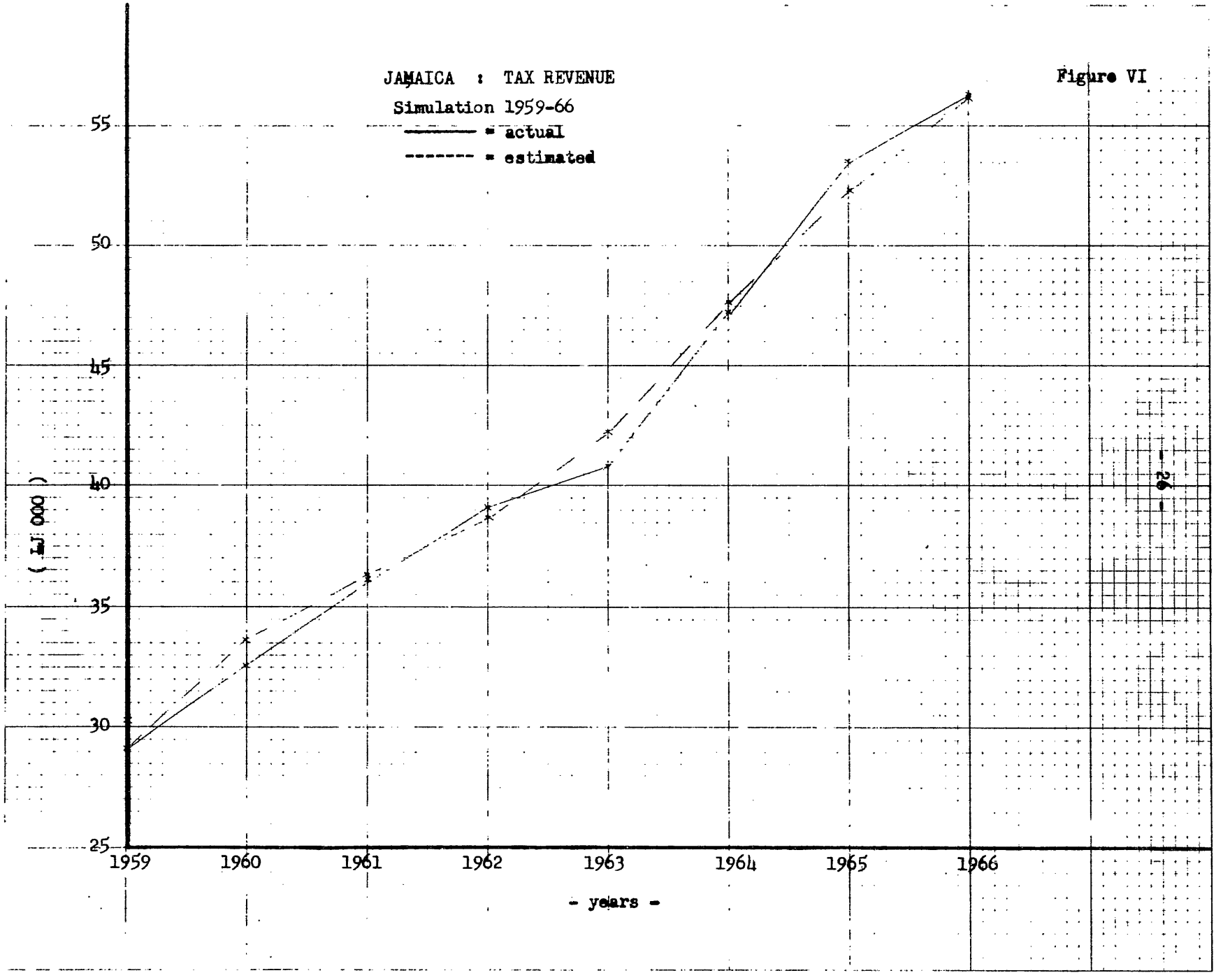

JAMAICA : TAX REVENUE
Simulation 1959-66
= actual
= estimated
55
50
45
40
35
30
25
(£ 000)
1959
1960
1961
1962
1963
1964
1965
1966
- years -

Figure VI

exogenously but rather are generated in the set of consistent endogenous variables, these equations do not use observed values, but rather the values that match the rest of the system. This is a fairly stringent test of a model and thus the good results of the simulation exercise tend to testify in favor of a fairly accurately defined model. In general about the only technical fault that appears is the tendency of the model to over-amplify somewhat the swings in the economic time series.

44. In the foregoing we have presented a macro-economic structural model of the Jamaican economy during the period 1959-66. In general it follows the familiar lines of such macro-models and is for the most part well-behaved. The items of particular interest are perhaps three in number. First, the consumption function is definitely discontinuous at the year 1964. At this point with the general recovery of the economy (or possibly causing this recovery) the private consumer indulged in hire-purchase for the first time to a substantial degree. For that particular year the marginal propensity to consume out of disposable income was considerably above unity, but taking this into account, over the whole period this propensity remained at about 0.80. Second, the investment function for the economy, particularly when it is considered without the mining investment, displays a high degree of correlation with the earnings from tourism. We attribute both variables to a confidence factor, and although the equation for investment uses tourist earnings we could just as easily have had an equation for tourist earnings using investment. Both are related to a variable for which there is no data as it cannot be observed directly, at least not in a quantitative fashion. This in itself is a good example of a reason why such models cannot be used well for forecasting. In order to use the present model for

such a purpose it would be necessary to predict, in a quantitative fashion, confidence in Jamaica - a variable composed of a variety of poorly understood political, economic and social factors. The third item of interest is the very high elasticity of food imports with respect to private consumption. While some of this is due no doubt to the consumption of tourists, which itself is excluded from national consumption, it points in general to an overall inadequacy of the agricultural sector in Jamaica and the inability of that sector to keep pace with the growth of consumption of agricultural products on the island.

ANNEX I: CATALOG OF VARIABLES

C_g/1	=	public consumption
C_p	=	private consumption
D_1/1	=	dummy (1959-63 = 0, 1964-66 = 1)
D_2/1	=	dummy (1959-64 = 0, 1965-66 = 1)
DIV	=	dividends
E/1	=	statistical discrepancy (product v. expenditure)
EAL/1	=	value of exports of bauxite and alumina
E_t/1	=	earnings from tourism
FIP	=	net factor income payments (-) or receipts (+)
FPI	=	factor income receipts - gross
FPO	=	factor income payments - gross
GDP	=	gross domestic product
GNP	=	GNP
I_m/1	=	mining investment
I_n/1	=	inventory investment
I_o	=	other investment
I_{ts}	=	indirect taxes less subsidies
K	=	capital stock (1958 = 0)
K_{-1}/2	=	capital stock (lagged)
L/1	=	net credit extended to the private sector by the commercial banks
M	=	imports of goods and services
M_c	=	imports of consumer goods
M_f	=	imports of food
M_i	=	imports of intermediate goods
M_k	=	imports of capital goods
MOS	=	imports of non-factor services
M_p/1	=	imports of fuel
PCU	=	undistributed corporate profits
Π	=	profits
Π_f	=	foreign owned profits
Π_l	=	local profits
S_d	=	savings from depreciation
SUBS	=	subsidies
T_d	=	import duties (excluding petroleum)
T_e	=	excise taxes (excluding petroleum)
T_{gp}/1	=	government transfers to persons
T_{oi}	=	other indirect taxes
T_p	=	taxes on personal income
T_π	=	taxes on corporate income
T_{wp}/1	=	transfers from overseas to persons
X/1	=	exports of goods and services
Y_{fm}	=	GDP at factor cost in manufacturing
Y_g	=	income from government enterprises
Y_n	=	national income

/1 Exogenous.

/2 Lagged endogenous.

ANNEX II: EQUATIONS FOR JAMAICA MODEL

		D.W.	$\bar{R}^2$
A. Estimated Equations (22)/1			
1.	$M_f = -1.8913 + 0.0935\ C_p$ (7.64) (11.42)	1.92	0.949
2.	$M_c = -7.1417 + 0.1545\ C_p$ (10.60) (6.94)	2.31	0.871
3.	$M_k = -2.8283 + 0.4369\ I_o + 0.9901\ I_m$ (5.29) (6.53) (6.73)	2.45	0.928
4.	$M_i = -0.6685 + 0.4208\ Y_{fm}$ (1.52) (7.04)	1.85	0.874
5.	$FPO = 0.1361 + 0.5777\ EAL$ (0.44) (9.30)	1.56	0.924
6.	$FPI = -2.8854 + 0.0444\ GNP - 3.8552\ D_2$ (39.44) (19.92) (13.59)	3.72	0.983
7.	$MOS = -1.0187 + 0.0639\ GDP$ (2.12) (5.84)	1.74	0.825
8.	$C_p = 26.2672 + 0.7979\ Y_{pd} + 16.5347\ D_1$ (82.34) (36.03) (12.52)	2.81	0.999
9.	$I_o = 27.4685 + 1.0822\ E_t + 0.6350\ L$ (24.36) (4.87) (2.82)	1.90	0.861
10.	$Y_{fm} = -8.9984 + 0.1659\ GDP$ (20.28) (16.42)	2.40	0.975
11.	$Y_g = -0.3251 + 0.0029\ GDP$ (12.75) (5.03)	2.84	0.777
12.	$T_\pi = -4.0711 + 0.3322\Pi - 1.4063\ D_1$ (18.36) (5.53) (1.52)	2.58	0.911
13.	$T_e = -2.9983 + 0.2591\ Y_{fm}$ (21.62) (13.76)	1.86	0.964
14.	$T_d = 3.8679 + 0.3336\ M_c$ (17.83) (7.63)	1.94	0.891
15.	$T_p = -4.5793 + 0.0523\ Y_p$ (58.43) (20.34)	1.13	0.983
16.	$T_{oi} = -3.8385 + 0.0423\ GDP$ (15.46) (7.48)	2.25	0.887
17.	$SUBS = -1.7304 + 0.0136\ GNP$ (16.45) (5.43)	1.70	0.803
18.	$S_d = 12.7536 + 0.0412\ K$ (84.60) (21.90)	3.13	0.986
19.	$PCU = -3.2458 + 0.5458\ (\Pi - T_\pi)$ (21.37) (20.22)	2.15	0.983
20.	$\Pi = 4.1552 + 0.9943\ Y_{fm}$ (8.15) (14.37)	1.84	0.967
21.	$\Pi_f = 3.6986 + 0.2921\ \Pi$ (42.93) (25.19)	2.94	0.989
22.	$DIV = -0.0957 + 0.1089\ (\Pi_L - T_\pi)$ (1.80) (7.06)	1.31	0.875

/1 Estimated for 1959-66; data for 1958 was used where one year lags appear. Numbers in parentheses below coefficients are "t-ratios".

B. Identities (11)

1. $M = M_f + M_c + M_k + M_i + M_p + MOS + FPO$

2. $GNP = C_p + C_g + I_k + I_n + X + FPI - M + E$

3. $Y_p = Y_n - PCU - T_\pi - Y_g + T_{gp} + T_{wp}$

4. $Y_n = GNP - I_{ts} - S_d$

5. $FIP = FPI - FPO$

6. $K = K_{-1} + I_k - Sd_{-1}$

7. $I_k = I_o + I_m$

8. $I_{ts} = T_e + T_d + T_{oi} - SUBS$

9. $\Pi_L = \Pi - \Pi_f$

10. $GDP = GNP - FIP$

11. $Y_{pd} = Y_p - T_p$

ANNEX III: COMPARISON OF O.L.S. AND INSTRUMENTAL VARIABLES COEFFICIENTS /1

Equation	Dependent Variable	Intercept OLS	Intercept IV	Beta 1 OLS	Beta 1 IV	Beta 2 OLS	Beta 2 IV
1	M_f	-1.8913	-1.822	0.0935	0.0932/2		
2	M_c	-7.1417	-7.111	0.1545	0.1544/2		
3	M_k	-2.8283	-2.568	0.4369	0.4315/2	0.9901	0.9907
4	M_i	-0.6685	-0.8949	0.4208	0.4269/2		
5	FPO	0.1361	0.1360	0.5777	0.5777		
6	FPI	-2.8854	-2.8200	0.0444	0.0441/2	-3.8552	-3.7890
7	MOS	-1.0187	-1.147	0.0639	0.0643/2		
8	C_p	26.2672	25.2200	0.7979	0.8035/2	16.5347	16.1900
9	I_o	27.4685	27.4700	1.0822	1.0822	0.6350	0.6350
10	Y_{fm}	-8.9984	-9.1320	0.1659	0.1664/2		
11	Y_g	-0.3251	-0.3240	0.0029	0.0029/2		
12	T_n	-4.0711	-4.2750	0.3322	0.3384/2	-1.4063	-1.5370
13	T_e	-2.9983	-3.1140	0.2591	0.2622/2		
14	T_d	3.8679	3.6970	0.3336	0.3409/2		
15	T_p	-4.5793	-4.5970	0.0523	0.0524/2		
16	T_{oi}	-3.8385	-3.8530	0.0423	0.0423/2		
17	SUBS	-1.7304	-1.6960	0.0136	0.0134/2		
18	S_d	12.7536	12.7400	0.0412	0.0413/2		
19	PCU	-3.2458	-3.2110	0.5458	0.5447/2		
20	Π	4.1552	3.8040	0.9943	1.0040/2		
21	Π_f	3.6986	3.7260	0.2921	0.2914/2		
22	DIV	-0.0957	-0.0869	0.1089	0.1084/2		

Note: OLS refers to "ordinary least squares", IV to Instrumental variables and Beta to the estimated coefficient with respect to the independent variable.

/1 Instruments used: EAL, T, E, I_m.

/2 Endogenous variable.