

THE THEORY OF OPTIMAL FOREIGN EXCHANGE RESERVES IN
A DEVELOPING COUNTRY.

(with empirical application to the economy of Jamaica)

by

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IN A DEVELOPING COUNTRY

ABREGE

Le but de cette étude est d'établir un modèle permettant aux autorités de certains pays en voie de développement de déterminer le niveau optimum de réserves de devises que doivent conserver les institutions officielles. Cette analyse s'adresse aux pays dont la croissance est freinée par une insuffisance de ressources extérieures. Les réserves de devises étant une ressource extérieure potentielle, il découle que, lorsque la disponibilité de ces ressources extérieures limite le taux de développement, la politique adoptée à l'égard des réserves affectera ce taux.

Le modèle est établi à partir d'une infrastructure conceptuelle existante: le niveau optimum des réserves dépend du degré de sécurité présenté par les niveaux respectifs des différents fonds de réserve, et de la comparaison des dépenses encourues respectivement par les ajustements de la balance des paiements et par l'entretien des fonds de réserve. L'infrastructure théorique existante est ajustée à la lumière d'une explication économique (et non purement statistique) des phénomènes de régression utilisés pour estimer le degré de sécurité. Cette caractéristique établit une relation entre la projection des réserves et, d'une part les politiques monétaires et fiscales, d'autre part les perturbations ayant une cause extérieure.

Le coût de l'ajustement et des fonds de réserve est mesuré d'une façon nouvelle. Celle-ci découle du lien établi entre croissance et ressources extérieures. Contrairement aux méthodes utilisées dans les ouvrages antérieurs, les profits et pertes encourus au sujet des fonds de réserve sont mesurés en termes de croissance potentielle non réalisée.

Bien qu'on ait vu récemment un grand nombre d'études des réserves de devises, rares sont celles qui fournissent une méthode permettant de déterminer le niveau optimum de ces réserves pour un pays donné, à une date déterminée.

Notre modèle permet d'effectuer ce calcul de la façon suivante: Prenons comme exemple la banque centrale de la Jamaïque.

- 1° Nous établissons pour chaque niveau de réserve, un barème des valeurs du manque de croissance (croissance potentielle non réalisée pendant une période de planification donnée).
- 2° Nous établissons ensuite un barème semblable pour le coût des ajustements de la balance des paiements rendus nécessaires par un déséquilibre extérieur temporaire en l'absence de réserves.
- 3° Nous choisissons notre période de projection. Nous tiendrons compte de notre connaissance des valeurs prévues pour le revenu national, la dépense publique, les fluctuations de capitaux importés et exportés, afin de déterminer d'une part les niveaux de réserve possibles à la fin de la période envisagée, et d'autre part le quotient de probabilité associé à chaque niveau.

Ces niveaux de réserve assortis de leur quotient de probabilité respectifs seront ensuite introduits dans l'équation de calcul des dépenses. Le niveau de réserve correspondant à la projection de dépenses la plus basse, sera notre niveau optimum.

Dans une épreuve empirique pour la Jamaïque, le modèle se montre valable, et il a donné des résultats admissibles. Il fait penser, cependant, que les autorités jamaïcaines poursuivirent des politiques de réserve plutôt conservatrices, en protégeant des niveaux de réserve qui étaient un peu plus hauts que notre optimum estimé.

ABSTRACT

The objective of this study is to construct a model which can be used by the authorities of certain developing countries to determine the optimal level of foreign exchange reserves to be held by official institutions. We are concerned with countries where growth is constrained by a scarcity of foreign resources. Foreign exchange reserves are a potential foreign resource and therefore reserve policy will affect growth possibilities if foreign resource availability imposes a limit on the rate of growth.

The model is based on an existing conceptual framework: optimal reserves depend on the degree of security afforded by each reserve level, and on the comparative costs of balance of payments adjustment and of reserve stocks. The existing theoretical frame is extended by providing an economic explanation (as opposed to a purely statistical one) for the regression which is used to calculate the degree of security. This feature links the determination of reserve targets to monetary and fiscal policies and to externally induced disturbances.

New measures of the costs of adjustment and of reserve stocks are introduced. These derived from the link between growth and foreign resources. In contrast to previous work, the costs and benefits of reserves are measured in terms of potential growth foregone.

Although there have been many recent studies of foreign exchange reserves, there have been few which provide a method of determining the optimum level of reserves for a given country at a particular time. This can be achieved with our model as follows. Assume we are the foreign exchange authority of Jamaica. First, we construct a schedule of the opportunity cost (i.e. the growth rate foregone over a chosen planning period) of each reserve level; second, we construct a similar schedule for the costs of balance of payments adjustment policies which must be employed

if there is short-run external disequilibrium and no available reserves. Third, we fix the forecast period over which our reserve level is to be projected; we use our knowledge of desired levels of money supplies, government expenditure, capital inflows and exports to determine the possible levels of reserves at the end of the forecast period, and the probability associated with each level. These reserve levels, each weighted by its own probability, are substituted into the cost equation. The optimum reserve level corresponds to the minimum sum of these expected costs.

In an empirical test for Jamaica the model is shown to be feasible and to yield reasonable results. It does suggest, however, that the Jamaican authorities pursued rather conservative reserve policies, acting to protect reserve levels which were somewhat higher than our calculated optimum.

PREFACE

This thesis was conceived and written during my tenure with the Institute of Social and Economic Studies, University of the West Indies and the Central Bank of Barbados. I owe a great debt to my colleagues at both institutions for their encouragement, assistance and critical comment on my ideas as they developed. I wish to acknowledge financial assistance of the Institute and leave allowance from the Bank; both have proved essential to the completion of the work. I have received generous secretarial and statistical assistance; here I must express special appreciation for the efforts of Rosalind Alleyne and Julia Cutting in preparing the completed draft.

I have also been helped by the Centre for Developing Area Studies of McGill University, the Regional Programme of Monetary Studies of the Caribbean Economic Community and the Bank of Jamaica. The Centre provided some financial assistance and the Monetary Studies Programme has acted as a forum for the presentation of some of the ideas contained in this thesis; the Bank provided data and fruitful criticism at all stages in the development of the project.

The assistance of one's thesis supervisors is of course taken for granted. However, in one small but important respect my supervisors should be specially commended. They recognised the importance of the occasional small word of encouragement which in no way blunts the force of criticism but helps reinforce one's self-confidence just when it tends to falter.

In the final preparation my greatest thanks are due to my sister, Joyce Belgrave and to my friend and host in Montreal, Owen Johnson.

A preface of acknowledgements such as this is always incomplete. If one had the time and liberty to trace carefully all one's sources of inspiration and support, the history of the development of the project would go back a long way. But there are, after all, other times and occasions to acknowledge the debts which it would be inappropriate to express here. Let me merely say to those whose affection and confidence in me have helped to sustain the work that they are always in my mind.

The theory of foreign exchange reserves continues to excite a great deal of interest among economists, and a number of new contributions have come to my attention since the thesis was completed. These include an unpublished paper by R.W. Thompson¹ and articles by Makin², Claassen³, Agarwal⁴, Pereira-Leite⁵ and Baltensperger⁶.

Thompson discusses optimal reserves when a particular domestic stabilisation policy is specified beforehand. In our model domestic adjustment policies are not specified, so this represents a possible

¹R.W. Thompson, "The Optimum Level of Reserves for an Individual Country: the Canadian Case", Working Paper, Department of Economics, McMaster University, July 1974.

²J.H. Makin, "Exchange Rate Flexibility and the Demand for Foreign Exchange Reserves", Weltwirtschaftliches Archiv 1974 (2), pp. 229-242.

³E.-M. Claassen, "The Optimising Approach to the Demand for International Reserves", Weltwirt. Arch. 1974 (3), pp. 353 - 397.

⁴S. Pereira-Leite, "Optimal Monetary Reserves for Developing Countries" (note), Weltwirt. Arch. 1974 (2), pp. 344-8.

⁵J.P. Agarwal, idem (reply), pp. 349 - 351.

⁶E. Baltensperger, "The Precautionary Demand for Reserves", American Economic Review, March 1974, pp. 205 - 210.

extension of our efforts. Claassen introduces the possibility of discontinuous adjustment - a possibility mentioned but not developed in our Chapter Eight. Makin introduces exchange rate flexibility and demonstrates that greater flexibility reduces the variance of reserves. Agarwal and Pereire-Leite have an exchange over the importance of holding reserves as an inducement to foreign investment, with Agarwal taking the view that it is overall economic performance which attracts foreign investment, rather than reserves as such. Baltensperger introduces the cost of acquiring information in order to predict reserve movements more accurately as a factor in the optimisation of reserve levels.

Each of these articles makes a contribution to the development of a more comprehensive and realistic model of reserve optimisation. They do not, however, contain anything which calls for a revision of the model we have advanced.

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CHAPTER 1

General Statement of the Problem

The intention of this study is to devise and test a method of calculating the optimal level of foreign exchange reserves in a particular category of developing countries. This category consists of countries with a fixed exchange rate whose development is constrained by the scarcity of foreign resources. The method requires that the competent authority in any given country stipulate a normal period for projecting reserve requirements (say six months) and the period of the current economic development plan (say five years). Using this and other information derived from the structure and recent performance of the economy, the model presented in this study can be used to determine the level of reserves which is optimal for the country. This exercise is performed for the Jamaican economy as a means of demonstrating the feasibility, scope and limitations of the model.

This thesis derives its inspiration from the recent considerable interest in the question of international liquidity. There has been much discussion and research into the adequacy of international liquidity - and, more recently, its abundance - as well as the composition of the supply of liquidity. While a great deal of this debate has focussed on the global issues - regarding the world as a whole - there has been a great deal of interest in the liquidity of individual countries as well. These two aspects are clearly related very closely to each other, for the reserve requirement of each country will, together with trade, exchange rate, monetary and fiscal policies, help to determine the adequacy of world liquidity.

In this study the question is viewed from the single-country aspect. Insofar as reserve requirements as derived from our model differ from those obtained from alternative rules, the results will have implications for the global analysis, but this is a matter for future exploration. Also, the study

deals with a fixed exchange rate, whereas floating rates are an option which has to be taken into account in the global analysis. Although we do not investigate floating rates at length, we argue that there is no reason why the principles on which we compute optimum reserves would be rendered invalid by floating rates. (However, if floating were a recent experience it would be some time before the empirical requirements of the model could be satisfied).

The reason we make a distinction between countries where the availability of foreign resources is a growth constraint and countries where this is not the case, is that foreign exchange reserves may be considered a potential foreign resource. Since, rather than hold foreign financial assets, the country may choose to acquire additional goods and services from abroad, the holding of reserves has implications for the rate of growth. In the chosen class of countries, therefore, the costs and benefits of holding reserves will have significant functional relationships to the growth rate. This has not been the measure usually employed, and our argument is that other measures are less appropriate to the special case we are considering. Different measuring rods will lead to different results, and reserve requirements derived by other methods would be non-optimal in the sense that they would not secure the greatest possible rate of growth for the country. If maximising growth is the principal economic objective (we do not argue that it should be, but rather infer that it is) then alternative measures of cost benefit are less appropriate.

In the Commonwealth Caribbean, foreign exchange reserves have received much attention, beginning in the 1950's with the debate on the Currency Board system. The Currency Board is still in operation (in modified form) in the smaller territories of the Eastern Caribbean, though it has now been replaced by Central Banks in Jamaica, Trinidad and Tobago, Guyana and (most recently)

Barbados.

The various Currency Boards were responsible for the issue of currency in the colonies of the British empire. They operated within very narrow limits, and one of the stipulations was that domestic currency could only be issued if there were sterling assets of an equivalent amount in the Board's portfolio. This 100 percent reserve system came under heavy attack from economists¹ who felt that there was no economic justification for holding such large stocks of foreign assets in economies critically short of foreign assets. The debate on appropriate levels of reserves has continued into the Central Banking era in the Caribbean. It has been argued that conservative Central Banking policy has perpetuated the Currency Board practice of holding reserves larger than strict economic rationale would dictate.

The present study is a child of this debate. On the one hand it provides, conceptually, a means of measuring the sacrifice economies which are short of foreign resources must make in order to hold reserves. On the other hand it shows how various levels of foreign reserve holdings are justified as a precaution against fluctuations in foreign exchange receipts.

The Background: Summary of Important Developments in Reserve Theory.

The area of foreign exchange reserves has, in recent years, been one of the most heavily researched by economists both at the practical and theoretical levels. This is understandable in the light of current concern over the international payments system. A number of insights have evolved from the activity of economists in this field, and these are incorporated in our approach

¹ See C.Y. Thomas, Monetary and Financial Arrangements in a Dependent Monetary Economy, p.21, where a list of the early protagonists is given; also Wendell McClean, Money and Banking in the East Caribbean Currency Authority Area, pp. 34-35.

to the question of desirable levels of foreign exchange holdings. In what follows we give a brief outline of the most important ways in which our study shows its debt to recent explorations in foreign exchange theory.

Firstly, the notion that reserves should be related solely or principally to the level of imports has been severely criticised. The notion still retains some currency with the international financial institutions and central bankers, but it is discredited by most others. Essentially the argument is that it is the variability of net foreign exchange transactions, and not the level of foreign payments, which is the important determinant of reserves. Reserves are, after all, not used to buy imports. In an equilibrium situation, on the contrary, imports are paid for out of foreign exchange earnings, with no change in reserves. Reserves are held against the possibility of a (reversible) deficit in foreign exchange earnings, and are therefore properly a function of the occurrence of such deficits, i.e. the variability of foreign exchange earnings relative to foreign exchange expenditure. This is the approach taken in our model, and it is developed in some detail later.

Our approach also owes a debt to the cost-benefit analysis of reserve holdings which has characterised many recent studies. There is a cost of holding a reserve stock, which in other cases is taken as an income sacrifice, and in our case is taken to be a growth sacrifice; and there is a benefit of reserve holding, in that the country may thereby avoid the costs of income variability or, in our case, the distortions and disruptions which are a consequence of adjustments forced on the country by reserve exhaustion.

Our analysis follows the trend towards the use of statistical method in the description and prediction of reserve levels and variability. Since reserves are in the nature of a contingency fund, it follows that they should be related to developments which are expected to occur over the future time period for which reserves are to provide cover. A regression model with

predictive powers is a standard means by which we may arrive at expected values of such a variable, together with probability associated with other values in the region of the expected value.

Reserve management has to be seen in the context of a range of other policy tools which may be used for short-term balance of payments accommodation. Some recent models have approached the question from the point of view of an optimal choice of policy instruments. We have eschewed this approach, mainly because of the high degree of abstraction required. We have, in the formal statement of the model, followed the more common practice of comparing reserve adjustment with only one alternative, that is internal adjustment by way of income and expenditure. However, we discuss at some length how the effects of alternative policies may be incorporated in any practical exercise aimed at establishing the desirable levels of foreign exchange reserves.

These advances in the theory of exchange reserves should help to elucidate historical patterns of reserve changes, but, perhaps more importantly, they should provide the basis for more rational reserve management. It is necessary to warn, however, that there remain serious areas of difficulty. Existing statistical theory leaves grave weakness in all the predictive models available (including our own) and the theory of the determinants of reserve changes is still badly underdeveloped. In spite of these deficiencies, we trust that the current exercise does make a meaningful contribution to the goal of rational reserve management, and that this will become evident when the ideas which have only briefly been introduced so far are elaborated in later chapters.

Introduction to the Model

The need for foreign exchange in a "developing" country is widely accepted and fairly well understood. Development typically requires substantial inputs of foreign resources at some stage, and it is therefore necessary to generate earnings of foreign currency with which to procure these inputs.

The need for foreign exchange reserves is a slightly different matter.

This is foreign exchange which is not to be spent to satisfy current foreign resource needs. It consists of foreign currencies, securities of foreign institutions (public and private), gold, subscriptions to the International Monetary Fund and allocations from the IMF which form a kind of inventory of foreign exchange. Why hold this fund of foreign exchange in reserve?

It cannot be simply that there is no other use for the fund. Clearly it could be used to buy machinery, fertiliser, expertise, fuels, etc., from abroad. These are urgently needed items. If reserves were used judiciously to acquire such items, the rate of development in the country could undoubtedly be speeded up.

Why should the possibility of accelerated development be sacrificed so as to hold funds in reserve? Simply because the monetary and exchange authorities anticipate that there will be times, when, for some limited period, the country will be unable to cover its "normal" foreign exchange requirements. Reserves are then employed to tide over this period.

It would be irrational, nonetheless, to make the sacrifice involved in holding reserves if the failure to meet "normal" exchange needs were a matter of little consequence. Similarly, holding reserves would be unjustified if other means could be found to correct the situation without incurring a sacrifice of growth potential.

The study therefore hangs essentially around these three factors: the cost of holding foreign exchange reserves, the consequences of not holding foreign exchange reserves (when there are no alternative measures) and the availability and cost of alternative measures.

Let us assume a position of (dynamic) equilibrium on the foreign exchanges. That is to say, earnings of foreign exchange each year are sufficient to pay for the foreign resources required for that year. How do we go about deciding how much foreign exchange should be held in reserve?

The first thing to decide is what are the possibilities that the country will be faced with a temporary foreign exchange crisis. Evidently if there is little or no risk of such a contingency, few reserves are needed; and conversely, high risk will indicate a need for substantial reserves:

This question of estimating risks is difficult and to some extent intractable. We cannot really predict with any accuracy when export prices will take a dip, when natural calamities will strike and when policies of foreign governments and institutions will put export earnings in jeopardy. And yet it is factors such as these which will reduce the capacity to import from its target level.

The major section of the study deals with this problem of prediction. What may be said at this point is that the reserves are not a cover for any and all crises in the balance of payments. If the inability to import derives from some basic cause which is expected to persist, then the use of reserves is clearly inappropriate; for, in that case, the reserve stock would be exhausted and still the country would be faced with the problem of a gap between its foreign exchange earnings and foreign exchange requirements. Therefore, we will not try to anticipate what economists usually refer to as "fundamental" disequilibria. Reserve management cannot alleviate such imbalances; reserves are directed towards short-term accommodation. In assessing a desirable level of reserves, therefore, we are concerned with the likelihood of short-run disturbances only.

The probability of short-run balance of payments disturbances is determined from the pattern of past transactions. These transactions are in turn measured by movements in foreign exchange reserves. The movement in foreign exchange reserves presents a mirror image of the net transactions balance, by virtue of the balance of payments accounting identity. Thus, in order to derive the probable movement of net foreign transactions in

forthcoming time periods we propose to extrapolate from recent trends in reserve movements, constructing an interval estimate for the expected value of reserves at the target date by means of standard statistical techniques.

What we suggest is that policy makers should use certain economic indicators to predict the probable movements of net foreign exchange reserves. A priori we believe that the following economic variables are important in explaining whether net earnings of foreign exchange are positive, zero (the "equilibrium" case), or negative: the money supply, net inflows of foreign capital, government expenditures and export earnings. We try to establish the empirical links between these independent variables and the dependent variable, reserves. So that if we know or can reasonably predict the values of these variables, we can then calculate a value for net foreign exchange reserves.

As is usual with predictions, we will not be able to say with certainty that reserves will attain a particular value. Rather we wish to assign a probability weight to each possible value of reserves at the target date. We go on to argue that each level of reserves will incur a certain cost which is proportional to that level. The probabilities above are used to weight the cost of each level of reserves in accordance with the likelihood that this amount of reserves will be required to make up the foreign exchange deficiency. The logic of this formulation is that the authorities will wish to hold only such reserves as are necessary to meet the expected deficit, since excess reserves are not costless. If there is only a small probability that a certain level of reserves will be needed, then the authorities will be reluctant to undertake the cost of reserve holdings. Conversely, if the probability is strong, there will be greater incentive to hold reserves at the required levels, because, as we shall see, there is also a cost to reserve exhaustion.

The level of risk to be undertaken will be governed by the remaining factors to be analysed: the comparative cost of exchange instability and reserve holding, and the availability and cost of alternative measures.

Neglecting for the moment the use of alternative policies, let us compare the consequences of not holding reserves with the costs of reserve holding. We demonstrate how, in theory, both alternatives can be measured in terms of potential growth sacrificed. In the case of reserve holding, under certain restrictions, we can make a direct link between growth rates and foreign exchange needs. For instance, we know that there is an excess demand for food, hence some food must be imported; a certain rate of industrial expansion will require intermediate and capital imports of a given amount; and so on. By aggregating the industrial and basic consumption requirements we can estimate foreign resource needs, under stated assumptions about domestic supply conditions. From this we can infer the growth sacrifice required to immobilise resources in a foreign exchange reserve fund.

Measuring the cost of not holding reserves is more difficult. If external equilibrium is maintained, then there is no cost whatever. However, if a country does face disequilibrium, then it will have to resort to measures which will force it to 'live within its means'. These measures, it is argued, will reduce growth potential. For example, it may be necessary to postpone the purchase of expensive but necessary transport equipment, fuels and so forth. If such measures are widespread, it is reasonable to presume that the rate of growth will be affected. What is more, the expectations of private local and foreign decision makers may be adversely affected as well. People may begin to lose confidence in the economy, capital inflows will drop, and investment activity in general will decline. This will, of course, reinforce the fall in the rate of growth. The conclusion is therefore drawn that the cost of not holding reserves is, if there is a disequilibrium, a

sacrifice of potential growth.

The argument needs to be modified because of the following factors:

(a) it depends on the assumption that no alternative means of insulating the economy against temporary disequilibria exist. This is clearly an unrealistic assumption. Loans, lines of credit, stand-by and other arrangements for deferring payments are standard means, readily available, for meeting temporary disequilibria;

(b) it assumes that shortages of foreign exchange will affect all imports equally; or alternatively, that all imports are important to the growth process. In fact, one can establish a hierarchy of imports, starting with those which are most essential to the growth process and ending with "luxury" items. Shortages of foreign exchange can then be regulated so as to impinge first on the last-mentioned items, moving gradually back along the scale as the squeeze becomes tighter. With respect to short-run disequilibria, it is in the nature of this case that we should rarely have to move very far back along the continuum;

(c) the argument, though valid, may have empirical significance only in the case of large and persistent disequilibria. In such cases, as we have earlier pointed out, foreign exchange reserves are not the appropriate corrective. Other instruments of planning and policy are required to deal with this entirely different (and decidedly more important) question.

To return to the main outline of the discussion, we now have a link between reserve holdings and the growth rate, and a second link between zero reserve holdings and the growth rate. The former sacrifice is incurred with certainty; that is to say, whenever we hold reserves, we incur the cost. The latter

sacrifice is incurred in different measure with different probability; that is to say, there is certain probability that net exchange earnings will be either positive or negative close to zero, so that no cost is incurred. But larger shortfalls in net earnings, associated with other probabilities, will incur positive costs of growth sacrifice.

The policy maker must choose a level of reserves which will minimise the expected growth sacrifice by manipulating the level of reserves and the level of risk. Before making his choice, however, he must consider the alternatives for accommodating balance of payments disequilibria. The use of such alternatives may substantially reduce or eliminate the risk of instability leading to growth sacrifice, even if we have no foreign exchange reserves. In such a case, the need for foreign exchange reserves may be reduced to near-zero. However, this is the case only if the alternatives are themselves costless, which typically they are not. A third cost element, the cost of alternative policies must therefore be introduced.

What can we do to prevent instability if we find ourselves temporarily short of foreign exchange? We can appeal to overseas suppliers to extend lines of credit, we can borrow short-term funds abroad, we can ration the exchange we do have, we can sell foreign exchange at rates which discriminate against certain types of foreign transactions, we can restrict imports by ban, tariff or quota, we can reduce the domestic money supply, or we can combine any or all of these policies.

Costing these alternatives in terms of the growth rate is quite evidently going to be a very complicated business. We can mention some factors which contribute to the complexity. One is the problem of deciding on the best mix of all these alternatives. A second is that some possibilities may not always be open (short-term loans, for example) and some alternatives are not practical (some kinds of rationing may be beyond the administrative capacity

of the authorities to enforce). Thirdly, some alternatives may be available only on a restricted basis. Restrictions may, in the case of some loans, come in the form of specified policy measures to be taken; in other cases, credit may be available from some suppliers and not from others. A fourth consideration is that the nature of the balance of payments disturbance may rule out some alternatives. An example would be speculative outflows of capital; import restrictions are probably an inappropriate corrective measure.

Although it will not be possible to develop rigorously a minimum-cost policy package, we can be sure that what we may call the "passive" policy of non-intervention represents the maximum cost alternative to holding reserves. It will usually be possible, by judicious use of alternative policies, to reduce the growth sacrifice implicit in the "passive" policy; if we neglect the possibility of inappropriate policy, we need never increase the growth cost. Analysis which compares foreign exchange reserves with zero reserve policy and no corrective measures will typically overstate the need for reserves.

Briefly, then, our approach to rationalising holdings of foreign exchange is as follows. First we ask what is the growth sacrificed by holding reserves, and we measure this by estimating the foreign resources needed for any rate of growth. Then we estimate the growth sacrifice consequent on a zero-reserve holding, "passive" policy, analysing the arguments for induced instability, induced allocative inefficiency and loss of confidence as factors reducing growth. Weighting these costs at each reserve level by the appropriate probability and comparing, we can arrive at a minimum-cost level of reserve holding. Finally, we examine the alternatives which might constitute an "active" zero-reserve policy to see how the growth sacrifice of the "passive" policy might be reduced. We should thereby be able to evolve guidelines towards a realistic policy of foreign exchange holdings.

A 'Guided Tour' of the Study.

The remainder of Chapter One is devoted to definitional questions. Chapter Two gives a brief word-picture of the Jamaican economy and recent developments; it is intended mainly to give background information for readers unfamiliar with the economy. It does not advance the argument as such. In Chapter Three we present a critical review of previous studies of the theory of optimum foreign exchange reserves.

Discussion of the model is resumed in Chapter Four, where all the pieces are fitted together in an outline of the overall formulation. This outline is fleshed out in Chapters Five and Six which deal respectively with the determination of risk and the measurement of the costs associated with various levels of reserves and other means of accommodating foreign payments disturbances.

Chapter Seven provides the test of the preceding three chapters. In it the model is quantified by (a) calculating the degree of risk, (b) drawing up schedules of costs and (c) bringing these elements together in a single equation which expresses the expected cost of every level of reserves as a function of the rate of growth of the economy. This equation is graphed and its minimum point determined; that point is defined to be the optimal level of reserves.

Chapter Eight deals with extensions, modifications and reflections on the model, its assumptions and the results obtained. Chapter Nine contains a brief recapitulation and assessment of the usefulness of the exercise.

Vocabulary of Foreign Exchange Analysis

Throughout the study we will encounter a variety of terms such as 'balance of payments deficit', 'net foreign exchange earnings', etc. Much confusion can arise when such terms are used ambiguously; to avoid this we will explain the use of our terminology at this point.

The Balance of Payments

We should mention, by way of introduction, that there is still no generally accepted definition of what represents a balance in international payments. Machlup¹ has shown that variations in the definition of the U.S. balance of payments can convert large surpluses into deficits. Definitional problems of the same order do not arise in Jamaica; for one thing, there is a small variety of transactions, particularly on capital account; and the U.S. situation is complicated by the fact that the U.S. dollar is a "reserve" currency.

We should nevertheless anticipate some problems in the definition of the balance of payments in Jamaica. Such a problem is the valuation of exports. In 1970, it was agreed between the government of Jamaica and the bauxite companies that exports of the bauxite industry should be revalued. Price rises of 92 percent (bauxite) and 36 percent (alumina) were agreed on, retroactive to 1966. Appropriate adjustment in the balance of investment income and reserves (as a result of retroactive tax payments) would ensure that the balance remained unchanged², but the level of foreign transactions recorded would have increased.

¹ Fritz Machlup, "The Mysterious Numbers Game of Balance of Payments Statistics", in International Payments, Debts and Gold, N.Y., Scribners, 1964.

² The revaluation would affect only government revenues from the bauxite industry. When these payments are made, the reserves of the Bank of Jamaica rise (at least temporarily). In making up the balance of payments accounts, we have two choices. The additional foreign exchange may be pro-rated for each of the years affected. In this case, once we include an additional sum of investment income accruing abroad on the bauxite industry account, we should get back to the pre-revaluation balance. This is the assumption made in the text. If we were to adopt the alternative of recording the full amount of tax payments in the year of revaluation, then there would be a difference between the pre- and post-revaluation balance for 1966 through 1969. But this could in any case be accommodated by including a special item in the accounts for each year.

A second problem which has direct bearing on our analysis is the treatment of speculative capital flows. There are, from time to time, indications that significant flows of speculative capital are taking place. Consider the following data on 'unidentified net capital movements' extracted from a Bank of Jamaica publication¹.

	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>
\$Jmn.	3.5	-4.4	-4.8	-18.3	-3.5	-8.8	-5.4	14.6	-7.7

Recall that 1967 was the year of devaluation of the pound sterling and the Jamaican dollar. This certainly raises the question of speculative capital movements hidden in the unusually large negative balance of 'unidentified' capital movements.

The question which now arises is, how much error, if any, is introduced in the analysis by the presence of this speculative element of capital flows. We argue that for the purposes of the present analysis, the inclusion of speculative movements 'above the line' is desirable. It would seem that speculative capital movements are legitimately netted out when dealing with medium and long-term movements in the foreign exchange balance. However, in our case, foreign exchange balances are being used to help anticipate short-run movements in the foreign exchanges. Insofar as speculation is an important cause of such movements, its effect should be incorporated.

Bearing these qualifications in mind, we accept the balance of payments definition used by the Bank of Jamaica. 'Balance' means that there are no changes in foreign exchange reserves. All other items in the foreign transactions account are considered autonomous and are placed 'above the line',

¹ Research Department, Bank of Jamaica, Balance of Payments of Jamaica, 1964-70; 1972.

in accepted balance of payments terminology. This is consistent with the argument that speculative capital flows should be treated as cause rather than effect of balance of payments fluctuations, but it fails to make any accommodation on the question of export valuation. Further data refinement is required before we can deal with this issue.

Equilibrium

Next we tackle the problem of defining equilibrium. The concept which seems most relevant to the Jamaican experience is a 'dynamic, programming equilibrium'. By equilibrium we mean a situation in which earnings of foreign exchange are sufficient to cover commitments in foreign exchange for the given accounting period. By dynamic we mean that the levels of foreign exchange earning and spending are not expected to be the same from period to period. And by 'programming' we mean that the equilibrium is to be calculated on the basis of sources and uses of foreign exchange derived from a stated development programme¹.

We face some difficulties when we try to put these definitions into operation. One such difficulty is the choice of accounting period. Suppose we look at annual data. We may find balance in the accounts in each successive year - an "equilibrium" situation. The same data may yield continuous "disequilibrium" if our accounting period is one month, however. We shall, in fact, be using monthly series, but our analysis will be based on projections six months ahead. In terms of our definition, then, our accounting period is

¹ See Machlup, "Three Concepts of the Balance of Payments" in International Payments, Debts and Gold. The terms 'accounting', 'programming' balance are borrowed from this article.

six months¹. If the cumulative monthly deficits and surpluses sum to zero over each half-year, then we have "equilibrium".

We do not attempt the calculus from which sources and uses of foreign exchange could be derived. Strictly speaking, therefore, our analysis does not conform to the definition of 'programming' balance, unless the indicators which we do employ² accurately reflect the country's development programme. If government control over the economy during the period of analysis were total, and if policies were not directed specifically towards conserving or expanding foreign exchange, then our conclusions would be valid.

We do not expect in practice to find the foreign exchanges in equilibrium. There will usually be some net balance at the end of every period. Positive balances will lead to reserve accumulation; accumulated reserves are used to accommodate negative balances. The existence of continuous disequilibria is the rationale for holding foreign exchange reserves. This leads to the question of "temporary" as opposed to "fundamental" disequilibria. Reserves are directed towards the former, not the latter.

In ex-post facto analysis we can always identify a fundamental disequilibrium by the threat of reserve exhaustion, given that we started with an adequate reserve stock (as defined elsewhere in the study) and given also that no corrective measures are taken. There is, of course, a very small probability that purely random variations may lead to the exhaustion of an adequate reserve stock, but we have reduced this probability to levels which we can neglect³.

¹ The choice of an accounting period is not crucial. Six months probably corresponds most closely to the longest period over which the foreign exchange authorities in Jamaica would feel confidence in their projections.

² Money supplies, capital imports, government expenditures, and exports.

³ See Chapter Four.

Any tendency to exhaust reserves within our time horizon would thus indicate a fundamental disequilibrium. Thus reserve adequacy can be used as a test of fundamental disequilibrium.

We cannot make use of this to define fundamental disequilibrium, nonetheless. The reason is that to determine reserve adequacy we make use of the distinction between temporary and fundamental disequilibria.

Consequently, while the above notion is useful in some ex-post facto analysis, for definitional purposes we must go back to the source of the imbalance. A fundamental disequilibrium derives from inconsistency in national aspirations as they affect foreign transactions. With the aid of a suitable comprehensive description of the economy, we can estimate total foreign exchange earnings, using the definition earlier established for balance of payments credits and debits. We compare foreign exchange earnings with the foreign resource needs which the economic model forecasts, using the same balance of payments definitions. A persistent inability to meet the foreign exchange needs, even with the aid of autonomous capital inflows, would be evidence of a fundamental disequilibrium.

Temporary disequilibria derive from quite different circumstances. Strikes in crucial sectors or industries, for example, can reduce foreign exchange earnings and lead to disequilibria. The effect of an unusually dry (or unusually wet) crop season, the emergence of some new disease in some area of agriculture, the effects of an election year (which invariably brings a slow-down in economic activity) may all cause a shortfall in foreign exchange earnings which will last for a while but will permit a return to the expected levels of exchange earning when the crisis is over.

Some considerable judgement is evidently called for in deciding whether to label any disturbance 'fundamental' or 'temporary'. Should the effect of a natural disaster, such as a hurricane, be considered temporary or fundamental?

This particular example is of great relevance to Jamaica. A clue to the treatment can be derived from considering what policies would be considered appropriate for dealing with the situation and whether the effects of the particular disturbance have altered economic parameters sufficiently to cause a revision of the long run projections of foreign receipts and payments.

We are interested principally in the policy implications of the distinction between fundamental and temporary disequilibria. A fundamental disequilibrium can be tackled only by means of import substitution, shifts in export production, changes in parameters such as the propensity to import, changes in production structures and production techniques which economise on the use of foreign resources and so on. Contingency measures such as precautionary reserves are useful only if the balance of payments disequilibrium is temporary.

We use the terms imbalance and disequilibrium equivalently. There seems to be no objection to this so long as we are talking about ex ante balances. We do not anticipate zero balances unless the exchanges are in equilibrium.

An imbalance is the same thing as a deficit or surplus on the balance of payments account. The term net foreign exchange earnings is also used to mean the same thing. These terms all refer to the sum of net payments (debits minus credits) on each and every item of the balance of payments account, with the sole exception of the item 'Change in [Foreign Exchange] Reserves'¹. From the nature of the balance of payments accounts, it follows that the change in reserves is also equivalent to the deficit/surplus-imbalance-disequilibrium-net foreign exchange earnings, but with the opposite sign.

¹ See Bank of Jamaica, Balance of Payments of Jamaica, Table 1, 'Balance of Payments summary'.

From time to time we speak of the 'demand for foreign exchange reserves'. We mean by this the difference between the expected level of reserves at some future period and any other value of reserves which might actually occur at that time. That is to say, we project that reserves will attain a certain value at a particular time, but because of uncertainty, other values are possible. The demand for foreign exchange reserves is the difference between the expected value and each of these other values. For any one chosen expected value, the demand is a (random) variable, assuming many values. While this terminology may be unfamiliar, its usage should become clear from the analysis of Chapters Four and Seven.

Other terms used from time to time, such as 'target level of foreign exchange earnings' and 'normal foreign exchange requirements' should be understood to mean that these levels are derived from the development programme (or, in our case, from knowledge of money supplies, government expenditures, capital inflows and exports). Similarly, a balance of payments crisis refers to a disequilibrium, usually fundamental¹, which involves a deficit rather than a surplus.

The Definition of Foreign Exchange Reserves

Our analysis is concerned with the problem of short-run demand for exchange reserves. It follows that the appropriate definition of reserves must include all foreign assets which are available to the public at short notice. Or, to be more precise, the value which acceptable external assets

¹ The context will show whether or not it is fundamental.

would realise if they must be redeemed at short notice. Thus our definition should include both long- and short-term securities which are marketable, but the appropriate valuation must be the current market value.

There are two problems which present particular difficulty in applying this definition. These relate to the question of "tied" assets and the treatment of privately held foreign assets and liabilities.

The problem of tied assets arises because some portion of the total foreign assets is invariably committed in advance, and cannot be used to finance balance of payments deficits. Let us look more closely at some ways in which this commitment arises and the ways in which it can affect the analysis.

Some deferred commitments may derive from the nature of capital movements. Capital movements may be classified according to their source and method of payment. Some transfers are effected within the framework of multinational corporations. If the capital inflow is to be spent on imports, we have no increase in reserves; if the capital inflow finds its way into the domestic expenditure stream, reserves are unequivocally increased; as this increase in expenditure generates additional income, however, imports will rise. This is by no means a negligible consideration in the Jamaican economy where capital inflows of the order of \$100 million (Ja.) have recently been recorded, and where marginal import propensities have been estimated in the region 0.8.¹ A capital inflow increases the 'free' reserves in the system by its own value net of all induced import charges. Hence we should deduct induced consumption imports as well as induced capital imports.

¹ See Chapter Seven.

We can ignore this problem only if capital inflows do not create a noticeable impact on national income, if marginal propensities are low, if capital inflows are maintained at a stable level or if the import effects are instantaneous.

It is unlikely these conditions will obtain in Jamaica. Since 1951, capital inflows have constituted a substantial proportion of domestic investment in the country in every year except 1963¹. In years when producing facilities were being expanded in the bauxite industry (e.g. 1955/6 and 1968/9) foreign capital outweighed domestic capital in the proportion of its contribution to capital formation. As far as marginal propensities to import are concerned, the extraordinarily high figure for Jamaica was noted in the last paragraph.

The third factor which might mitigate the effects of deferred foreign exchange commitments on our analysis is stability in the pattern of capital inflow. Again this is a condition which is violated in Jamaica.

The years of massive capital inflow (1968-72) were preceded by years of more moderate inflow. If the impact of imports were instantaneous, this would cause no problem, since there would be no net change in the reserve position. However, in the more usual situation, reserves will rise² as the foreign funds are disbursed, only to fall later as import expenditures

Net Capital Movements	
	\$ Ja. mn.
1964	14.9
1965	11.8
1966	46.7
1967	64.9
1968	114.4
1969	91.7
1970	139.5
1971	174.8
1972	109.3

Source: Bank of Jamaica,
Balance of Payments of
Jamaica, 1964-72

¹Owen Jefferson, The Post-War Economic Development of Jamaica U.W.I. 1972, p.189 and Jamaica Economic Surveys, National Planning Agency, 1970-73.

²Private as well as official reserve holdings.

occur. In theory, there would seem to be two ways of solving the problem: either choose a long period of account or net out the expected increases in imports. In practice, neither solution will be possible in our case. We have elected to use a monthly series for a number of other reasons, and the difficulties of estimating accurately the import impact of a particular capital inflow are such as to make this exercise of dubious value.

A different problem of 'tied' reserves arises from the presence of sinking funds and other amortisation accounts held overseas. Again these funds, though they appear in foreign exchange accounts, are not 'free' reserves which can be liquidated to meet unforeseen disturbances in the balance of payments. These committed funds should be deducted from the foreign reserves total.¹

A more intractable problem in Jamaica derives from the establishment of special exchange accounts as 'securities' for foreign loans. In order to secure loans in a tight foreign market, agreements were made whereby special accounts are held in foreign securities with specified institutions. These special accounts are not sinking funds, since they are not intended for use in amortising the debt (except presumably in 'unusual' circumstances). Nevertheless, it is not evident how they could be utilised for balance of payments purposes. It would appear, therefore, that these special accounts ought to be deducted from the 'free' reserves total as well.

The second definitional controversy concerns the treatment of the

¹ This is done in the Bank of Jamaica's published series since 1968; problems of valuing the sinking fund contributions preclude correction for earlier years.

foreign assets and liabilities of the private sector. For all practical purposes this means the commercial banks, since no data is available on the foreign assets of other private institutions. The question is whether we should include private foreign assets and/or liabilities in reserves as defined for our purposes.

To what extent are privately held foreign assets available to meet balance of payments contingencies? To what extent do private foreign liabilities represent a commitment of foreign exchange reserves? It is clear that the banking system can supply external liquidity to assist in meeting a short-term balance of payments crisis. What is not clear is whether the amount of such financing bears any relationship to foreign assets or liabilities at any particular time.

It is possible, for example, that stocks of foreign assets would be run down to create credits for external payments in favour of customers whose revenues were temporarily reduced because of the effects of export instability. It might, therefore, be argued that the commercial bank's foreign assets are legitimately a part of the nation's unconditional liquidity.

The foreign liabilities of commercial banks present a more difficult problem. On the one hand it may be argued that these liabilities are a charge on the foreign exchange reserves and must therefore be deducted before we can arrive at a true figure for 'free' reserves. On the other hand, there is reason to believe that banks are willing to run up foreign liabilities to fairly substantial levels to finance a balance of payments deficit provided their confidence in economic management were not shaken. If this is so the unconditional liquidity available to the country from the banking system does not consist only of the bank's foreign assets; there should be added an amount equal to the maximum foreign liability that the banking system is prepared to sustain. The situation is analogous to that of the monetary

authorities. Their foreign liquidity includes any unconditional lines of credit as well as their foreign exchange holdings.

The key to resolving this issue must be in empirical study. We need to have specific information on two questions : (a) what level of foreign liabilities is considered "normal" by commercial bankers? (b) would this norm be the same in times of balance of payments

disequilibrium; would the banks be prepared to raise their ceiling of foreign indebtedness or would they feel compelled to lower it?

Evidence on the commercial bank's liabilities is inconclusive with respect to "normal" levels of liability. There has evidently been a change of policy since the establishment of the Bank of Jamaica. Previously, negligible foreign liabilities were held abroad, but since 1961, year-end figures have been substantial. However, it is not clear that any norm has been established. Roughly speaking, there were two periods 1964-66 and 1969/1970 when liabilities were of the order of \$25-\$30 million; in the other years \$10-15 million seems a more characteristic figure. What can be said is that there is only one assumption which would justify subtraction of the full amount of foreign liabilities from

Commercial Banks' Foreign Liabilities	\$J. mn.
1953	0.6
1954	0.2
1955	0.4
1956	0.7
1957	2.7
1958	3.3
1959	4.5
1960	7.7
1961	16.0
1962	10.8
1963	12.4
1964	25.4
1965	32.4
1966	24.0
1967	16.6
1968	14.6
1969	28.9
1970	37.9
1971	17.4

Sources: Bank of Jamaica, Statistical Digest, and International Financial Statistics

the total reserves; the assumption that a balance of payments disturbance would cause commercial banks to react by reducing liabilities to zero. This would seem to be highly unlikely. No foreign liabilities should be subtracted from the total, on this argument, unless the current levels of foreign liability were in excess of the maximum the banks were prepared to sustain. On the contrary, if current foreign liabilities were less than this maximum, then an amount should be added to unconditional reserves. This amount, the difference between current foreign liabilities and their maximum, would represent the willingness of the private sector to provide additional foreign liquidity if it were needed.

We may pause briefly to note the quantitative and qualitative significance of the inclusion of commercial bank's net assets in the reserve series. In the first place, we reduce the apparent level of reserves by including this item¹. This is true of all but four months in the series since 1965. Secondly, commercial bank's foreign transactions appear to follow the same seasonal pattern as official reserves, so that there is no change in the shape of the series. However, the amplitude of variations appears to be much higher for the commercial banks, and this is aggravated by what appear to be discrete shifts in the levels of foreign liabilities, (for example, from November 1969 to January 1970).

The Bank of Jamaica definition of foreign exchange is used for the most part, but we usually omit the foreign assets and liabilities of the commercial banks. The reserves therefore consist of Sterling securities (mainly securities of the U.K. government), small amounts of U.S. government

¹ i.e. the commercial banks' net assets have been negative

securities, time deposits with commercial banks in the U.S. and U.K., the IMF gold tranche, Special Drawing Rights with the IMF, and small amounts of currency and money on call.¹ In some cases the net foreign assets of the commercial banks are included for comparative purposes, but nothing can be done to take account of deferred commitments on foreign exchange in the private sector.

¹ Bank of Jamaica, Balance of Payments of Jamaica, 1964-70 p. 27

CHAPTER 2

A Survey of the Jamaican Economy

The most remarkable feature of post-war development in Jamaica has been the emergence of the bauxite-alumina industry. In 1945 the economy derived its economic impetus mainly from export agriculture, though there was some tourist development and some food production for the local market. In 1952, however, bauxite mining began, and Jamaica rose rapidly to become the world's leading producer. Bauxite and alumina now constitute the island's principal exports, and are among the most important contributors to the Gross Domestic Product.

A second sector which has recorded substantial growth since 1945 is tourism. From a relatively small base at the beginning of the period tourist capacity increased rapidly between 1955 and 1962. Growth since then has been less rapid, but nonetheless significant.

A corollary of these developments has been the declining importance of agriculture in the national accounts aggregates. Export agriculture has suffered from a number of problems, chief among them being low productivity, labour unrest, migration from rural areas, unstable prices and periodic weather calamities. Domestic agriculture has had to contend with the additional problems of inadequate marketing, discriminatory land use policies and lack of adequate sources of financing. As a result, though the value of agricultural output has increased, the increase has not been sufficient to maintain the relative share of agriculture in GDP.

There is however a contrast between the national accounts picture and that presented by the employment data. Agriculture still absorbs much the larger portion of the labour force, and tourism, public administration, and the distributive sector all contribute far more to total employment than does the mining industry.

The remaining noteworthy feature on the production side is the emergence

of the manufacturing sector to a position of prominence, both in contribution to national output and employment. This sector, too, has been largely export oriented. Many of the industries established under an official program of government incentives and promotion were designed to exploit the North American market, using imported raw materials. And in more recent years, industries which were established to serve the domestic market have been responding to newly emerging prospects for exports to other territories within the Caribbean area.

A consequence of the fact that the leading economic activities are, by and large, export oriented, is Jamaica's heavy dependence on foreign trade and payments. In this respect the historical pattern which is to be observed in all Caribbean economies has been preserved. The ratio of foreign trade to national income is in all cases extraordinarily high, as it has been from the time of the first European penetration.

The question of heavy reliance on external trade has been one of the major issues of development policy in the Caribbean in the post-war period. There is first of all the question whether dependence on trade is itself inimical to development. One may argue that while dependence as such may not be harmful, dependence on a few undifferentiated export lines to the extent which is characteristic of the Caribbean, reduces the scope for domestic economic management. The economy has little scope for compensating for difficulties in one export activity by expansion in others. Therefore Caribbean-type dependence is undesirable. The question then is whether much can be done about it, given the presumably limited natural resource and population base of a country like Jamaica. The answer to this question hangs on the results of an analysis of the sources of economic dependence, which should reveal whether dependence is a function of size and resources or of institutional

and traditional factors. The necessity and the possibilities for reducing external dependence are areas of development policy which are still being explored.

A second development issue has been the chronically high level of unemployment of labour in the country. Close to one-quarter of Jamaica's labour force is unemployed, and many have become unemployable as much because they have never had the discipline of work as because of lack of education and skills. Migration to the towns (particularly the overcrowded capital, Kingston) and the relative decline of agriculture have contributed largely to this problem. As yet no strategy has emerged to secure a substantial reduction in the ranks of the unemployed, and this remains a basic unfulfilled development goal.

The third central development issue which the country faces is one of income distribution. Jamaica suffers from a severely inequitable distribution of income, and much debate has centred on the relationship between income distribution, national savings and investment and development.

Table 2-1

PERCENTAGE DISTRIBUTION OF EMPLOYMENT
BY INDUSTRY GROUP - OCTOBER, 1972

Industry Group	Percent
Bauxite & alumina	8.4
Agriculture, Forestry, Fishing.....	25.2
Manufacture.....	12.7
Construction & Installation.....	6.6
Transportation, Communications and Public Utilities.....	4.1
Commerce.....	13.1
Public Administration.....	10.8
Tourism (accommodation only).....	1.5
Other Services.....	17.5
Total.....	100.0

Source: Jamaica, Central Planning Unit, Economic Survey of Jamaica, 1972.

Contribution of Sectors to GDP at Current Factor Cost 1972

Table 2-2.	\$ Jamaican (million)	(%)
Agriculture	105.6	9.1
(Export Agriculture)	27.6	2.4
Mining	141.1	12.2
Manufacturing	165.5	14.3
Construction	130.9	11.3
Electricity	18.9	1.6
Transport	84.0	7.3
Distribution	160.3	13.9
Financial Institutions	76.8	6.6
Ownership of Dwellings	31.7	2.7
Government	108.6	9.4
Tourism	68.6	5.9
Miscellaneous Services	65.6	5.6
TOTAL	1,157.6	100.0

Source: Jamaica, Central Planning Unit, Economic Survey of Jamaica, 1972.

Bauxite-Alumina

We now pause to give a brief word-picture of the structure of production in Jamaica - the principal activities, their output levels, marketing arrangements and factor use. We begin with the bauxite-alumina industry, which is the most important growth promoting activity in the country. This is so in spite of the fact that, in terms of GDP contribution, mining ranks a little behind manufacture. The difference between the sectors, which makes for the fact that mining is regarded as more "dynamic", lies in their differential foreign exchange impact. The export component of manufacturing is small, whereas the entire output of the mining sector is exported. In fact, gross export earnings give little indication of the net foreign exchange contribution of the mining sector, since all firms except one are foreign owned, and there

are few domestic factor imports apart from labour (which is a small proportion of total cost). Net foreign exchange earnings therefore derive mainly from labour incomes and tax payments, which may total substantially less than gross earnings. The same strictures will however apply to much of the manufacturing sector; in fact, since most operate under tax incentive schemes, many will contribute only labour income to the national aggregates.

Both mining and some manufacturing contribute foreign exchange during their establishment stages as well, bringing into the country the capital needed to design, construct and initiate their operations. But here again the size of capital inflow and its effects on other economic activities (particularly construction) is considerably greater in the case of bauxite and alumina. However, in the mining industry this inflow is necessarily of a transient nature. The creation of new capacity is a large discrete operation, not normally repeated for a number of years thereafter. The same is true to some extent of manufacturing, though because of the greater range of activities the lumpiness of investment projects may be evened out by sequencing.

Measured in terms of foreign exchange contribution, therefore, mining comes out ahead of manufacturing, but its net contribution is (a) much less significant than gross figures would suggest and (b) subject to sharp fluctuation over the long period.

The mining industry employs relatively little labour. The difference between the sector's percentage contribution to output and its percentage contribution to employment illustrates this point, and is an indicator of high capital intensity. This is one reason for low domestic value added¹, since labour is the only domestic factor which is used in significant amounts in

¹ Another might be the arbitrary method of valuing output, referred to elsewhere.

the industry.

The mining industry has followed very closely the model of the "enclave" industry: on the input side there are no important backward linkages with other domestic industries, except when construction is going on; and on the output side, there are no forward linkages beyond the alumina stage, since none of the product is processed in Jamaica. The extraction of aluminum from alumina (which is still a crude material) requires very large quantities of cheap electricity, which hitherto have not been available in Jamaica. The industry has not helped to change Jamaica's long tradition of trade dependence.

In fact, bauxite may have reinforced the trade oriented structure of economic activity. Wage levels in the industry have been high relative to wages elsewhere in the country, and this has led to a "demonstration" effect, tending to raise the level of wage expectations throughout the country. As money incomes have risen in response to this, domestic output of food and other necessities has not kept pace. This is undoubtedly one reason why propensities to import have been steadily rising.

Tourism

Estimated tourist expenditure in 1972 was \$107.9 million, with GDP contribution of \$68.6 million. Since all of this is foreign exchange earnings, tourism ranks second to mining as a source of foreign exchange, if we take gross earnings as an indicator¹.

¹It ought to be noted that gross export earnings is really not a good indicator at all: (1) in the case of mining, retained earnings amount to about 50% of gross; (Owen Jefferson, The Post War Economic Development of Jamaica p.167. (2) for tourism, earlier studies have shown leakages abroad of 40% of gross earnings. (See G. Cumper, 'Tourist Expenditure in Jamaica' Social and Economic Studies, September 1959). Current data on retained earnings are unfortunately not available.

The industry's employment contribution is also considerable, even though workers at hotels, guest houses, etc. account for only a small portion of the labour force. This count does not include the large numbers of ancillary workers whose jobs appear under 'Other Services' in our table.

Although tourism is overshadowed by a number of other sectors in the national accounts, two important points should be noted. First, tourism is a prime mover in that expansion (or contraction) in the sector will affect levels of activity in other sectors - construction, distribution and entertainment in particular. Secondly, tourism is vital to the economy of Jamaica's north coast. Although Jamaica is a small island, it exhibits two noticeable regional characteristics. One is the urban-rural dichotomy, familiar in most Third World countries; the other is the concentration of tourist activity in the island's north coast, where the principal tourist attractions are located. The economy is not sufficiently flexible to compensate for the effects of a slump in tourism on the economic life of the north coast region.

The larger proportion of tourist capacity is foreign owned. In 1968, non-nationals owned 55.6% of hotel capacity (guest houses and apartments not included)¹. The overall ratio is probably in this region: guest houses are owned predominantly by nationals, but there is significant foreign ownership of apartments. Furthermore, the increase in capacity since 1968 has resulted largely from the construction of foreign-owned convention-type hotels and apartment complexes.

The industry caters mainly to the North American market, which supplied about 85% of "landed visitors" in 1972², 75% from the U.S. alone. This

¹Owen Jefferson, The Post War Economic Development of Jamaica p.178

²The category excludes cruise passengers; based on data from Bank of Jamaica Statistical Digest (monthly)

constitutes one weakness, in that the secular pattern of activity in the sector is very heavily dependent on the U.S. domestic economic prospects and her balance of foreign payments. There is some fear of other tourist areas which compete for the American travel dollar, but the resilience of tourist demand in Jamaica in the face of low European fares (since 1971) and American government attempts to promote internal tourism suggest that the degree of substitutability between various tourist markets may have been over-estimated.

The industry suffers from considerable seasonal variation, despite marked success in attracting summer visitors with cheaper rates of accommodation. The industry now has two peaks of activity, one about March and the other around July. Each peak is followed by a noticeable slump.

Finally, tourism is notoriously subject to fashion and sensitive to changes in social and political climate. Disturbances in the late 60's led to widespread nervousness about the prospects of tourism. Vigorous campaigns have been mounted to promote an image of political stability and Jamaican hospitality so as to ensure the health of the sector.

Agriculture

The agricultural exports which were once the backbone of the Jamaican economy have now declined to relative unimportance. Export agriculture contributed only \$27.6 million to the 1972 GDP. Since total GDP contribution for this sector amounted to \$105.6 million, this means that agricultural production for home use now constitutes the more important portion of the sector's activity.

There is a sharp contrast between the income contribution and the employment contribution of the agricultural sector. Income contribution is

is less than 10%, employment contribution is over 25%. The contrast is a symptom of the low levels of productivity in agriculture. Low productivity has been the bane of agricultural development and its causes are still a matter of dispute. However, among the causes the following must undeniably be listed: reluctance to abandon traditional farming methods, the fact that a rational land-use pattern has not been consistently followed for the country as a whole, and resistance to further capital intensity in a social milieu in which labour to perform unskilled agricultural tasks is in increasingly short supply.

There is some plantation cultivation of food crops for domestic use, but fruit and vegetable production for the domestic market is mainly in the hands of small farmers with 5 acres of land or less. Much of this land is in the less fertile hilly regions which comprise two-thirds of Jamaica's land area. More recently, substantial production of livestock and poultry for local consumption has been undertaken.

The large plantations and estates which hold about 50% of all farm lands¹ concentrate mainly on export crops. The chief export staples are sugar, bananas and citrus, in that order. Production in all three crops peaked in 1965/66. Since then there has been a notable contraction.

The agricultural sector has been plagued by marketing problems, labour troubles and land-use problems. Domestic marketing of agricultural produce has been subject to poor management, poor quality control and inadequate storage and collection. Export marketing has been subject to price uncertainty (even in the case of so-called 'guaranteed' markets) and variation in quality

¹ Jefferson, p.81 : 54% of acreage fell into the 100 acre-and-over category in 1968

(in the case of bananas and citrus). The labour problems have arisen because of the low wages and traditionally bad working conditions which characterise the industry. Rising expectations in the labour force as a whole has made agricultural employment an unattractive proposition. The existing patterns of land-ownership are a further barrier to agricultural expansion, in that they inhibit flexibility in shifting resources in accordance with marginal profitability criteria.

Manufacturing

The tables reflect the importance of the Jamaican manufacturing sector's contribution to GDP; its employment contribution is also substantial. The output of the sector consists mainly of light manufactures for the domestic market. The principal categories in order of importance (1972 data) were food processing, metal products and repairs, textiles, cement and chemical products. A considerable governmental initiative aimed at stimulating export manufactures has met with little success. Manufactured exports accounted for 9.4% of total exports, and 10% of the output of the manufacturing sector.

Government

The government of Jamaica concentrates its attention on the country's social and economic infrastructure. Apart from general administration, it is concerned with roads, hospitals, police, education and agricultural services. There are no major state enterprises (except the Post Office) and even public utilities are privately owned. In spite of this, the government sector is large, and it employs a disproportionate percentage of the labour force.

Construction and Distribution

There are two other large sectors in the economy: construction and distribution. The construction sector has grown to major importance in response to the expansion of capacity in mining and manufacturing, as well

as the increase in national and per capita income, which has led to increased demand for housing. Distributive trades and allied services are, as in most Third World countries, the sectors which absorb large numbers whose skills do not fit them for jobs elsewhere. Its contribution to employment is therefore greater than its contribution to GDP, though the breakdown of our tables fails to demonstrate this clearly.

Developments since 1960

Our detailed analysis of the Jamaican economy begins in 1960, the year before the Bank of Jamaica was established. The choice of a beginning point for economic analysis is always to some degree arbitrary, and we might have chosen the end of World War II (a popular starting point) or the mid-fifties when the shape of the economy was transformed with the establishment of mining and the rise to prominence of tourism. We have chosen the date of the Bank of Jamaica's establishment, however, because this marks the emergence of some real possibility of foreign exchange management, which is, after all, the focus of this investigation. Prior to the Bank's establishment there was no authority whose focus was monetary and foreign exchange management. The currency board which the bank replaced was concerned merely with the issue and redemption of currency, and such supervision as was carried on by Government over the financial system was principally to satisfy legal requirements. The period of the Bank of Jamaica's operation is therefore properly the period of our interest, though a background sketch of post-war developments was a necessary introduction to this chapter.

The national income of Jamaica has risen rapidly since 1960. In that year Gross National Product stood at J\$455.0 million; by 1972 the figure was J\$1,196.2 million¹. This rapid expansion has been reflected in each of the

¹Table "Jamaica : National Accounts"

components of aggregate demand, with the main impetus coming after 1967 in every case. Private consumption shows a sharp upturn in 1969 from the not unsubstantial, but less striking, rate of increase in previous years. Exports (goods and services) recovered in 1968, mainly due to tourism which had slumped badly in 1967. Some of the increase in exports in between 1966 and 1969 was, however, the result of revaluation of bauxite exports¹. Gross Domestic Fixed Capital Formation again surged ahead in 1968 relative to the slowly rising levels of \$100-150 million which prevailed between 1960 and 1966. The substantial increase in 1968 was associated with the expansion of capacity in the mining sector. This sector is highly capital intensive, and is characterised by "lumpy" investment, so that any new activity invariably has a most significant effect on overall capital formation in an economy as small as Jamaica's. To complete the picture, the consumption expenses of government also rose at a pace no less rapid than was characteristic of the other demand components. This was less the result of dramatic changes in the orientation of government policy than a response to pressures for increased wages and better social services. These are the areas to which the largest part of government current expenditure is directed.

The increase in private consumption expenditure undoubtedly owes much to the increases, from 1968 onward, in output in the country's main economic activities.

¹
The revaluation yielded additional government revenue (including retroactive tax payments), but had no other economic effect.

In 1960, the mining industry was in the last phases of the first period of rapid expansion which followed its establishment in 1952. Output rose sharply in 1962, and the years following saw a more gradual expansion of production. In 1968, there was a decline in bauxite production, but the same year witnessed the beginning of a second period of rapid expansion in capacity. The new alumina plant which was established increased bauxite output by two million tons in 1969 and by an additional 1.5 million tons in 1970.

The tourist sector experienced rapid growth between 1964 and 1966, after a period from 1960 to 1964 when there was a slump in the industry. There was another low point in 1967, but thereafter we notice a renewed tendency for rapid expansion. The manufacturing sector has maintained throughout the period a rate of growth in excess of the rate of growth of GDP. During the decade of the sixties, Jamaica moved into a significant import-substitution phase, and there is as yet no sign that the limits of this policy have been reached.

Agriculture on the other hand did rather badly. The agricultural sector lagged badly after an early period of expansion between 1960 and 1963. Export agriculture put in a particularly weak performance. Output of sugar, bananas and citrus - the main agricultural exports - all declined significantly towards the end of the period from levels reached in the mid-60's. Record levels of sugar production were achieved in 1965, but output declined by 28.5% over the next four years. Production has remained stable at the new low level of 380,000 tons since 1969. The value of banana production declined by 15% between 1968 and 1971, and citrus production fell by 37% between 1969 and 1971. This disappointing performance, caused by a variety of factors including production technology, labour supply, weather and marketing problems, has not been offset by a switch to domestic agriculture.

The net effect of these developments would have been to increase national income and expenditure. It is not clear, however, how substantial an increase would result from impulses of the magnitude of those recorded in tourism, mining and manufacture. The reason lies in the fact that all three sectors use substantial proportions of foreign imports. The domestic value added is therefore less significant than might at first be thought and one must be wary of attributing most of the increase in income to expansion in these sectors.

This caution is reinforced by a look at inflationary trends. The only available indicator of prices is the retail price index, which, though it may not be a good indicator of actual magnitudes of other price changes, is nevertheless a useful guide to the direction and speed of such changes. The picture is, as we might expect, one of accelerating inflation. It is most noteworthy that the acceleration of price increases in fact coincides with the upturn in GNP in 1968. The unavoidable implication is that the rise in national income is accounted for very largely by price increases.

Investment, foreign capital and domestic saving

Changes in the level of investment in Jamaica are determined principally by decisions made in the export sectors. A decision to expand productive capacity in mining, tourism or export manufacture will not normally be frustrated by domestic constraints such as lack of finance. Foreign ownership predominates in all three of these sectors, and the metropolitan parent firms of the Jamaican operations can always make their investment decisions effective by importing the capital, skills and other inputs which they require. What results is a high proportion of foreign to total investment in these sectors. Furthermore, their rate of expansion is, as far as the domestic economy is concerned, exogenously determined and not subject to domestic economic management.

The fact that the export sectors have been the major impetus for growth in the period of our analysis means that the observations of the last paragraph are true for the pattern of investment as a whole. Agriculture is the only sector in which domestic investment predominates, and, as we have seen, its performance has been poor. Government does depend to some extent on local sources for its investment expenditure, but foreign aid has been sought for the majority of large infrastructural projects. Thus the rate of government investment is largely determined by the supply of foreign capital to Government. Domestic investment in manufacturing and construction is not large enough to alter the pattern of foreign to local investment and external determination of the rate of investment.

The high foreign contribution to capital formation is a consequence, not so much of limited savings potential, as of institutional factors. It is probable that the mining industry for one would continue to attract foreign capital even if local investment funds were available, chiefly because of the lumpiness of investment in the industry and the scale of investment requirements at any one time. However, the same would not be true of tourism, manufacturing and government, and one must ask why these sectors have continued to rely so heavily on external initiative and capital.

First of all, an indication of the untapped savings potential of the economy is the recent growth of financial savings. Interest-bearing deposits with commercial banks, building societies and other financial institutions have grown at a rate even more rapid than the rate of growth of income. The fact that real savings have not grown so rapidly indicates that much of the accumulation of financial assets by the public was channelled into consumption rather than investment by the financial intermediaries. This in turn is a consequence of the skewed development of the financial sector. The commercial

banks, which operate in the short end of the market and generally finance consumption-oriented activities, have penetrated the country with a well-developed network of branches. On the other hand, the institutions which would tend to favour long-term investment-type lending - development banks and merchant banks - are small and relatively recent innovations.

The nature of ownership of production is another factor which prevents the economy from realising its full savings potential. The local offshoots of metropolitan companies did not often resort to local borrowing at the time when they were free to do so; and since 1971 they have been discouraged from such borrowing by the Bank of Jamaica. If domestic saving is available it is theoretically possible for local entrepreneurs to rise to prominence alongside foreign firms. The fact that this has not happened to any significant degree may be a result of the lack of long-term finance just mentioned, but undoubtedly factors of considerable importance have been the underdevelopment of entrepreneurship, inability to compete on even terms with metropolitan firms and the absence of expected "spread effects" in raising general levels of skills and expertise.

Net capital inflows in 1971 amounted to 73% of Net Domestic Investment. In addition, much of the domestic investment which was financed internally by companies would have occurred in companies under foreign control. Further evidence of the importance of foreign capital can be had by comparing the pattern of capital inflows with the growth of domestic investment since 1960. The correspondence is very close. Between 1960 and 1965 capital flows were low, less than J\$20 million annually. In 1963 there was actually a net outflow of capital. Domestic investment remained constant between 1960 and 1963, and a rise in 1963/64 was paralleled by the change from capital outflows of J\$ 7million in 1963 to a net inflow of \$15 million in 1964. Between 1964 and

1968, the increase in capital inflow was quite dramatic, and domestic investment also rose steeply. A slackening of the rate of increase of capital inflows after 1968 was accompanied by deceleration in the rate of increase of domestic investment.

The Balance of Payments

Foreign capital inflows have financed a large and growing deficit in the current balance of payments account. Foreign inflows have been so large that until 1972 they not only financed the current account deficit but also led to a build-up of foreign exchange reserves. Exports of goods and services have in fact risen steadily since 1960, mainly as a result of the growth of non-agricultural exports. The most significant rises have taken place in mineral exports (assisted by an increase in the negotiated price) and in light manufactures (exported chiefly to other Caribbean territories). However, imports have risen far more spectacularly, particularly after 1968, and the burden of investment income and other transfers has increased with the increase in foreign investment. No impression has been made in the food import bill by local import-substituting production, and the growth of manufacturing, mining, construction and tourism has led to substantial increases in import requirements for raw materials and fuel. Rising national income has brought increased demand for consumer durables which are imported, or, if produced locally, require imported components. World-wide inflation in recent years has worsened the picture, even though the prices of some exports have risen¹. The major influences on the balance of trade were (a) conditions of supply

¹Bauxite price rises were negotiated in 1971 retroactive to 1966 and prices of export manufactures have risen; but the prices of agricultural exports have tended to weaken except for that of sugar which remained stable prior to 1974 (Sugar prices are negotiated on long-term agreements).

and demand for the principal export commodities, (b) the growth of national income, (c) patterns of import substitution and (d) the devaluations of 1967 and 1973, together with the attendant uncertainty on the foreign exchanges.

As far as the bauxite-alumina industry is concerned, there is no domestic supply constraint (though there may be some lag in the response of supply to demand if the limit of capacity has been reached). The companies mining in Jamaica determine the level of their output according to demand conditions in the North American market, which absorbs the entire production. Factors of production needed to ensure the required output are imported as necessary. The observed pattern of production and exports in the mining industry therefore reflect North American market conditions, with output expanding almost constantly over the period, faltering only once, in 1968.

Generally rising trends in the tourist and manufacturing sectors have accounted, together with mining, for the generally rising trend in exports. Although the pattern has been uneven, the demand for Jamaica's tourist services remained strong throughout the period. Manufacturing exports have depended heavily on the North American market, but, with initiatives towards Caribbean economic integration¹ an increasing volume of exports has been directed to the other English speaking territories of the area. Like mining, tourism has suffered only temporarily from insufficient plant; foreign inputs have always become available in response to surges in demand for tourist services. The growth of manufacturing has depended on the establishment of new markets in North America and the Caribbean. However, because Jamaica commands such a small share of these markets, possibilities for increasing output (by displacing

¹The Caribbean Free Trade area (CARIFTA), inaugurated on May 1st, 1968, was replaced by the Caribbean Common Market (CARICOM) in 1973.

existing sources of supply and through demand increases, however marginal) still exist. The main constraint on the rate of growth here has been the creation of productive capacity.

On the other side of the balance of payments, imports have risen more quickly than exports and just as quickly as money national income. Since so few of the items consumed in Jamaica are locally produced, the marginal import content of any additional income which is spent will be high. With a low marginal savings ratio, there will be a close link between imports and national income.

The import substitution program has done little to change this pattern. Efforts to substitute for food imports have met with comparatively little success, and most import substitution has taken place in manufacturing. The manufacturing sector is, however, heavily import-dependent, so that rather than a reduction in imports there has been a switch from final goods imports of manufactured items to the import of intermediate items required for their manufacture. Furthermore, because income increases have increased overall demand, and because of the development of new import markets, imports of both final and intermediate goods have continued to rise.

Devaluation of the Jamaican currency in 1967 and 1972 did nothing to improve the trade balance.¹ In November 1967 the Jamaican pound, whose value was at the time fixed in relation to sterling, was devalued 14½% along with sterling. This had the immediate effect of raising the prices of the major portion of Jamaica's imports, which come from the U.S. These increases triggered general inflation, increases in money incomes and a general rise in imports. Exports, on the other hand, did not receive much stimulus except for tourism, where a significant increase in the number of arrivals was recorded

¹ The floating of the pound in 1971 affected the US-Jamaica exchange rate, but the trade-weighted exchange rate continued to fluctuate within narrow limits (See Chapter Seven).

in 1968. The overall deficit therefore worsened considerably between 1967 and 1968, almost doubling to reach J\$28.2 million.

The 1973 devaluations, which took place in January of that year, were a response to a badly deteriorating balance of payments situation in 1972. The 1972 deficit of \$40.6 million, the highest on record, absorbed about one-quarter of the country's international reserves. There were two devaluations within weeks of each other in January, for a total depreciation of 15% against the pound sterling. At the same time, the rate was fixed to the U.S. dollar. Restrictions on trade and other foreign exchange transactions followed the devaluation, but by the end of the year foreign reserve data indicated the measures had failed to secure more than a temporary improvement in the balance of payments.

Developments in the balance of payments confirm the leading role of mining, tourism and manufacturing in the Jamaican economy. Admittedly, new foreign exchange earnings in these industries have not provided enough foreign exchange to meet the growing import bill, leaving a large and rapidly growing deficit on current account. However, substantial capital inflows to provide new capacity in these industries have largely financed the current account gap, so that the only years for which an overall deficit was recorded were 1964, 1965, 1969 and 1972.

The Development of the Financial Sector

The Jamaican financial sector is dominated by the commercial banks which command 46% of the assets of all financial institutions.¹ The other large financial institutions are the Bank of Jamaica (the Central Bank), the insurance

¹ 1971 data; see Bank of Jamaica, Jamaica: General Economic and Financial Situation

companies, building societies, the Government Savings Bank, credit unions, and a number of newer private and quasi-government institutions, including merchant banks, the Jamaica Development Bank and Trust Companies.

With one exception, the commercial banks were established as branches of large overseas banks. The oldest and largest is the British Barclays Bank; it was followed by a number of Canadian banks, and, most recently, by some large American banks. The range and geographical coverage of banking services has increased rapidly since 1960, and commercial bank assets have grown at an average annual rate of 15%. In 1970 the government of Jamaica introduced a 'Jamaicanisation' policy which was directed to encouraging local participation in the financial sector (among others). As a result of this policy, several banks have incorporated in Jamaica and offered shares on the local market. Jamaicanisation has, however, caused little change in the banks' operations. All banks are operated as part of the global network of their parent institutions. This means, in particular, that foreign credit and deposit facilities are always available.

The commercial banks in Jamaica have a crucial role to play in the country's development because of their size and because they have been remarkably successful in attracting financial resources from the public¹. A problem arises in directing these financial resources towards long-term uses. The commercial banks themselves operate in the British tradition in the short end of the credit market, and there is not a range of intermediate institutions through which funds might be redirected to longer-term uses. It is difficult for the monetary authorities to re-orient commercial banks' operations, because

¹See Nugent Miller, Commercial Banking in Jamaica ISER (mimeo.) 1971. Time and savings deposits grew at 2 to 3 times the rate of growth of GDP between 1961 and 1969.

most market control mechanisms are difficult to apply, while non-market controls raise administrative problems. The difficulties with market controls stem (a) from the underdevelopment of the securities market, in particular the limited amount and range of short-term securities; and (b) from the fact that the local banks have ready access to resources from their Head Offices.¹ The Bank of Jamaica has faced considerable difficulty in credit control and control of the money supply because of these institutional features of the economy.

The Bank of Jamaica

The Bank of Jamaica is second in importance to the commercial banks in terms of its total assets. It is about one-third the size of the commercial banking sector. The Bank has been in operation since 1961, functioning as the government's banker and having the responsibility of regulating the financial sector.

The Bank began its operations very cautiously, lending to government mainly on a short-term basis, and using Central Bank Rate changes as the only instrument of financial control. The local Bank Rate was altered in response to changes in the London Bank Rate, with the intention of discouraging the outflows of funds from Jamaica to London. The Bank of Jamaica was at that time unwilling to apply exchange controls on Sterling transactions, so it was felt that local interest rates should be manipulated in such a way as to make the returns on local financial investments competitive. Surprisingly, the Bank has not produced data to suggest that its Bank Rate policy had any noticeable effect on the interest rate structure of commercial banks and other financial institutions. In the absence of such reaction, Bank Rate policy

¹ Though this has been the case until 1963, the recent world-wide economic uncertainties may force Jamaican branch banks to operate autonomously.

could not have been effective.

The repercussions of the devaluation of the British pound in 1967 led to a more active policy of financial management by the Bank of Jamaica, and subsequent payments and exchange difficulties have occasioned a range of policy measures. The measures which the Bank presently employs to regulate the financial system include (a) the control of all foreign exchange transactions, (b) manipulating commercial bank liquidity ratios, (c) imposing selective credit controls and (d) creating special deposit facilities to absorb excess liquidity in the commercial banking sector.

Non-Bank Financial Institutions

One weakness of the Bank of Jamaica's operation is the inadequate controls over non-bank financial institutions. Insurance companies are the most important non-banks, ranking third (after the commercial banks and Bank of Jamaica) in terms of assets. The premiums paid to life insurance companies in particular are an important source of personal saving. Other institutions which play a large role in mobilising savings are the Building Societies, the National Insurance Fund, private pension funds and the Government Savings Bank.¹

The Money Supply

The year 1968 marked a significant upturn in the rate of expansion of the money supply. The accelerated increase was maintained through 1971, but it slackened in 1972. The money supply increase resulted from the spectacular increase in commercial bank credit to the private sector, which rose 300% between 1966 and 1972.² Credit to government also showed marked increase,

¹ There is no reliable data on the extent to which such savings are retained domestically

² In fact, the rate of increase in credit was considerably in excess of the increase in money supply (currency and demand deposits) and rather more than the increment in total monetary liabilities.

though the rate of expansion was less rapid, and there were two years, 1967 and 1969, in which government credit contracted. Government credit amounted to only one-quarter at most of the outstanding private sector credit at any time, so small contractions had no noticeable effect on the money supply. The credit expansion was fueled largely by a remarkable increase in fixed deposits, which also rose 300% (from a rather smaller base) between 1966 and 1972. The foreign assets of the banking system rose rapidly as well, but here the pattern was more uneven, with falls of 12% and 34% in 1969 and 1972. The fall in foreign assets in the latter year was evidently a major cause of the slow-down in monetary expansion in that year; the earlier and less dramatic fall had no noticeable effect on the money supply.

Short-term Stabilisation Policies

During the period of the Bank of Jamaica's operation, there have been three major shortrun crises to which the monetary and fiscal authorities have had to address themselves. The first was the 1967 exchange rate dilemma, which arose out of the U.K. decision to devalue the pound sterling, to which the Jamaican monetary unit (in 1967, the Jamaican pound, now the Jamaican dollar) was at the time linked. The second problem arose with the phenomenal increase in credit, which contributed to the rapid increase in imports from 1967 onwards. The third problem came to a head in 1972 with a dramatic loss of foreign exchange reserves, beginning in May of that year.

Immediately after the 1967 British devaluation, the Jamaican government was faced with the prospect of massive speculation against the currency, in the expectation that the Jamaican pound would also have been devalued. For the first time, the Bank of Jamaica imposed general exchange controls and suspended dealings in foreign currency. These measures were adopted only temporarily, and controls were removed once the decision was taken to devalue

the Jamaican pound. As a consequence of the Jamaican devaluation, the authorities were faced with a severe price rise. The Bank of Jamaica, in its Annual Report for 1967, recorded overall price increases in excess of the 14.7% devaluation, with prices of items from other devaluing sources (e.g. U.K.) rising as well as prices of imports from non-devaluing sources.

No systematic analysis of commercial banking behaviour in the 1968-69 period has been done to determine the causes of the extraordinary credit increase which began at this time, but contributory factors may have been the resurgence of activity in manufacturing, mining and construction, fueled by high levels of capital inflow; and the price inflation which led to increased money incomes as wages reacted to expectations of continuing price rise.

The Bank of Jamaica reacted to the credit expansion only after considerable delay, issuing in October 1969 a directive imposing selective credit controls. Domestic credit continued to rise quickly in spite of the controls, though the 1969 pace was not maintained. In May 1972 the commercial banks' required liquidity ratios were increased by 2½ percentage points to 17½%, but the banks continued to hold excess liquidity despite the higher requirement. The credit restriction does not seem to have had the desired effect, but the loss of foreign exchange reserves which occurred in 1969 was reversed by capital inflows beginning in 1970, and the authorities were content to tolerate the credit expansion so long as reserves were not threatened. Prices continued to rise at about 10 percentage points a year despite continuing controls on selected items.

A more stringent regime of credit, exchange, trade and price controls was instituted in 1972. The measures were again triggered by a fall in foreign reserves. The mining and construction activities which had led to massive inflows of long-term capital in 1970 and 1971 came to an end, the uncertainty

of the international monetary situation led to stockpiling of imports and early payment, and the general election in March 1972 led to a pause in domestic activity. The authorities reacted by imposing import bans and quotas, tightening exchange controls, imposing wider price controls and issuing government initiative to stimulate production. The effects of these measures are not yet fully apparent.

Table 2-3.

Jamaica: Balance of Payments

	1964	1965	1966	1967	1968	1969	1970	1971	1972
<u>Goods and Services</u>	<u>-44.2</u>	<u>-34.0</u>	<u>-40.5</u>	<u>-60.6</u>	<u>-96.4</u>	<u>-114.9</u>	<u>-145.4</u>	<u>-160.4</u>	<u>-179.9</u>
<u>Merchandise</u>	<u>-25.8</u>	<u>-27.2</u>	<u>-5.7</u>	<u>-18.0</u>	<u>-67.7</u>	<u>-74.4</u>	<u>-89.2</u>	<u>-109.0</u>	<u>-121.0</u>
Exports (f.o.b.)	156.2	154.8	197.5	199.2	209.2	243.2	285.1	286.1	302.4
Imports (f.o.b.)	182.0	182.0	203.2	217.2	276.9	317.6	374.3	395.1	423.4
<u>Services</u>	<u>-18.4</u>	<u>-6.8</u>	<u>-34.8</u>	<u>-42.6</u>	<u>-28.7</u>	<u>-40.5</u>	<u>-56.2</u>	<u>-51.4</u>	<u>-58.9</u>
Foreign Travel	22.8	37.8	48.0	49.2	62.8	65.4	66.7	77.2	91.4
Investment Income	-28.8	-30.6	-64.8	-67.2	-61.0	-72.5	-81.8	-85.7	-100.4
Other Services	-12.4	-14.0	-18.0	-24.6	-30.5	-33.5	-41.1	-42.9	-49.9
<u>Transfer Payments</u>	<u>13.0</u>	<u>12.2</u>	<u>10.4</u>	<u>10.0</u>	<u>10.2</u>	<u>11.9</u>	<u>18.2</u>	<u>17.3</u>	<u>22.3</u>
Private						14.7	21.8	21.8	27.7
Official						-2.8	-3.6	-4.5	-5.4
CURRENT ACCOUNT	<u>-31.2</u>	<u>-21.8</u>	<u>-30.1</u>	<u>-50.6</u>	<u>-86.2</u>	<u>-103.0</u>	<u>-127.2</u>	<u>-143.1</u>	<u>-157.6</u>
<u>Net Capital Movements</u>	<u>14.9</u>	<u>11.8</u>	<u>46.7</u>	<u>64.9</u>	<u>114.4</u>	<u>91.7</u>	<u>139.5</u>	<u>174.8</u>	<u>109.3</u>
Official	8.2	6.0	5.3	3.0	10.3	10.3	-1.2	4.0	18.6
Private	3.2	10.2	46.2	80.2	107.6	88.2	135.3	156.2	98.4
Unidentified	3.5	-4.4	-4.8	-18.3	-3.5	-6.8	5.4	14.6	7.7
SURPLUS/DEFICIT (-)	<u>-16.1</u>	<u>-10.0</u>	<u>16.6</u>	<u>14.3</u>	<u>28.2</u>	<u>-11.3</u>	<u>12.3</u>	<u>31.7</u>	<u>-49.3</u>
<u>Change in Reserves (increase)-</u>	<u>16.1</u>	<u>10.0</u>	<u>-16.6</u>	<u>-14.3</u>	<u>-28.2</u>	<u>11.3</u>	<u>-12.3</u>	<u>-31.7</u>	<u>48.3</u>
Government	0.7	1.8	8.4	-1.8	-	0.3	3.1	0.4	1.9
Bank of Jamaica	-4.0	-0.2	-15.4	-7.5	-32.8	1.8	-9.2	-17.2	21.9
Commercial Banks	19.4	8.4	-9.6	-5.0	4.6	9.2	-	-14.8	24.5

Source: Bank of Jamaica, Balance of Payments of Jamaica 1964-70, 1972.

Table 2- 4.

Jamaica: Monetary Survey

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Foreign Assets	45.6	34.6	45.0	72.8	57.6	46.4	63.4	63.4	87.9	76.6	94.4	130.6	86.5	71.3
Domestic Credit	47.2	64.4	76.2	68.0	99.0	122.4	132.2	164.4	202.4	264.8	316.0	381.9	514.3	605.0
Claims on Government (net)	-31.4	-22.4	-6.6	-8.6	-5.8	-4.6	-2.8	18.2	28.4	19.5	36.5	56.0	98.2	100.1
Claims on Private Sector	78.6	87.0	82.8	76.6	104.4	127.0	135.0	146.2	19.5	245.3	279.5	325.9	416.1	504.9
Money	52.2	47.8	61.0	60.2	66.6	63.6	71.0	75.2	95.0	110.8	126.5	159.7	272.2	207.5
Quasi-money	49.4	56.4	65.4	82.6	92.6	104.4	122.0	136.8	176.3	213.6	252.5	310.6	355.8	394.7
Other items	-8.8	-5.2	-5.2	-2.0	-2.6	0.8	2.6	15.7	15.9	16.9	31.5	42.3	72.9	74.1

Source: IMF, International Financial Statistics

Table 2-5.

Jamaica: Government Finance

Item	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Surplus (+) or Deficit (-)	-10.8	-12.9	-11.7	-15.1	-15.1	-18.6	-23.3	-30.1	-20.5	-31.7	-47.8	-59.4	-90.5
Revenue	72.6	80.1	82.9	95.9	112.4	116.6	124.9	143.2	170.5	214.6	239.3	274.1	326.4
Expenditure	83.4	93.0	94.5	111.0	127.9	135.2	148.2	173.3	191.0	236.3	287.1	333.5	416.9
Financing	10.8	12.9	11.7	15.1	15.5	18.6	23.3	30.1	20.5	31.7	47.8	59.4	90.5
Net Borrowing	6.9	13.5	13.4	14.8	9.1	15.4	19.6	35.0	4.0	27.6	36.9	58.8	72.5
Use of cash balances	3.9	-0.4	11.7	0.3	6.6	3.2	3.1	-4.9	-0.7	4.1	10.9	0.6	18.1
National Debt	n.a.	45.0	56.2	63.2	72.4	83.3	101.2	122.2	136.4	172.1	210.3	256.8	308.4

Source: IMF, International Financial Statistics

CHAPTER 3

A Critical Survey of the Literature

The theory of international liquidity may be divided for convenience into two areas, along the lines suggested by John Williamson in a recent survey of the literature¹. The first area is concerned with the world's liquidity requirement, usually considered to be derived from the requirements of the countries which participate in the international payments system. The second area has to do with the creation of additional liquidity and the problems of how much, in what form, distribution between countries, rates of return on international reserve assets, and so on². This essay deals with a topic in the first of these areas. We are concerned only with the reserve requirement of a single country; we do not attempt to treat the issues raised in aggregating over all countries to determine world requirements. Moreover, our focus is specifically on the theory as it applies to developing countries. Our model has generic links with many recent suggestions for determining reserve requirements, and so the present chapter will be devoted to a review of these contributions.

Our task is made easier by the existence of four previous reviews of the literature in this field. Besides Williamson's essay (the most recent and comprehensive) there have been reviews by Clower and Lipsey

¹J. Williamson, 'International Liquidity: A Survey', Economic Journal, Sept. 1973.

²Williamson refers to the two areas as respectively the "positive" and "normative" aspects of the theory. We have avoided this usage because we wish to employ the term "normative" in a slightly different context.

(1968), Niehans (1970) and Grubel (1971).¹ We cover much the same ground as these earlier reviewers and we will inevitably make a number of points which are familiar. However, when the existing literature is viewed from the standpoint of our own model some new insights can be developed;² on a number of aspects which are of interest we provide a more explicit treatment and more attention is paid to the problems of developing countries.

Contributions to the literature will be assessed under two heads which correspond to a rough division of our model. These are the explanation and/or prediction of reserve movements and the alternative balance of payments adjustment measures and their costs. Many of the articles and essays to be reviewed fall into the first category; the remainder combine both aspects into a more or less complete model of reserve determination for a single country. Following the review of model-building, attention is given to the arguments of those who contend that the attempt to specify a theory of reserve determination is not a meaningful exercise. We then deal with the conclusions which have emerged from the discussion to date and a number of conceptual, theoretical and measurement problems which remain to be resolved. The chapter concludes with a re-examination of the theory of international reserves from the viewpoint of developing countries.

¹ R.W.Clower and R.G.Lipsey 'The Present State of International Liquidity Theory', American Economic Review, May 1968; J.Niehans in IMF, International Liquidity: Needs and Availability, Washington, 1970; H.G.Grubel, 'The Demand for International Reserves: A Critical Review of the Literature', Journal of Economic Literature, Dec. 1971.

² For example, the combination of systematic and stochastic elements in the determination of reserve variation (see below).

The earlier attempts to explain the behaviour of foreign exchange reserves over time tried to establish an exact relationship between reserve levels and some index of foreign transactions. The index most frequently employed was the level of imports. Thus, the earliest empirical investigations sought to determine reserve levels as a function of world levels of importation. The view that reserve adequacy is related in some determinate fashion to the level of imports still retains currency with some central bankers and with officials of international financial institutions¹, but its theoretical justification is open to very serious question.

In the first place, the monetary authorities in trading nations do not in fact use foreign exchange reserves to service day-to-day transactions. The reserve is rather in the nature of an inventory held as a precaution against unusual eventualities which adversely affect the foreign transactions pattern. Thus there is no reason to expect a linear relationship between reserves and the volume of transactions in any time period. However, this factor does not imply that no relationship of any sort exists; as we shall see shortly, the argument of this paragraph is compatible with a 'square-root law' of the relationship of reserves to transactions.

In a moment we will return to the 'square-root law of reserves', but first we must ask whether the value of imports is a reliable measure of the level of transactions. It may be that reserves are related to

¹ See, for example, IMF, International Liquidity: Needs and Availability, p. 471.

transactions, but unless there is a direct, measurable link between imports and the level of transactions, the empirical studies which have used the import measure are on shaky ground.

The first problem is that transactions consist both of receipts and payments. Is the level of reserves related to the total transactions (receipts plus payments) or to net transactions (the difference between them)? To relate reserves to payments alone would in either case appear to be a questionable procedure, and to use only a subsection of total payments (i.e. visible imports), as some writers have done, is indefensible on these grounds. There have, in fact, been some attempts to make a suitable modification.¹

A further problem lies in the definition of 'imports'. Mainly for practical reasons, only the current account is normally included, and in some cases, only visible items. We have dealt at some length with this problem in Chapter One, where we argued that the transactions against which a country's contingency reserve was held included capital as well as current account transactions.

If we are to consider the payments transactions only, and supposing we can successfully incorporate the capital account, there is still a question as to whether 'imports' so defined would measure the volume of transactions, the composition of the import basket, or prices. More specifically, an increase in imports may result from any of the following: an increase in the volume of transactions, an increase in the average size of each transaction, an increase in the ratio of large transactions to small transactions, and/or an increase

¹ See, for example, Ragnar Nurkse, International Currency Experience, League of Nations, Geneva, 1944.

in the price per unit of some or all transactions. These distinctions are important because, as we shall discover shortly, different conclusions can be obtained using different assumptions about the cause of the increase.

In Chapter One of this study we advanced the argument that, since reserves are intended to meet unusual variations in net foreign payments, the appropriate index of reserve adequacy is not the level of imports but the degree of variation in external transactions. Recognition of this factor led to the search for some meaningful index of payments variation; among those which have been tried are the coefficients of variation of exports and of reserves, the standard deviation of reserves and deviations from trend adjusted reserves series. In some cases the investigators proceeded on strictly empirical grounds, without any explicit theorising on the nature of the functional relationship between reserves and transactions variability. However, many studies have started from the notion of a link between reserves and payments variation to develop a consistent theory of reserve optimisation.

The search for an explicit relationship between reserves and payments variability may be regarded as the take-off point for most of recent theorising. It has led to the development of models which, having specified the way in which payments vary, then derive the degree of security¹ offered by any level of reserves. The three

¹ Following Olivera (loc.cit., 1969) we refer to this probability as the coefficient of security; it is the probability that reserves will exceed a stipulated minimum amount (greater than or equal to zero) after we have taken account of the expected demand for reserves and their variability.

studies of this type which we will review are to be found in articles by Streissler, Olivera and Archibald and Richmond.¹ The first two merely assume various kinds of distribution function for the variation of net foreign transactions (equal to reserves; see our definitions in Chapter One); Archibald and Richmond go further and perform empirical tests of their hypothesis about the nature of reserve variation. Kenen and Yudin,² in an earlier paper, tested a different hypothesis about reserve variation, and their analysis will be included in our review for purposes of comparison. Following upon these (in logical rather than chronological order) are the studies which use models of cost minimisation or utility maximisation in conjunction with the coefficient of security to determine an optimum or desired level of reserves.

Streissler and Olivera both have the same approach to the question. They assume a fixed coefficient of security and a variety of alternative hypothetical distribution functions for reserves; then they investigate the relationship between reserve levels and transactions. The basic thesis underlying the specification of reserve variations is that there is a non-deterministic element in the pattern of fluctuations over time in the balance of payments (and hence of reserves).

¹ E. Streissler, 'A Stochastic Model of International Reserve Requirements During Growth of World Trade', Zeitschrift für Nationalökonomie, Dec. 1969; J.H.G. Olivera, 'A Note on the Optimal Growth Rate of International Reserves', Journal of Political Economy, Mar. 1969; Olivera, 'The Square-Root Law of Precautionary Reserves', Journal of Political Economy, Sept/Oct. 1971; and G.C. Archibald and J. Richmond, 'On the Theory of Foreign Exchange Reserve Requirements', Review of Economic Studies, Apr. 1971.

² P.B. Kenen and E. Yudin, 'The Demand for International Reserves', Review of Economics and Statistics, Aug. 1965.

It does not matter whether the balance of payments is in fundamental equilibrium or not; in either case, there will be fluctuations around the mean value, fluctuations which are the result of purely random variation. Reserve movements are therefore made to depend on a random variable which has one of a number of distribution functions.

Olivera specifies the distribution function of net foreign transactions only. Streissler makes separate specifications for payments and receipts, and in one case, separate functions for the volume of transactions and for the average size of transaction as well. Since no effort is made to determine the actual relationship which obtains in any country, a number of alternative functions are tried. Included are the random walk, the normal distribution, the exponential distribution, the Poisson, and a distribution function derived from a simple Markov chain.

We will use Olivera's analysis to illustrate this approach.¹

The coefficient of security (α) is defined by

3-1. $\alpha = P(R \geq Z)$ where Z : net demand for reserves and R : probability (that is, α is the fixed probability that reserves will always exceed net demand for foreign exchange). If $Z \sim N(E(Z), \sigma)$, then it follows from the definition of the normal distribution that

3-2. $\alpha = F\left[\frac{R - E(Z)}{\sigma}, 1\right]$, F : functional notation

.. $R - E(Z) = \sigma F^{-1}(\alpha)$, F^{-1} : inverse of the function denoted by F .

¹ The analysis is taken from the second of the two papers by Olivera mentioned in the footnote on the previous page.

If the net demand Z is made up of n individual demands $\{D\}$, each with variance σ_D^2 , then

$$3-3. \quad \sigma^2 = n \sigma_D^2$$

$$\text{and } R = E(Z) = n^{\frac{1}{2}} \sigma_D F^{-1}(\alpha)$$

which establishes that R is proportional to the square root of the number of transactions¹.

Olivera also demonstrates how the optimum reserve level may be derived. The method is of interest because we have adopted the determining equation as the cost equation (4-1) of our model. We quote from Olivera (page 1103):

'Let h denote the holding cost of reserves; p the penalty cost, which is the cost of failure to satisfy net demand; Q the density function of net demand. The holding cost will be taken as a function of the reserve on hand at the end of the period. We disregard "transactions" or "transfer" costs. The expected total cost is

$$3-4. \quad C(R) = \int_{-\infty}^R h(R - Z) \phi(Z) dZ + \int_R^{\infty} p(Z - R) \phi(Z) dZ.$$

This is the equation we have adopted, simply changing the symbols in accordance with the convention we use throughout the study. Differentiating with respect to R yields the optimum reserve for any strictly convex function.²

¹ There appears to be an error on page 1101 of Olivera's paper, where equation (4) reads $\sigma = S[E(D)]$. Presumably it should read $\sigma = S[V(D)]^{\frac{1}{2}}$ where V represents variance and E represents expected value.

² The equation appears in an appendix to Olivera's article. No attempt was made to enlarge on the nature of the cost functions and the probability distribution of Z , nor was a solution derived for the optimal level of reserves. Olivera's treatment was essentially brief and abstract.

Streissler and Olivera both prove that reserves are not a simple linear function of the level of transactions. In addition, they stress the distinction we made earlier between the number, size, structure and price of unit transactions. Surprisingly, however, the results arrived at are somewhat different. Olivera concludes that in the case where the aggregate of transactions increases as a result of increases in the number of transactions only (with size, structure and price constant), the increase in reserves is proportional to the square root of the increase in transactions, with a fixed coefficient of security. Dealing with the same case, Streissler argues that there will be no change whatever in the corresponding reserve level. It appears that the different conclusions arise from the fact that Olivera assumes the expected value of reserves to be zero, while Streissler does not. Olivera's results are therefore valid only for what he calls the 'precautionary reserve', and this is in fact the main thesis of his argument. Streissler's results challenge Olivera's (subsidiary) contention that, for 'non-precautionary' and precautionary demand together, the elasticity of reserves with respect to transactions lies between unity and one-half (i.e. reserves are proportional to some variable W , where W lies between the total value of transactions and the square root of that value). Streissler's conclusion seems to be valid for this case. Streissler also argues that if the average value of transactions increases, (because of inflation, concentration of firms or concentration of payments in a given firm) then reserves must rise in order to maintain the existing coefficient of security.

The increase in reserves would be 'mostly in proportion to the increase in the average value of transactions, but, in certain cases' it would be less.¹

These studies are of interest, not so much because of their results as because the development of stochastic explanations of reserve movements is one of the keys to the further development of international reserve theory. Both studies make significant theoretical contributions in this area by establishing the properties of certain distribution functions as applied to reserve variation. However, apart from the absence of any attempt to find out which stochastic description fits the real world, these studies suffered from a number of restrictive assumptions. The particular assumption to which we now turn our attention is the implication that reserve variation is entirely a random phenomenon.² The next two articles to be considered, by Kenen and Yudin and Archibald and Richmond, consider reserves a function of time as well as a random variable.

Kenen and Yudin suggested that the typical pattern of reserve fluctuations for any country could be described by a simple first-order difference equation:

$$3-5. \quad \Delta R_t = p \Delta R_{t-1} + \epsilon_t, \quad 0 < p < 1 \text{ and } \epsilon_t \sim N(\bar{\epsilon}, \sigma_\epsilon^2)$$

where ΔR : change in reserves; ϵ : random variable.

¹ Streissler, opt.cit., p. 370.

² This assumption was relaxed by Olivera (1969, p. 1098) where he considers Markov chain

Kenen and Yudin were satisfied with the way in which the data they used fitted this equation. However, when Archibald and Richmond repeated the test with data from a later period they obtained unsatisfactory results. The only reason they were able to suggest was that structural changes had occurred between the periods covered by the two tests. Archibald and Richmond's tests led them to reject the Kenen-Yudin equation in favour of a simple autoregressive scheme. Reserves (R) grew over time (t) subject to residual variation (u) as follows:

$$3-6. \quad R_t = \alpha + \beta \cdot t + u_t.$$

The u_t are not however independent from period to period but behave according to:

$$3-7. \quad u_t = \rho u_{t-1} + \xi_t, \quad |\rho| < 1 \text{ and } \xi_t \sim N(0, \sigma^2).$$

The authors obtained good results on tests of this equation for most of the countries in their sample, though in three cases it appears that higher orders of difference are required in 3-7. An important qualification was the discovery that the variance of residuals is not in fact constant over time.

Although these two studies have the merit that they are testable and they include a variable to take account of systematic influences, they are still very simplistic. There is 'no attempt .. to build a sophisticated model of the system which generates the reserves time series'.¹ An attempt to devise such a model seems a

¹ Archibald and Richmond, op.cit., p. 246.

logical development, and this is one of the things we have tried to do in our own model.¹

Having obtained the parameters of their equation, Kenen and Yudin proceed to use them as explanatory variables in multiple regressions of cross-country reserve data. No rigorous theoretical analysis is provided as foundation for the regression. The Archibald-Richmond article develops in a (theoretically) more satisfying manner to derive the coefficient of security which is given by the prevailing reserve levels in a number of countries. It is in this sense a quantification of one of the theoretical models suggested by Olivera and Streissler.² However, Archibald and Richmond were unable to obtain very specific results from their model. They could only set upper and lower bounds to the coefficient of security, and in most cases the difference between the values computed for the upper and lower limit was so great³ that the results could be of little value to policy makers. Archibald and Richmond themselves merely make tentative comparisons between levels of security of various countries, without being able to say how adequate any level might turn out to be.

The studies reviewed so far establish the relationship between the level of reserves and the degree of security they offer once the

¹ See Chapter Three.

² It appears however to have been developed independently.

³ In three cases, the limits are zero and unity, 'that is to say, anything might happen'. See Archibald and Richmond, p. 255.

parameters of the distribution function for the reserve series are known. This information does not, by itself, allow us to specify an optimum level of reserves. To do that we must have some idea of the costs associated with, and the benefits to be derived from, any level of reserve holding. Then, by comparing the costs of increasing security with the 'stock-out' costs (that is, the costs of running out of reserves or of reducing reserves below the stipulated minimum), we can determine the desired level of security and the associated level of reserves.

The costs of reserves (or the utility of reserves) depend on the economic functions of reserves. The reasons for which reserves might be held have been a matter of some debate in the literature. There is general agreement that reserves cannot be used in place of structural readjustment if external payments are not on a path of long-run equilibrium. Where there is disagreement is on which of a number of short-term disturbances we should insure against by holding reserves. The issue is discussed elsewhere in this study¹, and we will return to it later in the present chapter. Most of the studies to which we now turn our attention make the assumption that reserves are designed to meet foreign exchange demand generated by random fluctuations in net foreign receipts.

The cost of 'stock-out' depends on the adjustments which have to be made in economic goals and economic policy if there is no means of financing a deficit in net foreign transactions. Thus, part of the

¹ See Chapter One.

requirement for specifying optimum reserve levels is that the authorities take account of alternative balance of payments adjustment mechanisms and their costs.

H.R.Heller was the first to provide a complete model incorporating all the above features.¹ The distribution function used was the random walk, under the assumption that reserves held by the monetary authorities were for precautionary purposes only. Transactions reserves were thought to be held by private financial institutions, which were not included in the analysis. The cost incurred by holding reserves is 'the differential between the social rate of return on capital and the return (if any) on the reserves'.² This is the return sacrificed by holding reserves instead of applying the funds to domestic capital formation. To arrive at the 'stock-out' costs Heller assumes that, in the absence of financing, national income must be reduced by an amount sufficient to reduce the demand for imports enough to eliminate the deficit. The marginal cost of holding reserves to finance the deficit is therefore equal to r , the difference between yield and social cost on the last unit of reserves held. The marginal cost of financing is $\frac{1}{m}$, where m is the marginal propensity to import. The probability of running out of reserves in 1 time periods (π_1) is given by

$$\pi_1 = (0.5)^1,$$

assuming equal chances of increasing or decreasing reserves during each period. The 'stock-out' cost is weighted by its probability

¹ H.R.Heller, 'Optimal International Reserves', Economic Journal, June 1966.

² Page 300.

of occurrence and the marginal costs equated to give

$$3-8. \quad i = \frac{\log r + \log m}{\log(0.5)}$$

This gives $\hat{\pi}_1$, the coefficient of security which minimises the overall costs. If the average size of deficit or surplus per period is h , we have the optimum level of reserves (R_{opt}) as

$$3-9. \quad R_{opt} = i h = h \frac{\log r + \log m}{\log(0.5)}$$

Heller's article was an important breakthrough in the theory of reserve determination, even though it suffers from several serious defects. The more important of these have to do with the specification of reserve variation and the simplification of the adjustment mechanism. The latter defect is shared by most subsequent articles, and, though more sophisticated stochastic models have been used, the real weakness still remains that no satisfactory explanation of systematic reserve variation has yet emerged. Because of his model's defects, Heller ran into difficulties. His choice of h , the average size of adjustment per period was necessarily arbitrary, the calculated optimum levels of reserves appear very conservative, and it has subsequently been shown¹ that the results are extremely sensitive to changes in the adjustment policies specified.

Most studies since Heller have used different probability distributions, but there is one which derives directly from the Heller article. J.P. Agarwal² has adapted Heller's cost equations

¹ Clower and Lipsey, op. cit., p. 591.

² J.P. Agarwal, 'Optimal Monetary Reserves for Developing Countries', Weltwirtschaftliches Archiv, 107(1), 1971.

to conform to important characteristics of developing countries, while leaving the stochastic specification unchanged. Agarwal argues that developing countries are constrained by scarce foreign exchange; there are domestic resources which remain unemployed because the country cannot afford the foreign inputs needed to complement them. Reserves might be used to provide some of these scarce inputs and so the marginal cost of reserves is replaced by a measure of the output which would be possible if reserves were so employed. The rationale is the same as we ourselves have used, but, unlike us, Agarwal considers only the present year's income sacrifice. Agarwal also modifies the cost of adjustment; assuming that the country has a regime of foreign exchange budgeting, adjustment measures will affect the availability of foreign resources essential for income generation. Hence the cost of adjustment (which Agarwal refers to as the 'reserve benefit') is also measured as a sacrifice of income (again, only current income is considered).

Agarwal's model and our own both set out to achieve the same goal: that is, to provide measures of the costs and benefits of reserves which reflect the income sacrifices which developing countries experience because of their critical shortage of foreign exchange. However, we go about the task rather differently. We use different explanations of reserve variation and, principally because Agarwal considers only one year, different cost equations. Consequently, there is little similarity between the models.

The next two models to be considered, those of P.B. Clark and

Michael Kelly¹, are very similar and may be taken together. They both use Chebychev's inequality as the basis for their inferences about the variation of reserves. This is a very general probability statement which holds irrespective of the distribution function of reserves, and allows Clark and Kelly to establish a relationship between the level and variability of reserves for any given coefficient of security. The costs of reserves and the costs of adjustment are measured in terms of the level of income and the variability of income, respectively. The combination of cost and probability distribution gives a locus of possible combinations of the expected level of income and its variation. This is referred to as the 'technical' trade-off between these variables. To arrive at the optimum combination a 'subjective' trade-off between the same two variables is given by the use of a utility function. The best possible combination is the one which maximises utility for the given level of security. This particular choice of income level - income variation in turn implies the maintenance of a specific level of reserves.

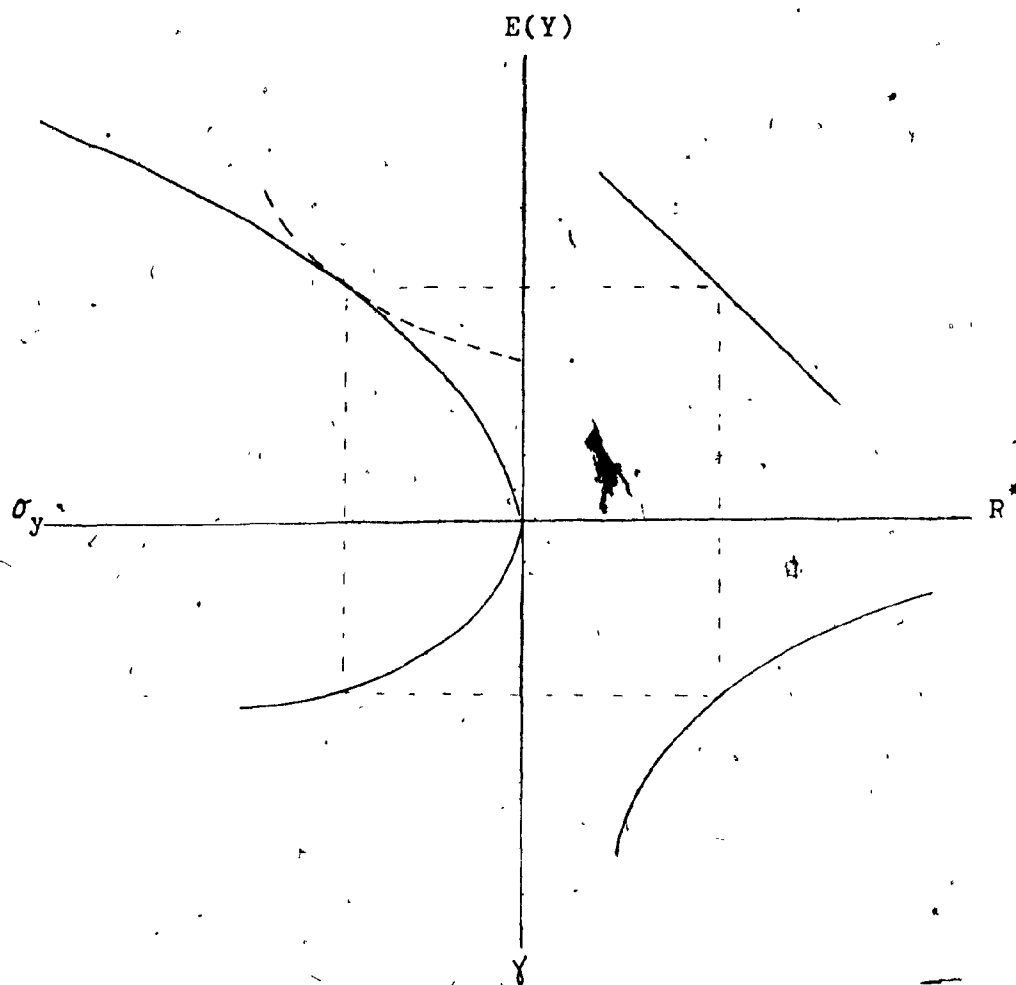
As an illustration of how the model works, we may borrow from the succinct one-paragraph summary of Clark's model which appears in Williamson's survey.² The reserve target to be chosen is R^* , and a package of adjustment measures to be adopted along with this is represented by the adjustment parameter γ . The analysis refers to Clark's Figure Eight³ which is reproduced here as Figure 3-1.

¹ P.B.Clark, 'Optimum International Reserves and the Speed of Adjustment', Journal of Political Economy, Mar. 1970; M.G.Kelly, 'The Demand for International Reserves', American Economic Review, Sept. 1970.

² Williamson, p. 691.

³ Clark, p. 371.

Figure 3-1. Clark's Model of Reserve Optimisation



$E(Y)$: Expected income level.

σ_y : Standard deviation of income.

'There exists a locus of combinations of R^* and Y , shown in the S.E. quadrant, which are consistent with the maintenance of a constant probability of reserve depletion: how this "acceptable" probability is chosen is unspecified. The problem of optimisation is viewed as that of determining the best point on this curve, taking account of the effects of this choice on the level and variability of income. A higher average level of reserves involves a sacrifice in the expected level of income (N.E. quadrant) because reserves are lower yielding assets than the alternative possible forms of investment. A higher value of Y (more rapid adjustment) involves a greater variance in income (S.W. quadrant) because the assumed method of adjustment is demand management; ... These three curves trace out a trade-off between the expected value of income and its variability (shown as the solid curve in the N.W. quadrant) implied by the choice of a combination of R^* and Y . The country makes this choice on the basis of a conventional quadratic utility function (dotted curve in N.W. quadrant)'.

One of the weaknesses of the Clark-Kelly approach has been pointed out in the quotation above. It is the specification of the acceptable probability level. It would seem that there is not one 'optimum' level, but a locus of such points, depending on the coefficient of security chosen. The second difficulty lies with the probability distribution of reserves. Clark and Kelly remain open to the criticism that a purely probabilistic description of reserve movements is inadequate. Moreover, Chebychev's inequality is a very weak probability statement and will therefore lead to conservative estimates of the level of reserves required to gain any given level of security. Calculated optimum reserve levels are therefore likely to be high.

Danny Otchere¹ has demonstrated how the difference in economic

¹ Danny Otchere, The Reserve Holding Behaviour of Developing Countries, unpublished Ph.D. thesis, McGill University, 1972.

goals of developing countries and metropolitan countries makes for differences in the reserve optima of these two groupings. In Otchere's model the technical trade-off between reserve levels and reserve variation (and hence between income levels and income variation¹) depends on the available foreign exchange and two alternative uses for that foreign exchange - importation of capital goods and importation of essential consumer goods. The choice as to the combination of importation and reserve accumulation is made on the basis of the relative social rates of return. A variety of combinations of the three uses of foreign exchange is compatible with any given level of risk. The locus of these combinations traces out the level of reserves in the 'portfolio'² and the associated variability in the 'portfolio'. This is the technical trade-off, which Otchere refers to as the opportunity locus. It will differ from country to country depending on the scarcity of capital and foreign exchange, and the structure of consumption imports.³ These factors would account for part of the difference between developing and metropolitan countries.

However, Otchere suggests that there is another source of distinction between developing and metropolitan countries - the shape of their respective utility functions. Because of their anxiety to promote economic development in the face of a foreign

¹ Since income is a monotonic (decreasing) function of reserves (See Clark, op. cit., Equation 11).

² Otchere regards the choice as one of holding an optimum portfolio.

³ For example, the proportion of essential foodstuffs in consumption imports.

exchange constraint, developing countries may be less averse to risk than some metropolitan countries. This is illustrated in the accompanying diagram, adapted from Otchere. I_1 , I_2 and I_3 are indifference curves which reflect increasing willingness to accept risk, the last being the case of risk indifference. For a given opportunity locus greater willingness to accept risk implies a smaller proportion of foreign exchange to be allocated to reserve accumulation. (The proportion of reserves held decreases from a to b and from b to c). Therefore, on account of both objective and subjective factors, there is reason to expect reserve behaviour of developing countries to be different from the behaviour of metropolitan countries.

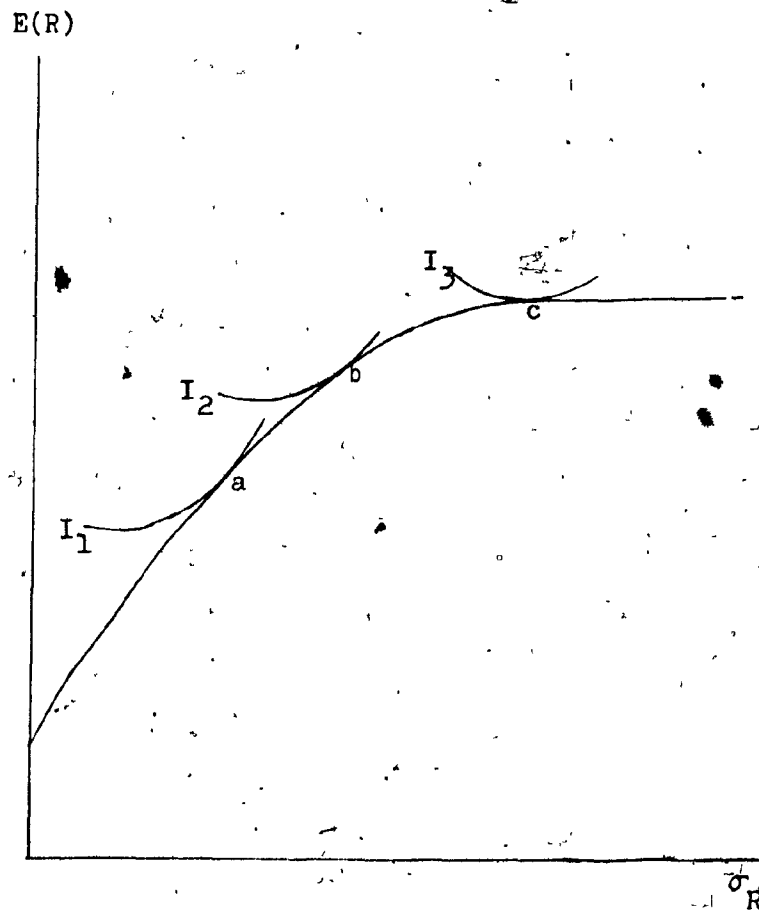
The three studies which follow all extend the analysis by considering future economic consequences as well as current effects. The analysis is made dynamic by the inclusion of the present value of future costs in the models devised by Britto and Heller and by Iyoha.¹ Jürg Niehans, in a work of a more tentative and exploratory nature, investigates the optimal growth path of reserves over time.²

Britto and Heller arrive at the optimum level of reserves by minimising the sum of the discounted expected costs (of alternative policies for balance of payments accommodation) over a selected planning period. Assume that there are n time periods and that time is measured from the last through the first. The amount of adjustment in any period (t) is u_t ; reserves at the beginning of the

¹ R. Britto and H. R. Heller, 'International Adjustment and Optimal Reserves', International Economic Review, Feb. 1973; M. A. Iyoha, 'Optimal Balance of Payments Strategy by Stochastic Dynamic Programming', Western Economic Journal, Dec. 1971.

² Jürg Niehans, 'The Need for Reserves of a Single Country', in IMF, International Reserves: Needs and Availability.

Figure 3-2. Levels of Risk Aversion and Optimal Reserves.



period are R , and there is random variation (equal to y) in the balance of payments. $g(\mu_t)$ is the cost of adjustment amounting to μ_t . N is the (arbitrarily specified) minimum allowable level of reserves and α is a discount factor. The distribution function of y is given by $\phi(y)$ and the minimum sum of the discounted expected costs of R (over all n periods) is represented by $C_n^*(R)$. Reserves at the end of period n are given by $(R + \mu_{n-1} + y)$.

The fundamental equation of the Britto-Heller model is

$$3-10. \quad C_n^*(R) = \min_{\mu_{n-1} \geq N-R} \left[g(\mu_{n-1}) + \alpha \int_{-\infty}^{\infty} C_{n-1}^*(R + \mu_{n-1} + y) \phi(y) dy \right]$$

The expected cost for the n^{th} period is the sum of the cost of adjustment in the next period ($g(\mu_{n-1})$) and the discounted sum of expected costs for all periods beyond. The values of μ must be chosen so as to minimise this sum, subject to the condition that adjustment in any given period must be sufficient to maintain reserves at or above the minimum allowable level. The equation is soluble, provided we have the value of the cost of adjustment for the last period. The optimal reserve level is set by the condition that the marginal benefit of reserves be equal to the absolute value of the marginal costs of adjustment. It is obtained by solving 3-10 for μ_{n-1} , differentiating with respect to R and putting the result equal to zero.

One important feature of the dynamic model is that it allows for the choice between adjustment now and adjustment later (or rather, greater adjustment now and less later, or vice versa). By prescribing the optimal pattern of adjustment to accompany reserve policy, economies should be possible in the use of reserves. Britto and Heller also compare the costs of a range of alternative adjustment

measures. They conclude, not surprisingly, that a 'mixed' policy is always less costly than one which concentrates on the use of one policy instrument only. The best policy mix is obtained by equating the costs of various policies at the margin.

The Britto-Heller model is nevertheless presented at a high level of abstraction. The distribution function of the random y is not specified, nor are the costs of adjustment (g) or the discount factor (α). The model needs to be fleshed out in these various aspects before we can arrive at testable hypotheses. In addition, it may be noted that this model does not solve the problem (which has featured in articles reviewed above) that the minimum reserve level must be arbitrarily specified.

Iyoha provides a more complete specification of a model which is in its essentials the same as the Britto-Heller model. The conditions for reserve optimisation are the same¹, but Iyoha allows for a constantly shifting time horizon. He specifies that the process underlying payments imbalances is Markovian, that there is one state variable (reserve levels) and one policy or 'control' variable (imports). The level of imports may be altered by means of deflation or import tariffs. Exports are exogenous but subject to random variation which is the only source of payments variability, since it is assumed that target import levels are always attained. The benefits from any constellation of policies are measured in terms

¹ Iyoha's equations are written in terms of benefits rather than costs, so his problem becomes one of constrained maximisation rather than minimisation.

of expected income. The system is solved for the maximum sum of discounted benefits for any given state at a given time, the solution yielding a value of K , the index of possible policies. With this policy option fixed, the exact composition (including the degree of financing via reserves) is obtained by equating marginal benefits, and the optimum level of reserves is thereby determined, much as for Britto and Heller's model.

An important contribution made by Niehans was to focus attention on the growth path of reserves over the long run. Most of the recent theoretical work has been concerned with the use of reserves as a short-period precautionary measure. Although it has been recognised that there is a transactions demand for reserves as well, little attention has been given to the determinants of transactions reserves. For example, in the Archibald-Richmond model, the implication is that transactions reserves increase by a constant amount over each time period. Niehans suggests that the growth of transactions reserves must be the same as the growth rate of income, so long as the parameters of the economic system remain unchanged. This seems reasonable, but, as we have suggested in Chapter Four, a more complete model of the national economy is needed to provide rigorous demonstration of the way in which the transactions demand for reserves is determined.

In most respects Niehans' model is too abstract to do more than suggest possible directions for investigation. In addition to transactions reserves, he specifies objectives in terms of employment and prices. No one has so far taken up this approach. Also, two

qualifications made in Michael Kuczynski's comments¹ on Niehans' paper should be noted. As he points out, Niehans neglects the disutility of tying up national resources in reserves; and he does not specify how the adjustment process works to bring the long term growth rate of reserves into line with the growth of income².

Parallel with the evolution of models of optimal reserves there has developed a degree of scepticism as to whether such an exercise can produce any useful results. Fritz Machlup was the first of the sceptics³. His argument was that the monetary authorities do not regard the achievement of any particular reserve target as an objective of policy. Reserves actually held are merely what results from the other economic policies specified, and authorities are satisfied with this so long as reserves do not fall too quickly.

This argument may be countered on normative and positive grounds. The normative argument is that since reserves have important economic consequences, it is illogical to ignore them. By so doing the authorities may in fact be sacrificing welfare by ignoring a relevant decision parameter; they may, as a result, keep non-optimal reserves at an economic cost higher than is necessary. The positive counter-argument is due to Grubel⁴. What economic analysis measures is not a

¹ IMF, International Reserves: Needs and Availability, p. 86.

² That is, the conditions which will make the adjustment factor satisfy the required condition.

³ F. Machlup, 'The Need for Monetary Reserves', Banca Nazionale del Lavoro Quarterly Review, Sept. 1966.

⁴ Op. cit., p. 1148.

country's 'need' for reserves (which is what Machlup concerns himself with) but its effective demand for reserves.. The latter can be measured irrespective of the economic policies pursued or the ends which authorities have in view. In our own model, for example, this is taken care of by relating reserve levels to the values of the main decision variables. As we have shown, this makes it possible to infer the patterns of growth and variability, unless economic structures change.

June Flanders¹ has a rather different criticism of reserve theory. She suspects that countries may be divided into two categories: those which hold relatively high levels of reserves and pursue active policies to maintain them; and those which hold relatively low levels and are less concerned about their erosion. This critique seems to present no conceptual difficulty for most existing models. It would require different utility functions for the two kinds of country, but the logic of the models would be unaffected. In the case of our own model where no utility function is specified, it would imply that the model would not provide a good explanation of the behaviour of all countries, but this level of generality has not been claimed for the model in any case.

Egon Sohmen² supports Machlup's argument that the monetary authorities are 'satisficers', but in addition he introduces new reasons for scepticism. He contends that metropolitan countries have

¹ M.J.Flanders, The Demand for International Reserves, Princeton Studies in International Finance, no. 27.

² 'General Reserve Supplementation: Some Issues', in IMF, International Reserves, Needs and Availability.

such a range of measures with which to deal with any balance of payments difficulty that they need never resort to the use of reserves. This argument does not affect the analysis of the papers reviewed earlier in any significant way, since the alternative measures are taken account of in the fully articulated models. If, as Sohmen implies, the alternatives are less costly than financing with reserves, then this should correspondingly reduce the optimum level of reserves.

Sohmen's second critique has to do with the distinction between temporary and fundamental disequilibria. He seems to be of the opinion that it is necessary to know ex ante whether any given disturbance is transitional or persistent. It is difficult to see why this must be so; if continuous analysis is undertaken of balance of payments trends in order to inform reserve management, then the onset of fundamental disequilibrium would be signalled by a sharp rise in the cost of all available policy options and combinations. This would indicate to authorities the need for a strategy to restore equilibrium. The fact that a certain proportion of reserves has not been put aside to 'buy time' for re-adjustment does not prevent authorities from in fact employing reserves for this purpose during the period of re-adjustment.

Sohmen's third criticism has to do with the scant attention given to capital flows as a means of financing balance of payments deficits. He points out that by using domestic interest rate policy, capital inflows may be induced to alleviate the foreign payments position. Furthermore, the same objective may be achieved by certain

kinds of forward exchange transactions, so that the foreign investor can be given a yield advantage without increasing domestic interest rates and inducing changes in the domestic economy thereby. The treatment of capital movements is an undoubted area of weakness in the theory as it now stands. Earlier analysts neglected capital flows; where they have been analysed (by Britto and Heller and by Iyoha) the interest rate policy and its consequences have not been fully explored.

The criticisms which have been made of exchange reserve theory so far would suggest areas of extension which might reward further research. They highlight some of the major issues which remain problematic. Shortly we will consider other outstanding issues of this nature, but first we comment briefly on the results obtained in a number of empirical tests of the various models so far described.

Archibald and Richmond discovered that, for the countries they tested, the variance of reserves increased over time as the average level of reserves increased¹. For the typical case variance increases by a factor of $3/2$ every five years. One implication of this is that reserves should increase over time, because reserves are directly related to the variance of net foreign transactions. There is a more important theoretical consideration. Since all the models so far devised depend on the assumption that the variance of reserves remains constant, the inferences to be drawn must be qualified. This introduces a further weakness in the theory, because no one has devised a way of deciding just how much bias is

¹ There was one country in their sample for which the variance did not increase.

introduced by removing the assumption of constant variance. The only way of avoiding this pitfall is to confine the analysis to a period short enough to ensure that there will be no significant increase in variance.

All the recent empirical studies have tested the relationship between reserves and the variance of foreign transactions. Several measures of that variance have been used, including the standard deviation of exports or of reserves, and indices of variation based on deviations from a moving average. Only Flanders failed to find a significant relationship; all other studies found the coefficient relating variability to reserves to be significant and well-behaved. This confirms an important thrust of recent theoretical work.

The variable which has had the longest history of empirical testing in reserve studies is trade in one or other of its many guises: exports, imports, total trade, adjusted net foreign payments, etc. Invariably, the results show positive association between reserves and trade. The question has been whether this relationship indicates that reserves are a function of levels of trade in some way, or whether the association occurs because the volume of trade is an indicator of the scale of foreign transactions. It is probably a combination of both. Insofar as the volume of trade reflects increases in the volume of transactions or in the prices of traded goods, the stochastic models lead us to expect a positive relationship. At the same time, for any given country, the volume of trade is an indicator of the scale of foreign transactions; the greater the scale, the greater the reserves for transactions purposes, assuming all else constant.

Granted that some relationship between trade and reserves is to be expected, what is the nature of the relationship? The empirical work offers no definite answers. The coefficients obtained on the several measures of trade are a mixed bag. What some results indicate, however, is that a breakdown of countries by some specific categories (in particular, developed and less developed) might be necessary.¹

In fact, this principle probably should be extended. I have argued, and so have others,² that special features of developing countries should be incorporated into the fabric of reserve theory. Apart from the relationship between reserves and trade other kinds of distinction between countries have been suggested. For example, Flanders thinks that countries may fall into two groups, differentiated by their subjective preference for risk.³ In fact, peculiarities of each country's economic structure may be such as to conceal the true nature of relationships when data for several countries are aggregated. As an indication of this, Kelly's study incorporated the use of dummy variables, one for each country. They were all found to be significant. This is not to say that no overall theory will fit the facts. General

¹ See J. Frenkel, 'The Demand for International Reserves by Developed and Less Developed Countries', Economica, Feb. 1974, p.19.

² Agarwal, for example.

³ Otchere would argue that one basis for this preference differential is the desire to accelerate development.

theories of reserves, or at least theories valid for countries with particular characteristics, should still provide explanations, but the parameter values may vary significantly between countries. For this reason some writers (including ourselves) prefer time-series analysis, applied to one country at a time and allowing for tests of the relationships as they apply to that country.

This review of the literature on foreign exchange reserves has highlighted some of the areas of difficulty in the theory. We will conclude with recapitulation and further comment on a number of these issues.

First, we consider the purpose for which reserves are held. We have insisted throughout this study that countries should regard reserves as a precaution against unforeseen short-run disturbances, apart from the predictable transactions requirements. We have specifically excluded accommodation of fundamental disequilibria, major national catastrophes and massive foreign exchange speculation. This conception of the problem has been challenged by some of the articles reviewed. Reserves cannot finance a fundamental disequilibrium, but they may finance foreign payments while other adjustments are being made; and some monetary authorities may wish to anticipate the other contingencies. There is no conceptual difficulty with factors in the second category but the probability of their occurrence is difficult to estimate, and the calculated optimum levels of reserves may be subject to very large margins of error. As to the treatment of fundamental disequilibria, we have suggested that flexible reserve management might accommodate this contingency within the limits of a model

which specifies the limited objectives which I have chosen.

Second is the definition of reserves. The points at issue - whether to use net or gross reserves, private as well as official reserves, and the balance of liquidity and risk in foreign assets - have been explored in our study and elsewhere.¹ It is an area where further work is urgently needed.

Third, more work is needed on the systematic determinants of reserve variation. The use of variables like time and lagged values of reserves is unsatisfactory. An explanatory equation which incorporates the effects of economic states and policies together with random variation is required.

Fourth, assumptions relating to large metropolitan countries and reserve currency countries have seldom been included, mainly because of the difficulties in dealing with repercussions of one country's actions on another and the treatment of foreign exchange liabilities.

Fifth, there is the problem of aggregation. The optimum levels of reserves as viewed from each country's standpoint, with given structure of the world payments system may not lead to an optimal level of world liquidity. Moreover, changes in the level of payments restrictions will alter the calculated optimum level of reserves for each country.

Sixth, the theory must be extended to cover a wider range of policy options. There is a dichotomy at present in that the analyses which cover a wide range of options do so at a high level

¹ Chapter One and Williamson, op. cit., pp. 687, 739.

of abstraction, while those which are less abstract are not so general.

The seventh point of issue concerns one particular adjustment mechanism, induced capital flows. The effects of interest rate policy on capital flows needs to be explored.

Eighth, there is need for further work on the dynamic aspects of the theory. Particularly suggestive areas which have been the focus of recent attention have been the model of intertemporal adjustment (Britto and Heller) and the optimal growth path of reserves (Niehans).

The ninth issue is the one with which we are specially concerned: the modifications required to make the theory relevant to developing countries. The special features of developing countries have been recognised in a number of studies. Stress has been laid on their underdeveloped capital markets and financial institutions (Sohmen), the higher elasticity of their reserves with respect to trade (Frenkel), the higher opportunity costs of reserves because of the relative scarcity of capital (IMF, 1953) and the structure of trading patterns (Flanders). However, the only models with which we are familiar which focus on developing countries are those of Agarwal and Otchere. Agarwal's model, as we noted earlier, suffers from a relatively unsophisticated distribution function for reserves. Otchere's difficulties are (a) that he does not explore rigorously the construction of his opportunity locus for various foreign exchange portfolios and (b) that he is unable to say specifically what the relationship is between the expected level of utility and the 'willingness to promote development'.

The theory of optimum reserves still has a long way to go. The most that any one study such as ours can hope to achieve is to provide some fresh suggestions and new insights into particular aspects and problems from the list enumerated above.

CHAPTER 4

An Outline of the Model

The model we are about to describe uses building-blocks which have become familiar in the course of the literature review of Chapter Three. These are, one, the coefficient of security, measuring the insurance against stock-out at each reserve level; two, the opportunity cost of each reserve stock; and three, the costs of balance of payments adjustment. It is in the way that these elements are measured that our model differs from those just described. The differences consist of the introduction of economic determinants of the coefficient of security, specification of costs in terms of rates of growth and a method of solving for the optimum level of reserves for a single country. The rationale for these innovations was given in the first Chapter.

We begin with some preliminary remarks on the problem of reserves in developing countries and in Jamaica in particular.

Perhaps the first question to be asked in approaching the model-building exercise is whether we need a special theory of reserve holding for underdeveloped countries. Among the reasons which have been suggested for viewing the liquidity of underdeveloped countries as a special case, we find: the relatively greater importance of trade in their economies and their vulnerability to fluctuations originating in the rest of the world; their highly specialised export trade and their greater concentration on volatile primary products; the fact that their imports are less "compressible";¹ the fact they have lower levels of reserves to begin with; and the higher opportunity costs of reserves in underdeveloped countries.²

¹ That is, there is less scope for trimming imports without reducing domestic production.

² June Flanders, The Demand for International Reserves, Princeton Studies in International Finance, no. 27, 1971.

Jamaica, like many underdeveloped countries, would qualify for special attention under a number of these headings. We may recall from our earlier survey that the Jamaican economy is characterised by very high levels of external trade and by export specialisation in three main areas: bauxite-alumina, tourism and sugar. Two of these are primary products and all are subject to external forces (though the degree of price fluctuation in mining and sugar is reduced by special marketing arrangements). In addition, on the import side, the high proportion of food and essential raw materials in the total import bill is a constraint on import cut-backs. However, we wish to concern ourselves particularly with the opportunity cost of holding reserves. We argue that this cost is not appropriately measured by the interest income foregone in countries where the ratio of investment to fixed capital formation is high. In such cases one must deal with the effects on the creation of additional capacity. From the point of view of the authorities, the most relevant alternative to holding reserves is to acquire real foreign resources so as to accelerate growth and development. We therefore suggest that in underdeveloped countries with a foreign resource constraint, the appropriate measure of opportunity cost of holding reserves is a certain rate of growth. Furthermore, the benefit of holding reserves, which is the cost of using alternative measures to cure a payments disturbance, is also to be measured in terms of a rate of growth. Conventionally, this latter cost is measured in terms of income variability, which is assumed to have a certain disutility, with this disutility to be minimised. If growth is the overriding concern,

however, then the disutility may in all cases be minimal, if it does not depress the rate of growth. Hence the rate of growth becomes the appropriate measure of the cost of alternative adjustment.

A word of caution is necessary. While we would maintain that this method of measurement is preferable to previous suggestions, it is itself a drastic simplification. For one thing, it assumes that there is the actual or potential ability to absorb additional foreign resources (or to absorb foreign resources at an accelerated rate). It assumes that foreign resources will have the same effect whether they originate from export earnings, from the use of accumulated foreign assets or from foreign capital inflow. It assumes that development is the overriding objective and in practice, it makes the usually invalid assumption that growth rates are a reliable measure of development. Because of these limitations, the method must be applied in a tentative and exploratory manner, with due allowance being given to qualitative as well as quantitative analysis.

The Jamaican experience with foreign exchange reserves has been atypical. If we look at the official holdings of foreign currency (including securities, bank deposits and drawing rights with the IMF) we find that reserve levels have been consistently high ever since the establishment of The Bank of Jamaica in 1961 (and beyond). This has been so despite a persistent and growing balance of payments deficit on current account¹. That is to say, capital inflows have more than compensated for the current account deficit, with the excess being accumulated in the form of foreign exchange reserves.

It seems rather anomalous that a country whose growth is constrained

¹ Bank of Jamaica, The Balance of Payments of Jamaica, 1964-70; 1971; 1972.

by the availability of foreign resources should hoard foreign exchange rather than use it to secure additional foreign inputs. In order to explain this behaviour fully, we need answers to the following questions: (a) are the existing reserve levels necessary to meet expected contingencies? (b) is there a limit to the domestic capacity to absorb foreign resources? (c) is there a cost to converting foreign reserves into real foreign resources? (d) is the accumulation of reserves the result of a misguided development policy (for example, total dependence on foreign enterprise to the neglect of local enterprise?)

This study is immediately concerned only with the first of these questions, that is, to determine the level of reserves appropriate to stated objectives. However, the policy decision which will be taken once we have some notion of an adequate level of reserves will be a decision determined by all the factors mentioned.

The Components of the Model

Let us outline formally the model for determining the level of reserves which will secure the optimal rate of growth. It is that level of reserves which will minimise the expected cost, in terms of a potential rate of growth, of financing net demand for foreign exchange. Assume (a) that we have only two alternatives for accommodating net demand for foreign exchange - reserves and internal adjustment; and (b) that any positive net demand for foreign exchange is met first by reserve depletion and that internal adjustment is a consequence of reserve exhaustion. For the moment, we define internal adjustment to be the passive adjustment mechanism (by way of income and employment reduction) which will eliminate the anticipated deficit in

foreign receipts.

We can write an equation for the expected value of the cost of holding reserves equal to \$R million when net demand is equal to \$D million:

$$4-1. \quad E(C/R) = \int_{-\infty}^R C_1 (R-D) \phi(D) dD + \int_R^{\infty} C_2 (D-R) \phi(D) dD$$

where $\phi(D)$ is the distribution function of net demand¹. The first term on the right hand side is the expected cost of actual reserves held at the end of the period; the second is the cost of internal adjustment. The equation gives total expected costs as a weighted sum of the cost of reserve holding for different levels of net demand for reserves up to the point where reserves are completely exhausted, plus a weighted sum of the cost of internal adjustment to net demand for reserves over and above the current level of reserves. The optimal level of reserves is that level which minimises the expected cost.

This equation is developed in the following fashion. The first part of the cost, the cost of maintaining the reserve stock, derives from the expected value of the reserve stock. The value of the reserve stock at the end of the period is the initial value of reserves, R, minus the net demand for foreign exchange during the period D. The cost of this stock is given by the cost function $C_1 (R-D)$, where C_1 will actually be measured in terms of g, the rate of growth. The expected value of this cost is given by

$$\int C_1 (R-D) \phi(D) dD,$$

since D is the only variable subject to random movements, R being our policy control variable. If reserves are completely exhausted, this cost is zero, so

¹See J.H.G. Olivera, "The Square-Root Law of Precautionary Reserves", Journal of Political Economy, Sept/Oct. 1971, Appendix C.

the cost will have non-zero values only when D is smaller than R . D may therefore vary from any negative value (however large) through all positive values smaller than R . This fixes the limits of integration for this part of the expression and yields a cost of maintaining the expected reserve stock as

$$\int_{-\infty}^R C_1(R-D) \phi(D) dD.$$

The second part of the expression is derived in analogous fashion, although in this case there will only be a non-zero cost if D is greater than R , that is, when reserves are completely used up. This follows from our assumption that internal adjustment begins only when reserves have been run down completely. Thus we have that the expected cost of internal adjustment is

$$\int_R^{\infty} C_2(D-R) \phi(D) dD$$

where $D-R$ is the amount of adjustment needed, C_2 is the growth-cost of adjustment, and D may be taken as any positive value greater than R .

What we can say about each element of the equation? We need to take expected value because we are dealing with a situation of uncertainty. We cannot know precisely what the demand for foreign exchange will be ahead of time. We will therefore have to address ourselves to the task of finding a distribution function for this variable.

We will return to this task shortly, but first we look at the cost functions, c_1 and c_2 . $c_1(R-D)$ is a function which gives a rate of growth associated with an amount of foreign resources equal to $(R-D)$. More accurately, it gives the additional rate of growth which an additional $(R-D)$ of foreign resources would make possible if these resources were made available over a stated time period. $(R-D)$ is of course the amount of foreign exchange reserves which remains idle after we have taken care of the net demand

for foreign exchange. We have a range of costs for every reserve level from infinity to zero (D goes from minus infinity to R); we weight each of these costs by its probability of occurrence. The resulting sum gives the expected cost of holding reserves.

In order to make the function relating (R-D) to the growth rate easily manageable we begin with the simple notion that foreign requirements are the difference between receipts (represented by exports (X)) and payments (represented by imports (M)), so that

$$4-2. \quad F_t = M_t - X_t$$

where M_t and X_t are the import and export levels associated with a level of income Y_t with existing structures of production, exchange and payments. If we assume that imports are a function of income alone, we have

$$4-3. \quad M_t = M(Y_t)$$

and

$$4-4. \quad F_t = M(Y_t) - X_t$$

Let us say that we are now in year zero and that we require income to grow at 100g% per year to year t.

$$4-5. \quad Y_t = Y_0 (1 + g)^t$$

We have therefore

$$4-6. \quad F_t = M[Y_0(1 + g)^t] - X_t$$

which gives us the foreign resource requirements in year t as a function of the rate of growth g if we know X_t . We can sum the equation over all t within a planning horizon to derive the foreign resource requirement for sustaining any growth rate. This is, in essence, the method popularised by Chenery and his various collaborators and used by UNCTAD in its survey of foreign assistance

¹The best known being H. Chenery and A. Strout, "Foreign Assistance and Economic Development", American Economic Review, Sept. 1966, pp. 689-691.

requirements¹.

Some crude estimates of the growth potential associated with levels of foreign input can be devised at this aggregate level, but the results must be viewed with extreme caution. The main qualification is that the aggregate analysis assumes that the parameters of the economic structure (which determine the link between income and imports in this simple formulation) are known with some degree of accuracy. Since the process of development in underdeveloped countries is a process of structural change, however, these parameters will be subject to change. They can only reasonably be predicted by disaggregated sectoral analysis. A second qualification is that the rate at which foreign resources are disposed may be altered with different effects on the overall growth rate even when the total resources available are the same. These considerations are introduced to indicate the more detailed analysis which would be required so that our method could yield less tentative results.

The cost $c_2(D-R)$ measures the reduction in the current growth rate which would result from internal adjustment to eliminate an ex ante foreign exchange deficit equal to $(D-R)$. By assumption, this cost will not be incurred unless net demand for foreign exchange exceeds the current reserves levels. The costs of adjustment with which we are concerned are those which will result in lasting damage to the production system. We should include all distortions in the allocation of resources, shortages which delay projects to expand capacity, projects which are started and abandoned because of changing cost conditions (particularly the cost of credit), the demoralisation of entrepreneurs which

¹UNCTAD, Trade Prospects and Capital Needs of Developing Countries, N.Y. : U.N., 1968.

may have long-run effects on the absorptive capacity of the economy and all other factors which will reduce growth potential by reducing the efficiency of resource allocation. In addition, there is the straightforward loss of foreign resources which were necessary to sustain the expected rate of growth.

Let us begin by considering this latter aspect alone. We first establish the rate of growth associated with expected foreign resource availability; we can then determine what sacrifice of growth will result from a reduction of (D-R) from this amount. This is the minimum growth cost of that reduction, since there will be additional growth sacrifice to the extent that we face allocative inefficiencies of the kind suggested above.

We must now determine what the net demand for foreign exchange will be over the next year; or rather, we must find the probability associated with a given net demand. The method is to devise statistical interpretation of recent experience to develop inference about this demand. We are dealing here with the net demand arising from market forces, so that we need to assume that there is no policy of active intervention to cause adjustments in the levels of foreign exchange held. During the period from which we draw our Jamaican data no policies of this kind were pursued, so that this assumption does not violate the facts of the case.¹

Difficulties arise with the attempt to explain the movement of net demand. Changes in net demand are identical to changes in the level of foreign exchange reserves (with an opposite sign) if we include the demand on capital as well as current account. Our task is therefore to devise a statistical explanation for the reserve series. There are a number of alternatives. One

¹See Chapter Seven.

possibility is to employ the autoregressive equation which Archibald and Richmond¹ have tested with good results for a large number of countries. It describes the reserves series as a function of time and a lagged value of reserves; from this the authors are able to derive a mathematical expression for the probability of net demand, though they are forced to make a very broad approximation.

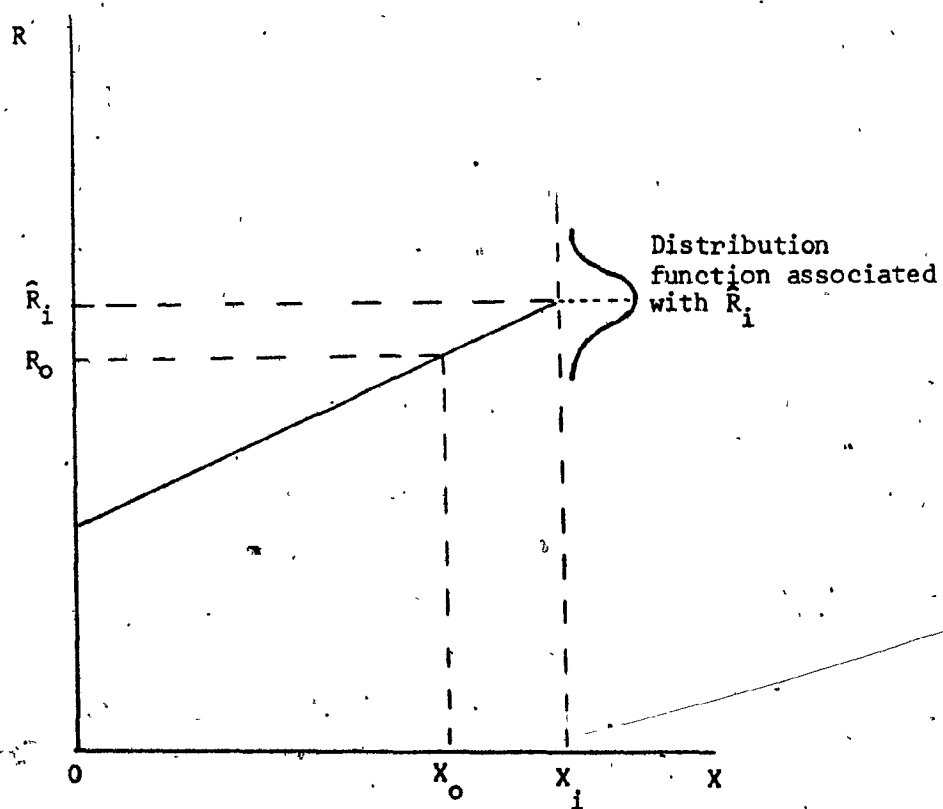
As an alternative to this method, we can attempt an economic explanation of reserve movements. What we should like to have is a complete description of the economy which we could employ to determine the effect on any dependent variable of given values of state or instrument variables.

In the next chapter we develop at some length our notions as to the predetermined variables which serve to explain reserve movements and the nature of the relationship between each of these variables and reserves. The objective there is to develop a strong a priori case for the use of a five-variable regression equation to describe the reserves series, with exports, money supply, capital inflows and government expenditures as the explanatory variables. The equation is used to predict the movement of reserves for some future time period and to derive the confidence intervals for this prediction. These intervals are then used to evaluate the probability associated with any level of net demand, defined as the difference between the expected value and any other predicted value which has a probability of occurrence. The predicted level is, in this case, not a single point, but a number of points, each associated with its own probability.

This is illustrated in diagram 4-1, for the case of one exogenous variable (X) and a straight-line regression. The current level of X is X_0 , and our projection is to be based on an X-value equal to X_1 . The point prediction of

¹G. C. Archibald and J. Richmond, "On the Theory of Foreign Exchange Reserve Requirements", Review of Economic Studies, Dec. 1971.

Figure 4-1. Net Demand for Foreign Exchange Reserves



reserves (R) is $\hat{R}_i$, but there is a distribution function associated with this value, illustrated on our diagram by the bell-shaped curve. Thus values greater or less than $\hat{R}_i$ are possible each with a different probability of occurrence¹. The net demand for reserves consists of an amount $(\hat{R}_i - R_0)$ which we will call the transactions demand, and an additional unspecified amount (negative, positive or zero in value) which we term the precautionary demand. It is the precautionary reserve which appears as D in Equation 4-1. The " R " of that equation is the predicted value of reserves ($\hat{R}_i$), which include the estimated transactions demand.

Once we have estimated the parameters of the equation expressing the total costs of adjustment, we can differentiate to find the value of reserves which will minimise this cost. The resulting 'optimal' level of reserves will be too high, because our discussion so far has not taken into account all the possible responses to a temporary foreign exchange deficit. Expenditure switching policies and measures to finance the deficit may reduce the cost of running out of reserves.

Expenditure switching policies - multiple exchange rates, tariff adjustments, quotas, prohibition - reduce the demand for foreign inputs in two ways. First, we can 'compress' imports. There may be very narrow limits to this policy, however, since it may not be possible to reduce imports very far without inhibiting the country's growth. Some indication of the possibilities and limitations of this policy may be had by decomposing imports by economic function and establishing a hierarchy of items, with those whose loss will most directly affect growth rates at the top of the list. From this we can make some assessment

¹There is no probability density associated with any of the points in the interval surrounding $\hat{R}_i$; in practice we estimate the probability associated with a small interval centred on these points.

of the amount by which imports can be reduced without significantly affecting growth. To be realistic, however; we must also take account of other factors which may put difficulties in the way of reducing imports. For example consumer imports may not be compressible because there are long-standing preferences in favour of certain imported items.

The second aspect of the expenditure switching policy has to do with re-ordering sectoral growth rates in favour of activities with lower foreign resource inputs. If the country is producing efficiently in a situation where growth is limited by foreign exchange earnings, it should be impossible to switch production in this way without impairing growth. The most efficient growth path in such a situation would be one which adjusts sectoral growth rates in such a way as to minimise the use of foreign inputs for any given overall rate of growth. If this efficient growth path is already followed, any reduction of foreign inputs would necessarily reduce the rate of growth. In practice there is usually some region within which changes in foreign inputs may not have a very significant growth effect, but increasing deficiencies in inputs of foreign resource can be expected to have increasingly significant effects on the rate of growth.

Expenditure switching policies have a positive cost in terms of the growth rate, if we make the assumption of efficiency. For a given economic structure, given set techniques and given policy instruments, a certain rate of growth will require a particular level of foreign resources; fewer resources will mean less growth, unless we remove some of the constraints or alter some of the parameters. Thus we have to compare the growth sacrificed by expenditure switching with growth sacrificed by the alternative means of responding to the foreign exchange problem.

Short-term financing may provide an alternative means of accommodating

net demand for foreign exchange. Again there are costs involved. Unconditional finance - loans and credits with no stipulations as to how and when they should be spent - involves only repayment costs. Repayment costs will depend on the size of the loan and the conditions of repayment. Conditional finance on the other hand, will involve efficiency costs as well. The real cost of a given amount of foreign input may increase because it is no longer possible to obtain it from the cheapest source; or sectoral growth rates may be thrown out of line because finance is available for some sectors and not for others; or trading patterns must be re-adjusted because it is not possible to finance trade with each trading partner to the required degree. Again assuming that we begin with an efficient pattern of growth, such disruptions will reduce the growth rate which is now possible.

The question which must be answered with respect to both expenditure switching and financing, is whether the cost involved for a given exchange deficit, is greater than the cost of internal adjustment. We can suggest a decision rule which would lead to a minimum-cost policy package to be used in the event that we run out of reserves. First we must decide what finance is available from what sources, and at what cost; we must also determine the cost associated with expenditure switching of various amounts. Then we can employ financing and expenditure switching instead of internal adjustment so long as the growth cost involved in either of these alternatives is less than the growth sacrifice involved in using internal adjustment sufficient to have the same effect. We can, in theory, replace the cost function $C_2(D-R)$ by a function which represents the costs, not of internal adjustment alone, but of a policy package which includes some financing and some expenditure switching as well.

Summary of the Method for Determining Optimum Reserve Levels

•It remains now to demonstrate how the elements of the model can be put together to arrive at a value of the optimum reserve level. Essentially, the task is to fix the parameters of Equation 4-1 and to find its minimum point.

The regression analysis on the determinants of R is used to test our hypothesis that $\phi(D)$ is a normal distribution. If this hypothesis is not supported by the data then it will be necessary to review this explanation of reserve movements. If the analysis confirms that $\phi(D)$ is normal, the regression will yield a value for its standard deviation. Since we know that the expected value of net (precautionary) demand is zero, this will enable us to specify the particular values of the normal distribution function to be used in our estimation.

We are examining the cost of different values of R , so that R becomes the predetermined variable in 4-1, with cost ($g\%$ per annum) as the dependent variable. Since we now can specify each value of D and the probability weight attached, we have the required range of values for $(R-D) \phi(D) dD$. The next step is therefore to estimate the parameters of the two equations linking the costs (g) and the expected reserve levels after taking account of the precautionary demand ($R-D$). For the first equation (the c_1 cost) this involves estimates of the propensity to import and the growth rate of exports; for the second (c_2 cost) it involves the complex of factors which determine the cost adjustment for any magnitude of adjustment required.

Once we have these estimates the two integrals of 4-1 can be formed and evaluated. In practice, limits can be set on the range of variation of D , since the mass of the probability density will be concentrated around the central value. Our method is to choose a set of plausible values for R which reflect a reasonable range of reserve holdings which the monetary authorities would wish to

consider and to determine the associated growth rate. From the plot of $R - g$ pairs we can identify the minimum-cost reserve holding.

The shape of the $R - g$ curve from which we deduce the optimum reserve level depends crucially on the parameters of the cost curve and on the planning horizon chosen. For this reason the relationship between reserves and growth becomes specific to the country being analysed, and the plot for Jamaica is therefore postponed to Chapter Seven, after the necessary parameters have been estimated.

CHAPTER 5

Predicting Reserve Movements

This and subsequent chapters will deal with various segments of the model in detail. Here we concern ourselves with the precautionary demand for reserves and the ways by which it may be measured.

If we start from a reserve level of R_t , the level attained n periods ahead (R_{t+n}) depends two facets of the demand for reserves: what we call the transactions and precautionary demands. It is with the precautionary demand that this study is mainly concerned. The precautionary demand arises because of the random disturbances to which the net foreign payments system is subject from time to time; these unpredictable short-run disturbances are precisely the contingencies against which the foreign exchange reserve stock is held.

The precautionary demand for reserves, therefore, is that portion of the net demand for reserves (over some interval n) which derives from the random influences to which foreign transactions are subject. As we demonstrate below, in our model this variable has a central value of zero, but there are as well a range of positive and negative values each of which has a measurable probability of occurrence. Part of our task will be to find the values of this probability distribution which are appropriate to the Jamaica situation.

The pattern of variation of net foreign exchange earnings is not entirely random, however. There is a systematic, predictable element which accounts for our "transactions" demand, and only when we remove the effect of this systematic variation do we get a random statistic from which the precautionary reserve levels may be derived.

We distinguish the transactions and precautionary demands by the nature of their origin. The transactions demand arises out of the normal

imbalances of day-to-day transactions. Receipts and payments are seldom matched within a given accounting period; nor are they balanced with each trading partner individually. Much of this imbalance will be taken care of by credit of some kind, but the remainder will be manifested in changes in the stock of exchange reserves. On the other hand, there is the precautionary demand, which results from unforeseen changes in foreign transactions. Precautionary reserves are therefore stored up against the possibility of failures in export crops, trade or payment restrictions by trading partners, inflationary spending on imports. Precautionary reserves can be used in these circumstances to ride out the disturbance (if it is temporary) or to buy time to make other adjustments (if the underlying economic conditions would seem to warrant it).

The Transactions Demand

If we observe month to month variations in net foreign transactions in Jamaica over a number of years, we notice a definite pattern. The year begins with net payments to foreigners; a period of net receipts follows, and is in turn succeeded by a period of net payments towards the end of the year. This pattern is what we would expect. Foreign receipts and payments do not coincide. Consumer expenditures on imports, for example, reach their maximum at Christmas time, whereas most export staples are bringing in foreign exchange in the second quarter of the year.

The variations in the levels of foreign exchange reserves will reflect the pattern of net foreign transactions. When we observe the reserves at the end of each month, therefore, we can deduce from the usual pattern of foreign transactions what future variations will be, provided we neglect the influence of chance fluctuations.

It is from this systematic variation in the demand for foreign exchange

that we derive the transactions demand. The transactions demand is that amount of foreign exchange required to meet the typical pattern of fluctuations. In addition, if we can predict any disturbances in the typical pattern, we can alter our estimate of the transactions demand accordingly. The transactions demand may therefore be considered as the expected value of the net demand for foreign exchange at any time. Before going on to examine how these expectations are formulated, we introduce the precautionary demand.

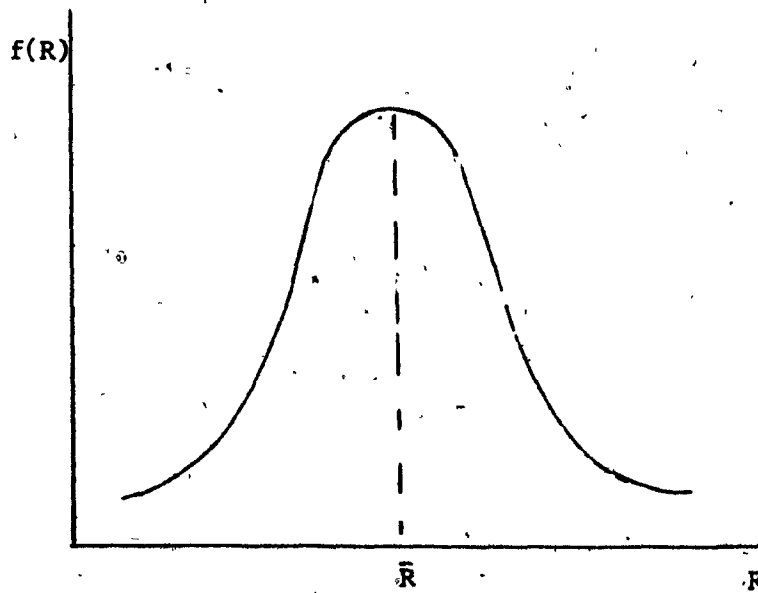
The Precautionary Demand

The precautionary demand for reserves is derived from the expected size of the deficit which may arise in the balance of payments in the given accounting period once we have taken account of systematic variation. A number of alternative approaches have been taken towards this estimate. Some analysts have made it a function of the largest deficit recorded in a certain historical period during which the economy has shown no major transformation. Alternatively, we might fit a trend to the balance in external payments and calculate an average deviation; this might then be used as an estimate of the change in either direction which might be anticipated from the current period.

These earlier approaches, however, lack the precision of the measures which enable us to make probability statements about the levels of precautionary demand. These latter measurements use historical data to estimate the variability of reserves and then use theorems on the probability distribution of these disturbances to calculate the degree of risk associated with each level of reserve holdings.

The mechanics of the operation can be illustrated by the use of the accompanying diagram, which represents the probability distribution of reserves.

Figure 5-1. The Precautionary Demand for Reserves



$f(R)$: probability distribution function of R .

R : reserve level.

Reserve variations can be assumed to be randomly distributed about their expected value $\bar{R}$, and their variation is assumed to be subject to the same influences in the current period as in the past. The standard deviation of the distribution is therefore estimated from historical data. If we start with a reserve level $\bar{R}^1$, we can calculate the probability that reserves will fall within any chosen range on either side of this central value. Armed with this information we can derive a complete description of the values and probabilities of occurrence of the whole range of precautionary demand.

Certain simplifying assumptions will have to be made in order to derive actual figures for the probabilities associated with various levels of precautionary demand. In particular, we will have to assume that changes in $\bar{R}$ will not affect the shape of the probability distribution.

We may infer that, for a given reserve stock, there will be a greater risk of reserve exhaustion if net precautionary demand is large relative to that stock. We have not so far had anything to say about the factors which influence the degree of risk policy makers are prepared to undertake under these uncertain circumstances. The degree of risk aversion of the exchange authorities will be governed by their perception of the consequences (not by any means solely economic) of alternative policies towards short-run balance of payments difficulties. We can identify some of these alternatives, and we intend to say something about their costs as compared to the cost of holding exchange reserves.

We should perhaps note two implications of the analysis as we have

¹In subsequent analysis we show that $\bar{R}$ is the expected value of R_{t+n} and is the algebraic sum of initial reserves R_t and the transactions demand for reserves.

outlined it. One is that we do not take into account the possibility of disturbances which last for more than one year. It must therefore be inferred that any deficit which persists beyond a one year period requires other means of adjustment. A second implication is that major disturbances which occur only once within the whole period will create a special problem. If the disturbance occurred in the past, and is not likely to recur, the coefficient of variation of the series may be inflated, and the target level of reserves may be unrealistically high. The obverse of this reasoning is that our calculations cannot take account of major disturbances which have no antecedents in the historical data. Again, alternative measures may be needed to take care of such occurrences. This latter issue points up the limitation inherent in an analysis which uses the past as a guide to the future. In the final analysis it is the policy makers who must judge the validity of that assumption.

Predicting Reserve Levels

We wish to combine the transactions and precautionary demand for reserves in a single explanatory equation with predictive power. The equation must explain both trends and seasonality in the pattern of reserve movements. Let us say, for example, that August is the month when reserves normally have an "average" value for the year; that is, in August the demand and supply of foreign exchange are just balanced, and there is no accumulation or decumulation of reserves. We require an equation such that, by plugging in the values of the explanatory variables which are appropriate for August, we derive a value of zero for reserve changes during that month.

This however neglects the possibilities of long-run trends. If the country is accumulating reserves over the long period, for example, even when net foreign transactions becomes negative (with respect to the year's average), reserves may still remain above their initial level at all times.

This possibility that reserves are moving on trend must also be accommodated by our explanatory equation. We must be able to deduce the trend by using appropriate values of the explanatory variables. Let us say that trends are measured by comparing year-end data; then by putting in the values of the explanatory variables at the end of the current year we can derive a value of reserves which will be higher than the reserve levels of last December if there is an upward trend and vice versa.

We turn now to the outline of such an equation. Take the balance of international payments for any one month. We have

$$B = Y - E, \quad \text{where } B : \text{balance of payments;} \\ Y : \text{national income;} \\ E : \text{national expenditure;}$$

This equation is familiar from the so-called "absorption" approach to balance of payments theory¹. The foreign balance is simply the difference between the total income of nationals and their total expenditure. This formulation takes for granted the equation of domestic supply and demand; so that if income exceeds expenditure there will be excess supply to the rest of the world and a balance of payments surplus (B is positive). Conversely, expenditure in excess of income implies excess demand for foreign goods and a balance of payments deficit.

From our earlier definitions (see Chapter One) we have

$$\Delta R = B \quad \text{where } \Delta R : \text{change in reserves.}$$

In order to derive an operating equation we must transform these identities into behavioural relationships, and specify the factors by which we can account

¹See Sidney Alexander, 'The Effects of a Devaluation on Trade Balance' and Harry Johnson, 'Towards a General Theory of the Balance of Payments' in American Economic Association, Readings in International Economics, Irwin, 1968.

for levels and variation of income and expenditure.

Income and expenditure depend on levels of national economic activity which may be represented by certain state and policy variables; that is, variables which are either to be set by policy makers to attain some specified goals or to be taken as given. We postulate the use of four such variables. Two of these, exports during the month and capital inflows during the month, are largely determined as far as domestic policy makers are concerned.¹ These variables represent the impact of overseas influences on the economy. The other two variables represent policy instruments: money supply, the monetary policy variable, and government expenditure, the fiscal policy variable. We have therefore

$$B = B(X, K, \Delta MS, G) \text{ where } X : \text{ exports;}$$

$$K : \text{ capital inflow;}$$

$$\Delta MS : \text{ change in money supply}^2$$

$$G : \text{ government expenditure}$$

The balance of payments in any month may be expressed as a function of the four explanatory variables by virtue of the fact that these variables are the principal determinants of income and expenditure (and hence the difference between them). It follows that

$$\Delta R = R(X, K, MS, G).$$

This equation in its exact form, and apart from any errors in variables, will yield the change in reserves (from any given initial value) which results from the transactions demand for reserves. This follows from the fact that

¹ They are not entirely predetermined. For example, government can alter the level of official capital inflow, and there may be some leeway for manipulating export quantities and prices.

² We use changes in money supply because all items are expressed as flows rather than stocks.

transactions demand has been defined as the predictable element in the demand for international means of payment. In order to incorporate the precautionary demand for reserves we must state the equation in stochastic form. The stochastic disturbance term is what accounts for the need to hold precautionary reserves. The demand for precautionary reserves (which may be positive, zero or negative) is measured as a deviation from the expected value of reserves after the transactions demand has been accounted for.

Let us assume an initial reserve level of R_1 , associated with levels of exports, capital inflow, money supply and government expenditure equal to X_1 , K_1 , MS_1 , and G_1 respectively. Assume that the levels of exports, capital inflow and government expenditure during the period of investigation are respectively X_2 , K_2 , and G_2 , and that the change in money supply is ΔMS . We can find the change in reserves due to transactions demand as the expected value of ΔR from the equation above. Let us call this amount $\overline{\Delta R}_1$. We can deduce the level of foreign exchange at the end of the period, taking account of transactions demand only:

$$\overline{R}_2 = R_1 + \overline{\Delta R}_1 \quad \text{where the bar indicates expected values.}$$

We are not however certain that the value of R at the end of the period will actually be R_2 . R_2 has the highest probability of occurrence, but other values on either side of this central amount may occur, each with a different probability. There will therefore be a range of values for R_2 from minus infinity to plus infinity given by

$$R_2 = R_1 + \overline{\Delta R}_1 + \Delta R_2 \quad \text{where } \Delta R_2 : \text{precautionary demand.}$$

In theory the precautionary demand varies from minus to plus infinity, but there will negligible probability density associated with the extreme values, so that

only the values immediately surrounding $\bar{R}_2$ will be significant.

It turns out therefore that the level of reserves at the end of the prediction period is a random variable with a stated probability distribution. Each value is weighted by the associated probability and this weighted value is the total which is costed according to the formula of Chapter Four.

The problem with this equation is that the presence of ΔR and ΔMS prevent us from predicting for more than a single period. If we use the expected value of R_2 as a base for prediction in the next time period we can no longer draw inferences about the probability distribution of the disturbance term¹. If the prediction period were made equal to the time period used in the regression (i.e. one month) the model is not particularly useful to policy makers, who are typically concerned with reserve movements between three months and one year ahead. There is therefore a dilemma between choosing a model which is a useful guide to policy and one which satisfies the criteria for reliable prediction.

We suggest that the dilemma might be overcome by redefining the time period when predictions are to be made. In the equation above, K_1 , G_1 and X_1 would be one-month flows; however, K_2 , G_2 , X_2 and ΔMS - the quantities used in projecting the demand for reserves - would be defined as flows over a longer period of perhaps three months to one year, as intimated above. So long as the time period does not itself enter the equation as an explanatory variable this seems an acceptable procedure².

¹See, for example, Carl Christ, Econometric Models and Methods, John Wiley, p.561

²The estimates of the prediction variance would still, however, be unreliable.

There is however one objection. In specifying changes in the explanatory variables over a year period, for example, we neglect changes which occur in the intervening period but which do not affect the end-of-period value of the explanatory variables. This raises the possibility that even if reserves are adequate to meet requirements one year ahead, sharp fluctuations within this period could lead to reserve exhaustion. One suggestion is that policy makers might take account of this possibility by recalculating the optimal reserve level each month for whatever time period has been chosen. This would, over time, give a complete trace of reserve levels for each month.

The Explanatory Variables

We have suggested four variables which will affect net foreign exchange earnings in a determinate and predictable way. These are exports, government expenditures, money supplies and capital inflows. In this section we will look separately at the ways in which each of these variables will cause the balance of payments to alter.

We begin by making some assumptions. The first is that there is a fixed exchange rate which is not altered by fiat during the period of analysis. The second is that no new payments restrictions (import or exchange controls) are imposed. Thirdly, there are no changes in the payments structure; that is to say, the financial system is not drastically overhauled, credit policies and instruments remain the same, there is no wholesale monetarisation of sub-

sistence sectors. Finally, we assume stability in the income generating process. This implies stable consumption, investment and import propensities, persistence of the initial structure of the productive sectors and stable tax propensities. None of our hypotheses about the mechanisms of foreign payments can be tested if these assumptions do not hold. If they cannot be tested, the propositions are not useful; even if they could be said to hold in some instantaneous sense, their effects would be indeterminate and unpredictable.

The Money Supply and Foreign Exchange Reserves

We begin our treatment of the relationship between the money supply and reserves with equilibrium in the domestic market, the market for foreign goods and services and the market for financial assets. The supply of domestic goods and services suffices to meet the demand, earnings of foreign exchange are adequate to the foreign exchange demand, and the supply of financial assets by surplus spending units is at the level required by deficit spending units, all at the current levels of income, prices and interest rates, and with fixed exchange rates, propensities to spend on imports and domestic goods, savings propensities and rates of taxation.

This equilibrium is now disturbed by the injection of additional money supplies which may originate either from Central Bank policy or from autonomous commercial bank action. Our object here is to analyse the effects of this injection on the country's foreign exchange reserves. In process of doing so we sketch briefly the way in which the whole economic system reacts to the money supply change.

The new money supplies may derive from Central Bank advances to commercial banks which form the base from which the banks may extend additional domestic credit. Alternatively, they may derive from the policies of commercial

banks themselves. If the banks hold liquid funds over and above their normal or statutory requirements, then these funds could be used to increase domestic credit. In a small economy with a dependent financial system, foreign borrowing may be a significant alternative source of finance for domestic credit. If banks become aware of significant new avenues of lending which offer substantial returns, then they are often prepared to borrow funds abroad to undertake such lending¹. In this latter case, the process begins with a loss of foreign exchange reserves, but this loss is sustained only if the new credit is actually spent on foreign goods and services². If the incremental expenditure is directed towards domestic production, the foreign exchange represented by the overseas borrowing will be held as part of the country's external assets, and there is no net change in reserves.

We may divide the impact of the money supply increase into direct and indirect effects, turning attention first of all to the direct effects. The new money will be used to expand credit or to acquire financial assets, except for any portion which is hoarded. The credit expansion, which would normally be in excess of the initial money supply increase, leads to increased expenditure on domestic and foreign commodities. The direct effects of creating new money are therefore (a) hoarding, (b) acquisition of additional financial assets, (c) additional expenditure on domestic goods and services and (d) additional expenditure on foreign goods and services. Clearly, then, there is a direct impact on foreign exchange reserves, and reserves will fall to the extent that incremental expenditure is directed towards imports³.

¹This remains true in spite of current exchange rate uncertainty, since borrowers can often be persuaded to accept the exchange risks.

²In fact, the implication of the analysis which follows is that new credit will affect expenditure on both domestic and foreign commodities.

³If the credit increase was financed from abroad then this represents the portion of the new foreign indebtedness which remains a charge on reserves in the first round.

The direct impact on foreign exchange reserves may be augmented by the acquisition of foreign financial assets, though rather special circumstances would seem to be needed to promote this eventuality. The banking system will hardly use its own additional foreign indebtedness to increase its holdings of foreign assets, and therefore we may expect increased foreign asset holdings only if the money expansion derives from Central Bank action. Given that this is the case, the new claims may be shifted into foreign asset holdings if interest rates abroad yield higher rates of return than lending to potential domestic creditors, or if there is a scarcity of domestic customers qualifying for loans under the banks' normal criteria of "credit-worthiness", or if foreign financial assets yield more than domestic financial assets after discounting for exchange risk and ease of convertibility.

We turn now to deal with the indirect effects of the money supply increase, which come about through a reaction cycle, deriving from the increase in domestic expenditure. This cycle will lead to secondary demands for foreign exchange, through a multiplier process.

We expect the increased expenditure on domestic goods to generate increased money income. If domestic industries have spare capacity and the necessary co-operating factors are present it is then possible to expand real output and income; otherwise prices of currently produced commodities will rise. If prices do rise there may be some substitution effects tending to raise the propensity to import. Domestic shortages and other rigidities would also tend to increase the propensity. These factors apart, the rise in income will itself generate a new round of expenditure with an associated increase in the money supply. The process is therefore repeated, with new acquisition of financial assets, additional hoarding, new demand for imports and domestic output.

Increases in financial assets can be expected to be substantial only if the money supply increase derives from Central Bank action. It is possible that financial institutions would wish to transfer assets from abroad to acquire domestic financial assets in special circumstances where the domestic yield were substantially higher or where these institutions expected to make gains from exchange rate movements. The narrowness of the domestic market financial assets means, however, that this would not be a normal practice.

In the case where the Central Bank acts to increase the money supply, commercial banks may wish to acquire additional financial assets to satisfy normal or statutory liquidity requirements or because they cannot find enough potential customers who satisfy their credit-worthiness criterion. The commercial banks may acquire obligations of the private sector as well as Central Bank deposits and government debentures and treasury bills. Normal commercial bank practice would suggest a bias in favour of the liabilities of official bodies, but we will take account of both possibilities.

If new financial assets are acquired only to satisfy liquidity requirements, whether customary or statutory, the parameters of the monetary system will remain unchanged. New financial assets would be acquired as a result of deposit growth which in turn will result from the growth in domestic incomes. The acquisition of financial assets will therefore be no greater than the income and expenditure cycle would warrant.

If however, there is an independent desire to hold additional financial assets (because of the lack of suitable bank customers) then there must be some re-adjustment of the normal ratio of real to financial assets. This will in turn have implications for the pattern of expenditure.

Let us consider first the case where banks wish to hold new private sector obligations. This demand can be satisfied only if the private sector generates new deficit spending. In this case it may well be that aggregate expenditure will turn out the same as if the bank has expanded credit with the funds used to acquire financial assets. However, the ratio of domestic to import expenditure may now be different, and a greater proportion of the newly created money may be used to increase productive capacity.

In the more normal case where banks acquire treasury bills and other government securities a similar result may obtain. The outcome would depend on government's expenditure pattern - whether it is more or less heavily oriented towards imports than private sector spending, whether the new funds are spent on capital projects and the degree of involvement by government in directly productive activity.

It is of course possible that no new financial assets are forthcoming from either government or the private sector to meet the requirements of the banking system. A rise in domestic interest rates may result which may not only affect banks' desire for financial assets but may affect domestic production and the ratio of foreign to domestic expenditure as well. In an undeveloped market for financial assets, however, perhaps the more likely outcome is a shift into foreign financial assets by commercial banks. Inelasticity of supply of financial assets may therefore aggravate the leakages from the domestic system.

The last of the alternatives facing the commercial banks is to increase their deposits with the Central Bank. To the extent that this is done, the original intention to expand money supplies is nullified.

Without establishing whether or not a new equilibrium will be attained, we can suggest the contours of any such equilibrium. If the parameters of the system remain unchanged, then the new money supply level should bear the same relation to income as the old, after all leakages have been taken into account. It is evident from our analysis so far that the net increase in money supply, and the net increase in income will depend on the leakages via hoarding, imports, foreign asset holdings and holdings of new Central Bank deposits. We can examine separately the new equilibrium conditions for the real market, the market for financial assets and the foreign exchange market.

To achieve equilibrium in the market for commodities without change of parameters we must have domestic commodity supplies increase (in money terms) exactly in the amounts of the new injection into the domestic expenditure stream. If domestic output and domestic prices are both inelastic in the short run then equilibrium cannot be achieved with the same economic relationships as before. A disequilibrium situation may persist with shortages and bottlenecks in various domestic activities; perhaps more likely, however, is the prospect that the difference between domestic demand and supply is directed towards imports. This additional import demand will precipitate additional demands for foreign exchange which will ultimately have repercussions on the money supply and on income. A new equilibrium is still possible, but only with changes in the relationships which define these economic interactions.

There is disequilibrium on the foreign exchange market unless the increase in money supplies leads to an increase in export production. So long as money incomes rise at all, there will be an additional demand for imports

and foreign exchange with which to procure them. This demand may be augmented by any demand for new foreign financial assets. There is thus a continuous charge on the foreign exchange reserves of the country, unless new sources of foreign exchange become available. Whether new money supplies will trigger additional export earnings will depend on the constraints on expansion in the export industries. If export industries are constrained only by financial considerations, then increased money supply will make credit available for their expansion. It is equally probable however, that export constraints derive from considerations of market, technology and expertise, none of which will be affected by the increased money supplies. We cannot therefore expect foreign exchange equilibrium unless there is a shift in one of the parameters of the system

Financial equilibrium requires that spending units generate new deficits (and, as a result, financial obligations) in the amounts demanded by the financial system. We have noted already the possibilities and limitations of expansion in the private sector. The public sector will generate a supply of financial assets which depends on government's expenditure policy as well as the effects of increased incomes, imports and expenditures on government revenue. If government supplies financial assets sufficient to meet any deficiency in private sector supply, we cannot conclude that equilibrium will ensue, however. This quantum of government obligations may permit additional government expenditure in excess of the spending appropriate to the new level of income. The additional government spending will therefore generate further income increases and foreign exchange losses.

The general conclusion to be drawn from this analysis is that an increase in money supplies in Caribbean economies will create a disequilibrium situation with a considerable drain on foreign exchange reserves. This conclusion

derives from the inadequacy of free market adjustment mechanisms in any one of the three markets just examined. On the domestic goods market, the price mechanism will not necessarily induce sufficient domestic supply response, and there will be a tendency for import propensities to rise. Foreign exchange markets are likely to be in disequilibrium because, with a fixed exchange rate, no mechanism exists to ensure that new exchange earnings are generated to compensate for the induced increase in foreign exchange spending. The market for financial assets similarly is unlikely to be in equilibrium, because there is no interest rate mechanism to ensure that the supply of financial assets equals the demand. It is evident, moreover, that disequilibrium in each market reinforces disequilibrium in the others, aggravating the already severe drain on foreign exchange reserves.

Exports and Capital Inflows

Existing regulations in Jamaica require that all export earnings be surrendered to the Bank of Jamaica. Consequently, any increase in export earnings will be translated into foreign exchange holdings in the first instance. The domestic currency issued in exchange provides increased income and increased spending, including additional expenditure on imports, thereby reducing the net contribution which export earnings make towards the reserve stock.

The net addition to foreign exchange reserves may in fact be very small. The combination of a high marginal propensity to import and a small propensity to save will mean little addition to domestic productive capacity¹. Most of the foreign exchange earned will be spent abroad.

¹ If for example we take the simple Keynesian model where the multiplier is given by $\frac{1}{s+m}$, the increase in income (ΔY) resulting from an increase in exports (ΔX) is given by $\frac{\Delta Y}{s+m}$. The induced increase in imports is $\frac{m}{s+m} \Delta Y$. When $s = 0$, all the additional foreign exchange earned from exports is spent on imports.

The peculiarities of the Jamaican monetary system raise the possibility that the induced foreign exchange spending may be greater than the autonomous increase in foreign exchange earnings. The prospect arises from the fact that increases in the money supply may well be triggered by the increased export earnings and the consequent increase in expenditure. This effect is not strictly predictable; it would depend on the size of the export increase, whether it was expected to continue and the confidence factor which derives from these considerations.

So far in this section it has not been necessary to specify whether the increase in exports is temporary or persistent. If we have a one-shot increase in exports, there is the possibility that the effect on import levels will outlast the initial export impulse. Individuals may wish to continue higher levels of spending after the additional foreign exchange earnings have been disposed of. Since the money supply may expand in response to this desire, it is possible that a net loss of foreign exchange reserves might occur.

The analysis of the foreign exchange impact of capital inflows is the same as for exports. Export revenues and capital inflows will generate the same sequence of reactions and induced foreign exchange charges. However, in the case of capital inflows the net accretion in foreign exchange for any given amount of capital will usually differ from the additional exchange yielded by the same amount of export revenues. The foreign exchange yield of the capital inflow is less by the amount of interest payment (and amortisation, if any) during the period. There may also be a difference resulting from the fact that the nature of the capital inflow (if for example it is tied to the purchase of imported machinery) may lead to a greater proportion of import expenditure out of a given capital inflow than would be the case

for exports. Therefore, although the effects of capital inflows may be accommodated within the framework of the analysis already outlined in this section, the quantitative impact may be different in the two cases.

Government Expenditure

Increases in government expenditure will lead to increases in imports, both directly and via the induced increase in national income and expenditure. In this case we will of course not have had an additional accretion of foreign exchange, and so we can say unequivocally that there will be loss of foreign exchange reserves. Unless the increased government expenditure induces an increase in money supplies via commercial bank action as mentioned before, the loss of reserves will be somewhat less than the expenditure increase. The difference will be accounted for by the domestic content of the additional expenditure.

There is the important further issue of the source of finance for the new government expenditure. Let us assume that the government borrows money locally. The government may borrow from the Central Bank, which then holds the government obligations in its asset portfolio, without any further effects on the money supply or foreign exchange reserves. If the loan is raised through the commercial banks, however, it is possible that some money supply consequences may be triggered.

Whether or not their lending to government will generate an increase in money supplies depends on the commercial banks' liquidity position and their reaction to it. Let us consider first the case of excess liquidity. If banks in Jamaica hold liquid funds in excess of normal or statutory requirements, these may be placed on deposit with the Bank of Jamaica, or with their Head

Offices, or they may be used to buy claims on the private sector, government or statutory bodies. Given any one of these circumstances, what will happen to the money supply if the banks now decide to buy new government securities?

If the funds are obtained by liquidating balances with the Central Bank or with Head Office, there is an injection of new money. The difference between the two cases is that, in the case of the Head Office balance, the new money is accompanied by an initial fall in the foreign assets of the banking system. This is only a superficial difference, however. Recall from our analysis of the effect of money supply changes on foreign exchange reserves that the loss in foreign assets will be sustained, in either case, only to the extent that there is an induced increment in import expenditure. If the banks funded government out of a surplus of private sector securities, or previously held obligations of statutory boards or government, there would be no change in the money supply; credit would merely be shifted from one sector to another. There would be an exception to this if government securities had to be sold to the Central Bank to secure the necessary funds. In this case there is an increase in total credit and an increase in money supplies.

If the banks had no excess liquidity they could accommodate the government only by reducing private sector credit or borrowing from abroad¹. The former is neutral in its effect on money supply, while the latter increases money supply with an equivalent fall in net foreign assets in the first instance.

We may now summarise the effects on foreign exchange reserves which

¹ We neglect the possibility of borrowing from the Central Bank, since this would be equivalent to direct lending by the Central Bank to government.

would result from commercial bank lending to government. In cases where there is an increase in the money supply we will generate disequilibrium dynamics leading to a loss of foreign exchange by the process outlined earlier. Where there is a switch from private sector credit, any foreign exchange loss would depend on the difference between the private sector and government with respect to their propensities to spend on imported commodities. If the propensities are the same, then there is no change in reserves, but if government spends a larger proportion on imports net foreign assets will decline.

These charges on foreign exchange reserves, where they occur, must be added to the initial foreign exchange impact of the government expenditure. When money supply increases, two expansionary influences are simultaneously at work on national expenditure (and hence imports): increased government spending and expanded money supplies. In the case where a credit switch is accompanied by different private and government import propensities, there is in effect a shift in the overall propensity to import. Where the import propensities are the same, the monetary effects are neutral. This yields three possibilities for net demand for foreign exchange. Taking the possibilities in reverse order, we have (a) a demand for foreign exchange no greater than would be induced by the increase in government expenditure itself (see first paragraph under "Government Expenditure"); (b) a net demand greater or less than this depending on whether government has a larger or smaller import propensity; and (c) net demand greater than for (a), the additional demand being determined by the extent of increased money supplies.

Three possibilities remain: government may finance new expenditure from previously accumulated surpluses, from new tax sources, or from borrowing

abroad, If government borrows abroad, the analysis is formally similar to the export case. The main modification would be that interest and amortisation payments must then be included in the import charges which are seen to derive from the additional government expenditure. As before, there will be a net addition to foreign exchange reserves if there is no increase in the money supply beyond the effect of the injection of new government expenditure into the national expenditure stream. If, however, money supplies rise as a result of commercial bank action it is possible that there will be a net reserve loss.

If government expenditure is financed from accumulated surpluses, we have the situation as stated in the first sentence of this section - a loss of foreign exchange (the result of increased imports out of new incomes) which may be increased by commercial bank action.

The more interesting possibility is that finance is obtained by increasing taxes. Let us consider income taxes and import duties separately as sources of revenue. If income taxes are increased domestic expenditures would be subject to deflationary tendencies. Income may fail to rise as much as it would under other assumptions, and the loss of foreign exchange will then not be as considerable. However, again we must take account of the money supply. It may well be that individuals demand more credit to sustain consumption at the pre-tax level; if commercial banks are liquid and are disposed to meet this demand, then the restraint on incomes and foreign expenditure may be less marked. It follows that if we are to protect foreign exchange reserves, then a policy of monetary restraint may be required to support the tax measures.

Let us now take the case where the additional revenues are raised from import duties. The effect will depend on the price elasticity of demand

for imports. We expect that the volume of imports will not fall significantly.¹ Thus there will be no saving of foreign exchange. What is likely is that the increased prices which nationals will have to pay for imports will cause inflationary tendencies. An increase in money incomes may then lead to further demands for imports and a greater loss of foreign exchange reserves.

We conclude that, depending on the method of financing², government expenditure may lead to (a) increases in foreign reserves considerably less than the amount of government expenditure (in the case of foreign borrowing only); (b) decreases in foreign reserves which may range from zero to amounts significantly in excess of the government expenditure.

We can summarize the discussion by showing a hierarchy of policies, ranked according to their (decreasing) contribution to foreign exchange or their (increasing) cost in foreign exchange. Let us first list the policies as we have analysed them above:

- I. Local borrowing from the Central Bank;
- II. Local borrowing from commercial banks;
- III. Foreign borrowing;
- IV. Use of accumulated surplus;
- V. Raising additional taxes on income;
- VI. Raising additional taxes on income with increases in the money supply;
- VII. Raising additional import duties.

¹The suggested reason is the high proportion of essential consumption and intermediate items in import expenditure. See Nassau Adams, 'An Analysis of Food Consumption and Food Import Trends in Jamaica', Social and Economic Studies, March 1968; and Adams, 'Import Structure and Economic Growth' Social and Economic Studies, September 1971.

²Naturally, several of the alternatives may be used together.

Table 5-1. The Financing of Government Expenditure and the Induced Effects on Reserves

Alternative methods of financing	Change in Reserves: Probable Range of Outcomes			
	Increase	Decrease		
		Negligible	Less than G	Greater than G
I			X	
II			X	X
III	X	X		
IV			X	
V		X		
VI		X	X	
VII		X	X	

The table below locates each of the alternatives along a continuum from those policies which lead to increases in reserves to those which lead to a reserve loss greater than the amount of government expenditure (G). The arrows indicate uncertainty generated by the possibility of autonomous commercial bank action.

Simultaneous Effects

The foregoing establishes our a priori notions of the relationship between each explanatory variable and the dependent variable, reserves. The four independent variables must now be combined to determine their simultaneous effect on reserves. A difficulty arises here because of the interrelationships between the explanatory variables themselves. The most evident example of such relationships is that between money supply and each of the "real" variables. In the course of the analysis so far we have commented extensively on this phenomenon at several points. Other examples might be adduced. For example, inflows of capital may be directed towards creating new capacity in export industries, thereby establishing a link between the variables "exports" and "capital inflows" (apart from any possible lags); and increased exports may lead to increased government revenue which may in turn lead quickly to additional government expenditure, assuming government were operating under a tight budget constraint.

The effect of this multicollinearity between the explanatory variables will be to introduce bias into the estimates of the parameters which define the relationship between each variable and reserves. It will not be possible to draw inferences about the effect of one variable on reserves, given that other variables are present. This is in itself not an important loss as far as our analysis goes, since the parameters of the equation,

though of great interest, do not enter into our reserve maximisation model as such. What does affect our maximising conditions is the variance of predicted values of foreign reserves. This is where our difficulty arises, since we can no longer say with complete accuracy that the distribution function of the predicted value will be normal. We are nevertheless forced to use the normal assumption as an approximation, even though we thereby sacrifice some degree of precision in our analysis.

Qualification of the Analysis

The equation we have devised in this chapter may be regarded as the reduced form of a system of equations which traces the interrelationships between all the major economic variables - income, consumption, saving, investment, government revenues, imports, prices, interest rates, exchange rates, etc. - and simultaneously determines their values for given policies. So as not to divert from the main purpose of the study we have had to forego an investigation of the complete system and concentrate on the simpler reduced form. While this does not introduce any error when structures remain unchanged, we may run into difficulties should changes occur in the (unspecified) equations which comprise the structure. For example, suppose trade or tariff controls are imposed, or there is a change in the exchange rate. These factors could imply changes in the functional relationship between reserves and the four chosen explanatory variables, and this would in turn mean a change in the variance of reserves. Let us suppose that this change took place somewhere within the period covered by the time series on which the estimation is based. What we would in fact be doing would be estimating as one equation what are in fact two distinct equations.

How should this problem be treated? First of all, notice that the problem does not arise if the changes affect only the values of our four explanatory variables and not their relationship to the level of reserves. It

is probable, however, that changes such as those mentioned above will alter the nature of the relationship. One approach would be to include these additional factors in our explanatory equation either directly or by the use of proxy variables. The other alternative would be to divide the data into two (or more) groups in accordance with the timing of the change. The first alternative would be preferred if changes are continuous; the second if they happen only occasionally.

This model of reserve determination has clearly not yet reached any advanced stage of refinement. I should hope, however, that the analysis of this chapter has established its claim to serious consideration. The results of estimation are sufficiently interesting to suggest further development of mixed models of this kind which combine "real" and "monetary" variables to provide a more complete explanation of macroeconomic fluctuations. Its chief usefulness for our purposes is to illustrate the method of computing optimum reserves, but, within the stated limitations we hope to use it to draw general inferences about actual reserve management in Jamaica.

CHAPTER 6
Measuring the Costs

Exchange reserves held by the authorities represent a claim on foreign resources, and foreign resources are vital for the process of development. However, exchange reserves are not used to procure foreign resource inputs which would accelerate this process of development. It follows that there is an opportunity cost implicit in holding exchange reserves, and we now turn our attention to the task of measuring this cost.

The question of foreign resources for economic development is associated most closely with the name of Hollis Chenery¹ whose work has inspired extensive studies on foreign aid flows². We will employ a simple version of the Chenery formulation as a basis for our analysis.

The foreign resource requirement at any time t is the difference between foreign expenditure at t and earnings of foreign exchange at t . Foreign exchange is earned from exports of goods and services (and transfer payments, factor incomes, etc.), and foreign expenditure goes on imports of goods and services (and transfers and factor income payments accruing to foreigners).

¹Chenery's argument is stated most comprehensively in H. Chenery and A. M. Strout, 'Foreign Assistance and Economic Development', American Economic Review, Vol. 56 (1966) pps. 679-733; further development of various aspects of the model and empirical tests are to be found in Chenery, 'The Role of Industrialisation in Development Programs', American Economic Association, Papers and Proceedings, May 1955 pps. 40-57; H. Chenery and O. Bruno, 'Development Alternatives in an Open Economy: The Case of Israel', Economic Journal Mar. 1962 pps. 79-103 and Chenery and A. Mac Ewan, 'Optimal Patterns of Growth and Aid: The Case of Pakistan', Pakistan Development Review, Summer 1966.

²Perhaps the most exhaustive is the UNCTAD II Study, Trade Prospects and Capital Needs of Developing Countries UN pub. TD/34/Rev I. A study along the lines of the UNCTAD models was done for Jamaica by D.J. Harris, 'Saving and Foreign Trade as Constraints on Economic Growth', Social and Economic Studies, June 1970, pps. 147-177.

Let us write

$$6-1. \quad F_t = M_t - X_t$$

where F_t is the foreign resource requirement and M_t and X_t are imports and exports respectively, so that we neglect transfers and factor incomes for the moment. Let us begin with the current year (year zero) and project to year t . For convenience, assume that exports grow at a steady rate of $x\%$ per year from zero to t . Then

$$6-2. \quad X_t = X_0 (1 + x)^t$$

Let us assume that imports are initially equal to M_0 , and that additional imports between zero and t are proportional to the increase in national income (Y) over the period. We have

$$6-3. \quad M_t = M_0 + m (Y_t - Y_0)$$

Now, what is the value of Y_t ? This we are to choose, and we do so by choosing a constant growth rate of income equal to $g\%$ per year over the period.

This gives

$$6-4. \quad Y_t = Y_0 (1 + g)^t$$

where Y_0 is the income at zero. Combining this system we get

$$6-5. \quad F_t = M_0 + m [(1 + g)^t - 1] Y_0 - X_0 (1 + x)^t$$

For any value of g chosen, therefore, we can find a corresponding value of F_t . We know the current values of imports, income and exports (M_0 , Y_0 and X_0 respectively). m and x must be estimated.

In estimating the rate of growth of exports we assume that the average rate of growth over a number of recent years will be sustained. This should be regarded only as an approximation for the convenience of this analysis. In an operational situation policy makers could derive a more informed estimate of growth prospects for each export activity from a careful examination of market forces, the expected supply of exports from domestic

sources and competing sources abroad and the prospects for new products and new markets.

The import propensity m also suffers from its aggregative nature. It is a special kind of import propensity, representing an 'average' value of the parameter over the period. The major criticism of this macro-parameter is that it may conceal quite drastic structural changes, which more disaggregated analysis might reveal. It is true that the assumption of a stable import propensity may be unrealistic in a developing country where structures of production and patterns of consumption are in a process of continuous change. However, as long as we remain aware of this factor, and make appropriate adjustment from time to time, the use of a constant m may still be useful for analysis in the medium term.

The equation we have just derived corresponds to the Chenery-Strout case of trade limited growth. There the target growth rate can be achieved so long as sufficient foreign resources are available, and there will be no deficiency of savings once the trade gap is closed by capital inflows. Chenery deals with a number of other possibilities, and we must determine their importance for this analysis.

One possibility is that the country may have a limited 'ability to invest' or 'limited absorptive capacity'. In this case, there is an upper limit to the growth potential, regardless of the amount of foreign resources available. This limit is set by lack of skills, entrepreneurship, social and economic infrastructure or any of a number of social, economic, political or psychological factors which prevent the use of available investible resources for development. If such a limit should exist in Jamaica, then we would be misrepresenting the cost of holding reserves if we found that

this cost, as calculated above, implied a rate of growth which could not in any case be achieved because of the capacity limit.

We feel that this possibility may safely be neglected in the Jamaican case. The reasons are (a) that the Jamaican economy has shown evidence of a capacity to absorb considerable increments in investment each year for most recent years; and (b) that the country's absorptive capacity may itself be increased by the injection of foreign resources, which may take the form of skills and techniques which previously presented an obstacle to the "ability to invest". The points are enlarged upon below.

A second possibility to be considered is the savings limit. The argument here is that there is a very low level of savings associated with the observed levels of exports, imports and national income. If we estimate the foreign resource requirement solely on the basis of trade flows, we will find in this case that the total savings (domestic saving plus foreign inflows) are insufficient to sustain the rate of growth which, on the basis of trade alone, would seem possible. Additional foreign resources will be needed to support the growth rate, not because there is any shortage of foreign exchange, but because domestic savings are inadequate. The situation leads to "excess" imports. If domestic savings were available to make up the discrepancy, there would not necessarily be these additional imports.

The implication for our analysis is that the formula at 6-5 will again overstate the cost of reserve holding, since that equation does not explicitly take account of the domestic demand and supply of investment funds. It assumes that if foreign resources can be had to fill the trade gap, then the resultant investment inflows will, with domestic saving, suffice to maintain total domestic investment at the target growth level g . If domestic

saving is insufficient, this value of g is unattainable and the given inflow of foreign resources can sustain only a lesser value of g . In other words, the level of g associated with any F in equation 6-5 is higher than the level which could be achieved in practice, and the growth sacrifice associated with immobilising any portion of F is overstated.

We may allow for this situation by restating our foreign resource requirement in terms of the now dominant "savings-investment gap". The minimum inflow of foreign resources at any given income level Y_t is the amount required to close the savings-investment gap, rather than the lesser amount required to close the foreign payments gap (equation 6-1). We have

$$6-6. \quad F_t = I_t - S_t$$

where I_t and S_t are respectively investment and saving in time t .

Investment required is given by

$$6-7. \quad I_t = k (Y_{t+1} - Y_t),$$

k being the incremental capital output ratio.

From 6-4 we have that

$$Y_t = Y_0(1+g)^t$$

so that

$$6-8. \quad Y_{t+1} - Y_t = gY_0(1+g)^t$$

Therefore

$$6-9. \quad I_t = kgY_0(1+g)^t$$

Express the savings function in a manner analogous to the import function of 6-3 and we derive

$$6-10. \quad S_t = S_0 + \alpha (Y_t - Y_0)$$

where α is the propensity to save defined in the same way as m . Therefore

$$S_t = \alpha Y_0 + \alpha \sqrt{(1+g)^t - 1} Y_0$$

The equation which replaces 6-5 as an expression of foreign resource requirements is

$$6-11. \quad F_t = Y_0 \{ kg (1 + g)^t - \alpha_0 - \alpha \sqrt{(1+g)^t - 1} \}$$

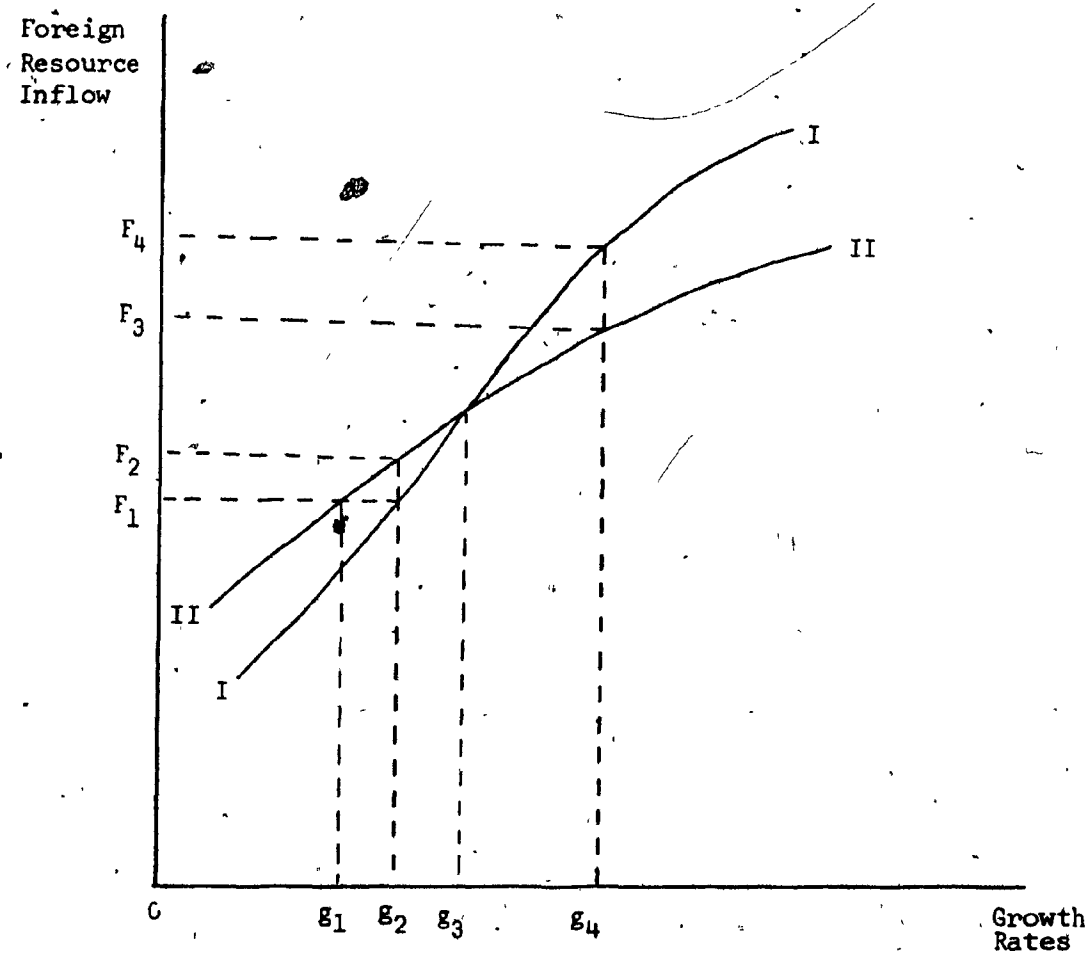
This equation may be used as an alternative to 6-5 if domestic saving is the growth-limiting factor.

At this point, we present a simple graphical illustration of the points just made. Curve I represents equation 6-5 and curve II equation 6-11. Let us suppose that these curves relate to a five-year projection. In other words, F_t is the total foreign resources which would be required to sustain any chosen growth rate between year zero and year five.

If we use equation 6-5 to cost exchange reserves, let us see what happens when our target growth rate is less than Og_3 . We would estimate that OF_1 of foreign resources would permit growth rate Og_2 , but in fact Og_2 growth would leave us short of domestic savings by an amount equal to $F_1 F_2$. Because the saving limit is effective here, OF_1 will generate growth rates no greater than Og_1 . Hence the growth-cost of reserves equal to OF_1 is Og_1 (less than Og_2). Equation 6-11 should be used in this range. Equation 6-5 becomes operative at rates of growth greater than Og_3 , where the amount of foreign resources needed to close the savings investment gap is less than is needed to close the trade gap. In this situation, foreign resources which would permit Og_4 growth, for example, would leave "excess" (unrealised) savings equal to $F_3 F_4$.

Neither 'trade-limited growth' nor 'savings-limited growth' is efficient in the sense of making optimum use of available resources, domestic and foreign. In the trade-limited case, some national savings are hoarded, spent on non-essential consumption goods or invested in non-productive activity, simply because if they were invested in production, additional

Figure 6-1. Trade-and Savings-Limited Growth



Note: Curve I represents Equation 6-5;

Curve II represents Equation 6-11.

Source: Adapted from Chenery and Strout (op.cit.).

import requirements would be generated which could not be met from available foreign exchange sources. In the savings limited case, that portion of capital inflow which makes up the savings deficiency will create an "excess" of foreign exchange, some of which may be accumulated in the form of reserves; however, there will also be generated demands for non-essential imports, particularly in a highly trade oriented economy.

It should therefore be possible, with some economic re-structuring, to find a growth path which would economise on the use of foreign resources by eliminating both excess imports and unrealised saving. New production techniques, different sectoral growth rates, import substitution, new export markets and changes in consumption patterns may all contribute towards this goal. The difficulty is, as Chenery and Strout demonstrated, that these are changes which take many years to effect. Therefore, in an analysis which looks ahead only five years there is probably very little that can be done to achieve more efficient growth. For longer periods some flexibility may be possible, though Chenery and Strout argue that even ten years is too short a period for noticeable changes of this nature to take root in many economies.

It follows therefore that the trade-and-savings-limited equations are reasonable approximations to reality for the length of period we employ in our projections, and the functional relationships with fixed parameters should yield acceptable estimates of the growth implication of any foreign resource input.

Before going on to the task of quantifying these relationships, we wish to substantiate our contention that the 'ability to invest' is not a serious growth limitation in the Jamaican case. The contention is partly based on the arguments, already mentioned, that foreign resource inputs may

raise the ceiling on the ability to invest. We can demonstrate as well that, even if we neglect this possibility, considerable growth is possible even with a low ceiling on the ability to invest.

The ability to invest is represented in the Chenery model by the parameter β , which measures the percentage increase in this year's investment over the year preceding. Therefore

$$6-12. \quad I_t \leq (1 + \beta)I_{t-1}$$

Even if desired rates of growth, capital-output ratios and development strategies require it, and, in addition, adequate resources are available, investment cannot be raised above I_t because the economy lacks the capacity to absorb any more investment. It is clear, on the other hand, that any rate of growth which demands less than I_t is possible (if resources are available). Thus, if high rates of growth (g) are possible with very small values of β , the ability to invest is of no practical importance as a limit to growth and the use of foreign resources.

If the incremental capital-output ratio is k , we may write (following Chenery)

$$6-13. \quad Y_t \leq Y_0 + \frac{1}{k} \sum_{T=0}^{T=t-1} I_T;$$

which gives

$$6-14. \quad (Y_t - Y_0) \leq \frac{1}{k} \sum_{T=0}^{T=t-1} I_T$$

By assumption,

$$6-15. \quad Y_t - Y_0 = Y_0 [(1+g)^t - 1]$$

with a constant rate of growth of income (g). And we may write

$$6-16. \quad \sum_{T=0}^{T=t-1} I_T = I_0 + I_0(1+\beta) + I_0(1+\beta)^2 + \dots + I_0(1+\beta)^{t-1},$$

assuming that the limit on the ability to invest does not change over T .

The maximum value of Y_t is given by

$$6-17. \quad Y_0 \frac{(1+g)^t - 1}{g} = \frac{I_0}{k} \{1 + (1+\beta) + (1+\beta)^2 \dots (1+\beta)^{t-1}\}$$

from which values of g corresponding to various values of β and t may be calculated.

In the accompanying table we present a selection of results based on the 1960 values of Y and I , and a calculated value for k of 3.89^1 . The figures in the boxes of the matrix give values of the maximum

rate of growth which is possible at various capacity

limits and over different time horizons. The

inference is clear. A capacity limit of 5%

which is way below anything we experience in

practice would permit growth rates of 6.8% and

6.5% in five and ten years respectively.

The capacity limit cannot in fact be anything of this

order, since the economy has demonstrated its ability

to absorb considerably higher increases in investment from year to year.

Percentage increases in gross domestic investment in the Jamaican economy

are given below for recent years:

1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1.4	-6.1	2.4	10.9	11.1	17.6	16.4	30.2	13.9	5.5	7.6	3.4

Source: IMF, International Financial Statistics

¹

Calculated from data presented later in this chapter.

Maximum Values of g (% per annum)

t (yrs) \ β (%)	5	10
1	6.3	5.6
5	6.8	6.5

$Y_0 = 383.1$ $I_0 = 103.8$, $k = 3.89$

These data give qualified support for our claim that, even when we make allowance for non-constant β and g , the economy does have the capacity to absorb capital in the amounts which growth targets might require. The qualification arises because the figures will not indicate whether the investment capital has really been employed to increase productive capacity. It is possible, in theory, that diminishing returns on increasingly less productive investment may lead to a situation where output does not increase. The effective ability to invest is then zero, in spite of the rise in actual investment expenditure. In fact, we doubt that this is an important qualification in the Jamaican economy, where foreign capital inflows are mainly associated with specific capacity increases in tourism, mining and manufacturing (See Chapter Two).

We will devise separate schedules along the lines suggested earlier for the trade-limited case and the savings-limited case. In equation 6-5 we estimate M_0 and m from historical data, regressing M_t on $(Y_t - Y_0)$ to obtain estimates of the parameters directly by equation 6-3. The growth rate of exports is obtained from the regression equation:

$$6-18. \quad \log X_t = \log X_0 + t \log (1 + x).$$

Substituting the estimated values of the parameters in equation 6-5 gives us values of F_t corresponding to various values of g for any chosen t .

In equation 6-11, α_0 and α are estimated from equation 6-10 using historical data. In order to derive an estimate for k the following incremental ratios of gross domestic investment to national income were calculated:¹

¹ Source: National Income and Product, 1972.

1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
4.33	5.50	3.86	3.30	3.20	4.23	3.34	3.79	3.73	2.97	4.58

In what follows the average of these ratios (= 3.89) is used as an estimate of k .

Our results are based on the following equations:¹

$$6-19. \quad \dot{F}_t/Y_0 = 0.8(1+g)^t - 0.1 - 0.55(1.047)^t \quad \dots\dots I.$$

$$6-20. \quad F_t/Y_0 = 3.89g(1+g)^t + 0.02 - 0.2(1+g)^t \quad \dots\dots II.$$

Equations 6-19 and 6-20 are the trade-gap and savings gap versions respectively. Foreign resource requirements have been calculated for a range of growth rates (with $t = 5$) in Table 6-1. These results indicate that the trade gap dominates throughout the range of growth rates in which we are likely to be interested. Consequently, Equation 6-19 is employed in all further calculations in preference to 6-20.

We now have values of foreign resource requirements against which to compare the current holdings of foreign exchange reserves. If any stated amount of foreign exchange reserves were systematically utilised to procure foreign resources over the next five years, then the rate of growth which would be possible can be obtained by substituting that value of reserves for F_t in Equation 6-19.

A qualification is necessary here. Suppose that the amount of reserves of the last paragraph were in fact to be used to expand the domestic productive structure. This augmentation of foreign resources in the current period would have the effect of increasing the current rate of growth; but in the following periods there are no means of sustaining the augmented resource

¹ For details of the calculations see Chapter Seven.

Table 6-1. Comparison of "Savings-Investment Gap" and "Trade Gap" in Jamaica

g	Values of F_5/y_0	
	Using Eqn. 5-19	Using Eqn. 5-20
0	.01	-.18
.01	.05	-.15
.02	.09	-.11
.03	.13	-.08
.04	.18	-.03
.05	.23	.01
.06	.28	.06
.07	.33	.12
.08	.38	.18
.09	.44	.25
.1	.50	.32

inflow because the excess reserves will then have been used up. Is it therefore legitimate to view the opportunity costs of reserves as measured over the entire planning period?

There are two ways of looking at the problems which avoid the apparent inconsistency in measuring opportunity costs over the planning period. One is to regard the problem as one of foreign resource management by the competent authorities. They will have determined the greatest potential growth rate which is possible, using all available foreign exchange - that is, borrowings and net earnings as well as accumulated reserves. Then if it were decided to utilise a given amount of reserves in the current period, it would be possible to even out the rate of foreign resource use by using these reserves to replace some equivalent amount of other foreign funds. For example, some borrowing might be postponed until later in the planning period.

Alternatively, we may discard the assumption that the rate of growth must be constant over the entire period. g may then be regarded as an average rate of growth. This is the less preferable alternative, because it is possible that the average rate of growth may be affected by the constellation of annual growth rates over the period, even with the same amount of foreign resources. For example, if a disproportionate use of resources and consequent expansion of capacity takes place in the early years, the economy may be able to generate greater internal surplus than it otherwise would, thus increasing the overall growth rate. To avoid such complications we will take it that the country's economic planners will so program the use of resources as to secure the maximum rate of growth possible with any level of foreign input. We may therefore concern ourselves solely with the aggregate resources available, whether these resources be from borrowings, net earnings or accumulated reserves.

Alternatives for Balance of Payments Accommodation

The list of policies which may be actively employed to restore balance to the external payments position in the short run includes direct

controls on imports, soliciting lines of credit and overseas loans, rationing of foreign exchange, differential exchange rates, reductions in government expenditure and in the money supply. These policies may be considered under the now familiar headings of expenditure reduction, expenditure switching and external financing. Let us briefly look at each one in operation.

We are dealing with an economy which is small in relation to its trading partners, so that there are no foreign trade repercussions as a result of import adjustment, and import prices can be taken as given. Furthermore, the major export activities (with the exception of tourism) have specific marketing arrangements such that prices, and, in some cases, output also is given. The implication is that the scope for switching resources from one export activity (which is subject to some temporary price slump, for example) to any other (which is enjoying more favourable conditions) is negligible. We have, thirdly, a limited range of significant export earners, consisting of tourism plus primary activities in agriculture and mining. Difficulties in any one of these sectors are likely to have important repercussions; this is much more so the case when we call to mind the importance of foreign trade in the national economy. We shall also take note of the importance of foreign firms in the commodity-producing and financial sectors, a factor which reduces the effectiveness of some domestic policy measures. In summary, the salient features of the economy to be borne in mind in what follows are: small size, specific marketing arrangements, high export specialisation and the importance of foreign firms.

We begin with balanced external transactions. We have a situation where initial earnings from exports and net capital inflows are just sufficient to meet intended import expenditure at the level of national income generated by autonomous expenditures (including exports and capital inflows). We now

introduce a temporary disturbance which reduces the expected level of foreign exchange earnings. The question is, what happens to income and the balance of payments as a result of this disturbance.

Internal Adjustment

The process of internal adjustment is automatic, though it may be augmented by official policies to reduce the money supply and government expenditures. In the absence of such policies, the fall in export earnings will itself produce a fall in real income¹, which will in turn lead to a fall in imports. By this means external balance could be restored.

This process of adjustment is likely to be accompanied by declines in money supplies and government expenditure, relative to expected levels, and by an absolute drop in the level of foreign exchange reserves. Let us look at the process in operation.

Viewed at the macroeconomic level, import decisions are not based directly on export performance. Export performance will eventually help to determine import expenditures, but decisions to import are made by different agents and at different times than export decisions². Consequently, attempts will be made to carry out original import plans, although export earnings will not now be available to the full amount. In the process, some portion of the domestic money supply is surrendered to the exchange authority to obtain foreign exchange. If exports had achieved the expected performance, then, in process of time (during the current accounting period) this loss

¹In the context of this discussion, a 'fall' must be interpreted as the difference between expected values and actual values.

²The obvious exception being imported inputs for export industries.

of foreign exchange would be made good, and the money supply restored to the level appropriate to the expected levels of income and exports. Since, however, foreign exchange is not forthcoming to the full amount required, the domestic money supply will fall, with reserves falling by an equal amount. If there are no idle balances in the economy, the fall in the money supply must be such that the new money bears the usual relationship to the lower level of income which the export shortfall induces.

If Government has no operating surplus and does not borrow, then Government expenditures must fall, since export taxes and import duties will both decline as a result of the foreign trade adjustments. This will hasten the decline in income levels. If some foreign borrowing is possible (through the monetary authorities) this will offset the export shortfall to some extent, reversing partly the effects on reserves (or imports) and the money supply. Domestic borrowing will also tend to increase the money supply (unless the Government competes away loans from the private sector) but although this will forestall some decline in income, it will do so at the expense of foreign exchange reserves.

The automatic mechanism of internal adjustment will restore external balance only if income is reduced to a level compatible with the level of imports which the available foreign exchange will permit. This will be accompanied by a fall in the money supply. There may be declines in Government expenditure and foreign exchange reserves as well.

If the Government intervenes directly with monetary and fiscal policy the process of adjustment may be speeded up. Moreover prompt reduction in the money supply may be used to protect exchange reserves from depletion. However, the condition for the restoration of the balance is the same.

Internal Adjustment and the Money Supply

We need to note that commercial banks may delay the process of adjustment. The commercial banks have direct access to Head Office support if they run short of liquid funds. Hence they do not need to pay much attention to their domestic liquidity ratios, even where these are fixed by law and directive from the Central Bank. Should they fall below the ratio, funds can be transferred from abroad. This fact raises the real possibility of perverse movements in the money supply.

This situation arises when the commercial banks decide to provide loan funds for imports under the conditions described above. In the absence of commercial bank action, attempts to sustain import levels will reduce transactions balances and contribute to the deflationary effect on income. New loans for imports from the commercial banks will frustrate this mechanism. If the disturbance is expected to be temporary, there is good reason why such credit may be extended, since import lending is relatively risk-free and relatively profitable from the banks' point of view.

The condition for restoring the balance remains unchanged, but commercial bank action will make it more unlikely that the automatic mechanism will quickly correct the situation. What is more, the delay will be at the cost of foreign exchange reserves, which are used to convert the new domestic money into foreign purchasing power.

Expenditure Switching

The whole purpose behind expenditure switching is that expenditure on foreign goods should be partially diverted towards domestic production. The policies which we have listed as expenditure switching - exchange controls, import penalties - merely tackle one aspect of the question, that is, the

reduction of expenditure on imports. Effective expenditure switching also requires policies to ensure that the funds newly made available on the domestic market are spent, and that they are spent productively.

Let us return to our initial postulate and see how an effective expenditure switching policy would work. We have export earnings falling short of what is required for external balance, and this in turn reduces income to nationals. Whereas the automatic mechanism adjusts imports with some delay, at the cost of foreign exchange reserves, we now have immediate import decline. As compared with the former case, we have no reserve loss and no fall in the money supply.

There is now an "excess supply" of money at the new lower income levels. The money balances may be held idle, in which case we may find a new equilibrium which is essentially similar to that achieved with internal adjustment. Income and the active money supply will be the same, but instead of reserve depletion we will have an equal amount of liquid funds in the financial system.

In the more likely event that expenditures are diverted towards domestic goods and services, we must deal with the question of their supply elasticities. We can expect that in any case money incomes will rise, but whether or not there is an increase in real income will depend on the scope for short-run increases in output.

Essentially, a successful expenditure switching policy will ensure internal balance at the intended income level by altering import propensities so that the level of external expenditure at this income level is compatible with the new, lower, level of external receipts.

This resolution cannot be taken for granted for a number of reasons.

In the first place, we must evaluate, on empirical evidence, the effectiveness of any given policy in reducing imports. If imports are price in-elastic, rises in import duties, differential exchange rates and other measures which work through the price mechanism will fail to reduce imports, and we will have instead import-induced price inflation. In the second place, we must have some notion, again based on empirical evidence, of the price elasticity of supply of domestic production, and this could involve assessing spare capacity, the availability of additional skills, shifting of real and financial resources between (for example) export activity and the domestic sector. And we must consider, thirdly, the import content of domestic production. There is a high probability that, in an economy heavily dependent on imports of fuel and raw materials, any attempt to increase domestic output will in itself generate demands for imports which may alter the parameters of the equilibrium situation.

Financing the Deficit

Measures of financing the external payments deficit allow us to compensate for the shortfall in export earnings in such a way that the expected levels of income are achieved. To do this, we need to counteract the deflationary impact of the export difficulties and at the same time to provide the means of meeting the deficiency in foreign exchange earnings. The measures which will achieve these goals are use of foreign exchange reserves, lines of credit abroad and loans.

There will be loss of foreign exchange reserves in any case if the automatic measures of correction are allowed to take their course, and the level of income falls. If we wish to protect the (higher) anticipated level of income, monetary or fiscal policies must be instituted to compensate

for the shortfall in exports. Income may then be maintained at the higher level, but at the expense of a larger and continuing depletion of reserves.

Whereas the reserve depletion in the automatic adjustment case was a one-shot transitional affair, in this case reserves will continue to be drawn upon as long as foreign exchange earnings do not recover to expected levels. There is thus a continuing lack of external balance; financing represents a disequilibrium solution to the short-run imbalance.

When external sources of financing are available for balance of payments purposes, these may be used as direct inputs via the real and financial sectors to sustain the income levels. If the inflow takes place via the commercial banks, for example, they may increase the money supply by making available new credit facilities. The increase in the money supply will generate the additional income needed to compensate for the export performance, otherwise there will be no demand for the additional imports which justified the capital inflow in the first place.

Growth and Balance of Payments Adjustment Mechanisms

Summarising the alternative responses to a balance of payments 'problem', we can identify four types of response: financing the deficit (official or private exchange reserves), use of foreign credit facilities (commercial banks, national and supranational sources), expenditure reduction and expenditure switching. We have dealt earlier with the effects on growth of use of reserves. It remains, therefore, to consider the growth sacrifice in the case of the remaining alternatives, expenditure reducing, short-term borrowing and expenditure switching.

Expenditure Reduction

The principal growth-related effect of expenditure reduction is the reduction in capacity creation. In order to sustain a desired rate of growth, new productive capacity must be created each year at the planned rate. A shortfall in foreign exchange earnings reduces the ability of the economy to provide this additional capacity. The loss is particularly important because it arises in the foreign sector, which we have established as the area of critical resource shortage.

There is therefore a direct growth cost of income reduction which may be measured in the same way as we measure the cost of foreign resources tied up in foreign exchange reserves. In the case of expenditure reduction, however, the loss is presumably reversible, since the foreign exchange shortfall is not expected to be permanent. This particular cost therefore arises only to the extent that exports fail to recover sufficiently to compensate for their earlier losses. If foreign exchange earnings over the plan period remain on target despite variation, then there is no direct resource cost.

There may however be other effects on capacity, deriving from the stop-go nature of the deflation-reflation process. It is possible, for example, that investment projects will fall behind schedule, that projects will be started and abandoned before completion, that promising ventures will be unable to get the required extra support in the establishment period, and that induced unemployment may create intolerable burdens on social and economic structures. For any or all of these reasons the expected rate of capacity creation may not be possible over the plan period, even if exports recover to satisfy initial expectations.

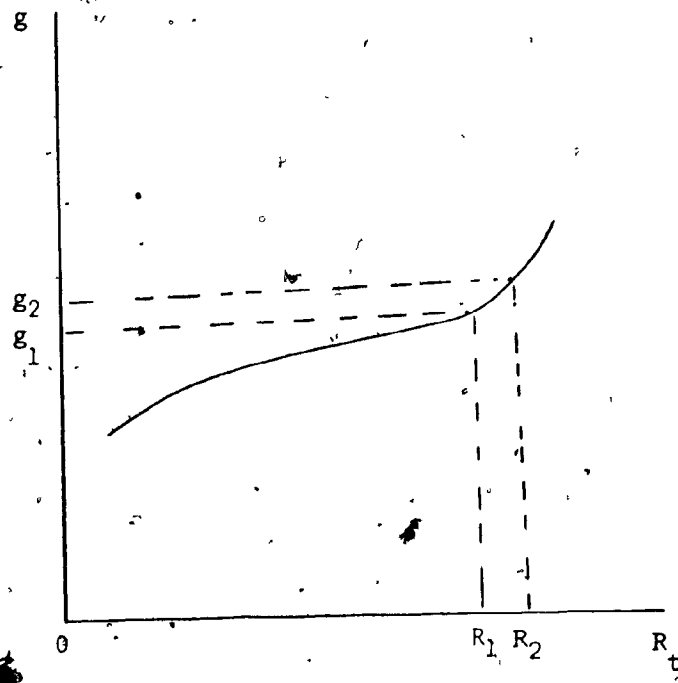
The deflationary process may also have negative effects on prices,

saving and resource allocation, with growth rate consequences which are fully explored in the section dealing with expenditure switching. These effects arise again because of the stop-go nature of the process. In spite of the fact that national income has declined there may be a general attempt to sustain expected levels of expenditure. If this expenditure is directed mainly towards consumption goods, national saving will decline. In a highly trade-oriented economy, there will also be pressure for imports to remain at expected levels, though this will be frustrated if there are no foreign exchange reserves on tap. Moreover, expenditure reduction will invariably be accompanied by some expenditure switching, as commodities previously bought abroad are sought from local suppliers and the mix of items in the consumption basket is shifted around in response to the reduction in income. Thus, in addition to the direct growth costs mentioned above, expenditure reduction will involve many of the costs which are enumerated when we deal with expenditure switches.

Loans

As far as loans are concerned, the cost which is common to all is the cost of interest and repayment. The burden of these costs will vary with the terms of the loan, so we cannot say a priori what the quantitative effects will be. In general, however, it is evident that some proportion of future foreign exchange supplies must now be set aside for the repayment of the loan. In another section we outline an approach to measuring foreign exchange commitments in terms of growth, and it is theoretically possible to determine the effects on the growth rate of the additional charge on foreign exchange. Starting with initial reserves of R_0 , the additional foreign resources

Figure 6-2. The Cost of Loan Financing



needed for any average rate of growth (g) are directly related to that rate of growth, giving a schedule of $(g, R_t)^1$. If foreign resources actually available at t are given by OR_2 , the expected growth rate is $0g_2$. If some portion of these resources are earmarked for loan repayment, the expected growth rate is reduced to $0g_1$.

Loans may carry other costs which are specific to some kinds of contract. One such is the cost of 'tied' loans, that is, credit which is granted for the purchase of specific commodities, or commodities from a specific source. There is an opportunity cost here if the commodity is available more cheaply elsewhere. This cost may be seen as a higher sacrifice of foreign exchange (for repayment) than would otherwise have been necessary. We do not beg the question whether the credit would have been available at all on other terms, because we are to measure the cost against the costs of all other alternatives, including the possibility of no financing.

Another possible cost may arise from stipulations about domestic policy measures as a precondition for foreign finance. The International Monetary Fund is the main source of such conditional finance, and measures of domestic deflation are often required before assistance is forthcoming. Insofar as these measures are of the same nature as expenditure reducing policies considered elsewhere, their costs can be measured in the same way.

Yet another relevant consideration is that the selective nature of credit arrangements may lead to distortions in the use of resources. For example, private sector credit may be more readily available for consumer imports than for intermediates. The desired pattern of growth may require that any short-run sacrifices should fall on the consumer, rather than raise the possibility of bottle-necks in production and the growth of productive capacity.

¹See Figure 5-2.

This brief sketch of the costs of borrowing indicates that, as an alternative to holding foreign exchange reserves, it is by no means painless. What we need to do in any given situation is to compare the growth cost of each alternative. In the case of loans, this can only be done when we have specified the interest and terms of repayment of the loan, the sectors in which special credit facilities are available, the conditions which are linked to credits from national and supranational sources. In addition, we must estimate the size of the credit facilities available in each category. We are faced with a number of imponderables here, particularly with regard to private sector credits. For example, we have noticed elsewhere the difficulty in deciding what levels of outstanding foreign liability the commercial banks are prepared to sustain in support of a foreign-exchange crisis.

Expenditure Switching

The effects of short-run expenditure switching policies on the rate of growth result from changes in relative prices, changes in the domestic price level, bottlenecks in production and consumption and the speed of internal adjustment. These may result in a reduction in surplus for investment and adverse effects on the efficiency of investment allocation.

The surplus is affected if various groups and sectors in the economy which have different spending propensities are affected in different degrees by price changes. Restrictions on the purchase of foreign goods will lead to a rise in the price of these goods. There will be a direct effect on import-substituting industries, whose net revenues will tend to rise. However, the price effects will spread within the economy, particularly in an economy which is heavily dependent on imports. All domestic prices and costs will tend to rise, a situation which will not be reversed when the

crisis is over, since prices are inflexible downwards. Let us assume that this inflation is taken to be a necessary by-product of the adjustment process, and no monetary or fiscal instruments are brought to bear in an attempt to stabilise prices.

The price rise will effectively re-distribute income in favour of firms producing for the local market as against exporters, in favour of profits as against wages and salaries, in favour of professionals and self-employed as against fixed income recipients, and, depending on the tax structure, in favour of government as against taxpayers. We need then to look at the spending propensities of each group to estimate the overall effect of the induced price rises. Furthermore, we need to estimate the retained surplus in each category, that is to say, the portion of investible funds which remains within the domestic economy.

In the absence of any evidence to suggest that exporting is more profitable than producing for the local market, the effects of the inter-firm redistribution will depend on the relative tendency of the two sectors to leak funds abroad. Presumably the balance here is in favour of the domestic firms, where we may expect a higher proportion of local ownership, but the situation is by no means clearcut.

It is usually accepted that the rate of saving out of professional income and profits is higher than the rate of saving out of salaries and fixed incomes. It is on this argument that the case for inflation as a factor inducing growth is based. It is argued, moreover, that the increase in net government revenues will permit surpluses to be accumulated for development projects.

If we are to make any general statement about the price level and the rate of growth, therefore, it would seem that there is no reason to expect

that investible surpluses will be adversely affected and some very tentative reasons to suspect that it might increase.

Against this, however, we have the question of allocative efficiency. The activities which offer the highest rate of return during inflationary periods are speculative in nature. It is therefore argued that the increased (?) surplus is misallocated in terms of development objectives and that the normal growth of real productive capacity is stunted.

A critical factor in the entire discussion has to do with the rapidity of price rises. We revert here to the question of the speed of adjustment. If domestic prices and costs react rapidly to controls on importation, then we may have noticeable effects resulting even from moderate difficulties in the external payments position. And, of course, a serious fall in foreign exchange earnings would have quite damaging effects. On the other hand, delayed reactions will allow time for the short-run imbalance to correct itself without such serious growth effects.

There is reason to believe that Caribbean economies do react sharply to rises in import prices. The reason lies in the nature of the commercial oligopoly which controls the foreign trade sector in all these territories.

Investment allocation may be affected by changes in relative prices (as distinct from changes in the price level) and bottlenecks in the supply of foreign inputs.

Changes in relative prices are very difficult to analyse. To begin with, the relative prices of commodities are changing continuously, so that it is difficult to pick a point of reference; furthermore, the impact of adjustment mechanisms is not instantaneous; hence there is difficulty in choosing an end point which represents the net effect of a particular disturbance alone.

As compared with the situation immediately before controls are

imposed, we can expect that costs will rise more quickly for sectors which use relatively more imported inputs, and that prices of importables will rise. It is highly probable, however, that, before any re-allocation in response to these changes can take place, further relative price shifts will take place, perhaps as a result of wage pressures or expenditure switches. We cannot therefore argue that relative price changes will affect investment allocation adversely, though we may anticipate some changes.

The discussion of the price effects on investment is subject to qualifications. We are dealing essentially with temporary disturbances, and we assume that the exchange and/or trade controls will be removed after the emergency has passed. Price levels will not fall, since we have assumed downward inflexibility, but inflationary tendencies should cease once restrictions are removed; price relatives will not return to the pre-emergency situation, since domestic costs will now have risen, with differential impact on various sectors, but it is to be expected that further re-adjustment of relative prices will accompany the removal of restrictions.

This raises the question of expectations. If investors are optimistic about the performance of the economy, they may simply ignore the immediate price disturbances in making their decisions, though they would still have to take account of rising costs. However, rises in costs and prices may themselves be mitigated by the knowledge that shortages will be only a temporary phenomenon. If pessimistic expectations prevail, on the other hand, the effects discussed above are more likely.

Another rider must be added, because, for a number of institutional reasons, industries and sectors of the economy do not respond to short-run price movements. Exhaustive in-depth research of business behaviour in the Caribbean still remains to be done, but it can certainly be maintained that

oligopolistic market structures and the dominance of multinational corporations preclude the operation of a price mechanism as a guide to intersectoral resource allocation for much of the economy. Such adjustment as does take place, then, may be largely confined to shifts among industries in those sectors where some degree of market competition exists.

Whether or not price changes have a decisive impact, the effect of shortages of foreign inputs will be felt by the producing sectors. The impact is not necessarily related to the proportion of foreign inputs used in the industry, since lack of some essential imported input may shut down the whole productive process. This kind of dislocation, which may lead to involuntary unemployment of local resources, may be the most damaging result of the short-run expenditure switch. By the same token, such dislocation is more predictable than price effects, and there is some leeway in the granting of import licences (or other selective controls on imports) to alleviate the situation in vital areas.

Combined Costs of Adjustment

Combining the costs of adjustment will be largely an empirical exercise. One reason why this must be so is that certain factors, such as the availability of external credits, can only be established by referring to concrete circumstances. However, even where it might be possible, in principle, to provide a theoretical costing of adjustment mechanisms, practical limitations would make such models different to apply.

We can illustrate this by referring to the costs of expenditure switching. In theory, we could estimate the growth sacrifice from a given diversion of expenditure from the foreign trade sector by means of a linear programming model, for example. The model would specify the structures of production and consumption, the parameters which govern economic interrelationships

and the limitations of resource availability by which the economy is constrained. Once the complete structure is specified, it is possible to determine the effect on the rate of growth of any value of the independent variables, or any change in these variables. So that by changing the values of the foreign exchange variables in such a model, we may derive growth rate implications.

There is, at present, no such programming model for Jamaica, and the immediate prospects for establishing one are not great, in view of data limitations. A model using the limited series presently available to estimate its structure would probably produce no greater degree of precision than our own empirical method outlined below.

The empirical method involves computing schedules of marginal cost for each of the adjustment mechanisms available.¹ Let us say for example that the marginal unit of needed adjustment is \$1 million; then, as shown in the accompanying table, a separate estimate is made of the cost of \$1 million external credit, \$1 million expenditure reduction and \$1 million expenditure switching. In each case the estimate is based on an assessment of existing economic possibilities; so that, for example, the cost of the first \$1 million of expenditure switching may well be considered negligible, if authorities believe that non-essential expenditure of this amount may be restricted without adverse effects. This exercise is repeated so as to derive marginal cost schedules for each alternative. The combined cost is then deduced by taking the minimum value of the marginal cost at each point.

It may not be possible to fine-tune the marginal cost estimates. It may therefore be necessary to define larger marginal units, for instance \$5 million or \$10 million. Also, it is evident that a large element of judgement intervenes in the calculations, and this is the reason we do not

¹ The principal involves computing the locus of minimum cost points and is illustrated (for continuous curves) in Figure 6-3 and (for discrete amounts) in Table 6-2.

attempt to perform the exercise in the course of this essay.

Table 6-2. Marginal Cost of Adjustment.

MU	L	ER	ES	Min.
1st	g_{11}	g_{12}	g_{13}	g_{11}
2nd	g_{21}	g_{22}	g_{23}	g_{23}
3rd	g_{31}	g_{32}	g_{33}	g_{33}
ith	g_{i1}	g_{i2}	g_{i3}	g_{i2}

MU : marginal unit of adjustment needed

L : opportunity cost of foreign short-term credits

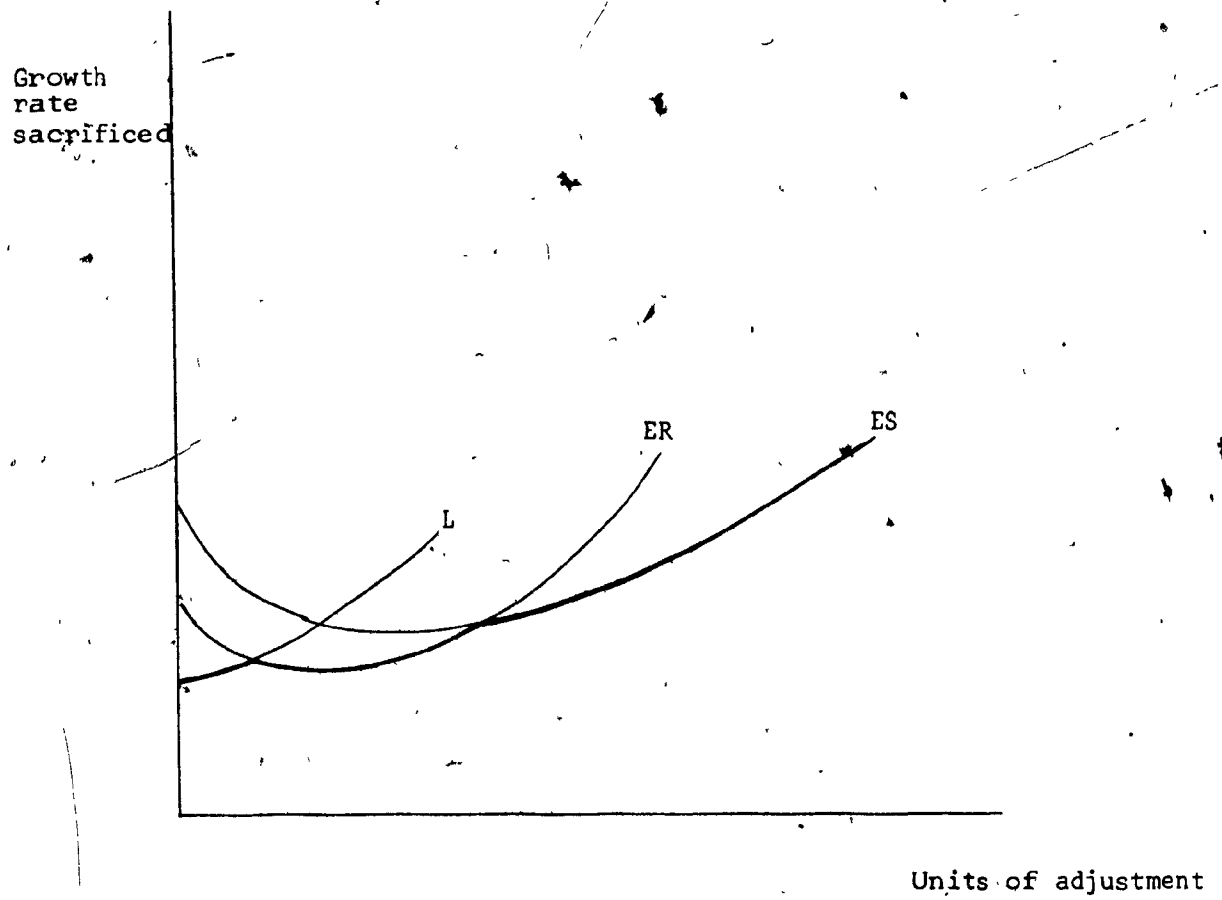
ER : opportunity cost of expenditure reduction

ES : opportunity cost of expenditure switching

Min.: minimum value of L, ER and ES.

Note: Each column gives the opportunity cost of the next unit of adjustment as a growth rate sacrifice. In the final column we choose the minimum value of g for that row (the actual values chosen in our illustration have no significance; we have no a priori notions as to which cost will be least at which value). The combined cost is the schedule of the first column plotted against the last (See Fig. 6-3.)

Figure 6-3. Marginal Cost of Adjustment



NOTE: The envelope (thick line) is the locus of minimum marginal costs.

CHAPTER 7

Calculation of the Optimum Level of Reserves for Jamaica.

This chapter deals with the results of empirical tests of the model outlined in the last three chapters. Here we specify and evaluate Equation 4-1, which is the centrepiece of the model. It should be recalled that Equation 4-1 is designed to provide an answer to the question: 'what level of reserves is optimal for a particular country (Jamaica, in this case) at a given time?' We are here concerned to demonstrate how the equation provides a specific answer to this question, once the following are given: one, the horizon of the country's current development plan; and two, the number of time periods for which the country wishes to provide some security against reserve exhaustion.

It might be noted that in this objective the study stands rather apart from previous investigations of the question. These have been addressed, for the most part, to testing hypotheses which proffer an explanation of past reserve behaviour of various countries and/or to finding the degree of security offered by a particular level of reserves¹. Our own approach, we feel, goes a little further than either of these, while incorporating both approaches in some form. For one thing, we do not regard the explanation of the history of reserve movements as an end in itself, but rather as a means to find the probability distribution of the net demand for reserves; this probability in turn helps us to find the reserve optimum. In formulating our model in this way we also incorporate the second approach, since the probability distribution of net demand for reserves (together with the existing reserve levels) is what determines the risk of running out of reserves.

¹ To date, Heller and Agarwal are the only ones to have provided a method of determining the reserve optimum for a single country; their method suffers from an inadequate specification of the probability of reserve depletion.

If recent developments in exchange reserve theory are to be incorporated into the management of reserves by national authorities, there must be a feasible methodology for arriving at an optimal level of reserves. Only in this way can the 'three-to-four-months-imports' rule of thumb be replaced by a target level of reserves which reflects the economic aspirations and constraints of the country in question.

This chapter therefore focuses on demonstrating the feasibility of the method we have described for finding an optimum level of reserves in Jamaica. The planning horizon chosen is five years; we deduce that much economic planning in Jamaica is done with a five year perspective from the fact that recently published plans have all covered five years. Six months was chosen as a reasonable time period for the monetary-fiscal-exchange reserve authority to project the country's requirements for precautionary and transactions reserves. The choice of period is not crucial to the methodology in either case, and if in fact the authorities' time horizons were different, then the calculations could be repeated on the basis of alternative horizons.

Our objective then is to show how Equation 4-1 may be evaluated and solved to determine the optimum reserve level for Jamaica at some chosen time, given that the growth sacrifice is to be measured over a period of five years and that levels of security are to be measured over six months.

The detailed solution of Equation 4-1 is given in Appendix A. Essentially, the solution consists of the following steps: first we find the parameters of the two equations giving the cost of the reserve stock and the cost of adjustment; these values are substituted in 4-1 to give an expression in which the expected cost is a function of reserve levels (R) and the net demand for reserves (D); this expression is integrated with

respect to D and evaluated for the appropriate limits (shown in Equation 4-1). These operations yield a cost equation which is a function of reserves alone. The optimum reserve level is defined where the function has its minimum point; we determine this by plotting the graph of the cost function in the region which covers all the values of R which appear to be feasible¹ and finding its minimum point².

We go on now to a description of the data employed and the sources from which they were obtained. This is followed by a section in which we demonstrate how to calculate the parameters of the cost equation, i.e. the first step outlined in the last paragraph. There are three distinct procedures here: one to determine the propensity to import (m) and the growth rate of exports (x) in the first cost equation; a second to determine the variance of the net demand for reserves; and a third to determine the parameters of the cost-of-adjustment equation. This information allows us to solve 4-1, and the resulting graph is plotted in the third section, where its properties are discussed and the optimum level of reserves is determined. This section concludes with observations on the differences between the actual level of reserves in Jamaica, the calculated optimum and the levels which would have been established under the 'rule of thumb' method of establishing reserve targets.

¹ The 'feasible' region chosen varies widely from reserve levels close to zero up to 40% of national income.

² An algebraic solution appears possible but is exceedingly involved.

The Data

Two sets of data are required to make the model operational. There is first of all the series needed for the regression equation to explain reserve movement. The variables involved here are reserves, money supply changes, exports, capital inflows and government expenditures; for these variables we employ a monthly series. The second set of variables are used to estimate the parameters of the equations which establish the opportunity cost of reserve holding. Variables in this set are national income, foreign receipts and foreign payments, domestic saving and domestic investment; here annual time series data are appropriate.

The sources of the monthly series are (a) the Bank of Jamaica's monthly Statistical Digest and (b) the Jamaica Government Department of Statistics' monthly Abstract of Trade Statistics. We have defined reserves to include the total of "official" reserves derived from Bank of Jamaica data. Official reserves comprise the holdings of the Central Government, together with those of the Central Bank. The justification for this definition is given in Chapter One. The period of analysis begins in January 1969 and ends in December 1971. The period was dictated by data considerations. As of January 1969 the Bank of Jamaica's series for reserves was adjusted by the exclusion of statutory sinking funds; since the information on the market values of these assets is not available for earlier years, the adjustment cannot be pushed further back. The earlier data might be employed (at some risk) by including a shift parameter to accompany them, but this would introduce distortion if there had been substantial fluctuations in the value of sinking fund assets during the period. This possibility was not pursued because an adequate number of subsequent observations was available. The end-point was dictated by the availability of data, not on reserves, but on the series for other variables.

at the time the regressions were run.

The conventional definition of money supply (currency and demand deposits) was used in our tests. There is some feeling among economists in the Caribbean that the broader definition (including time and savings deposits as well) is more meaningful since savings deposits, at any rate, are often used in much the same way as demand deposits¹. The question is, in the Caribbean as elsewhere, still unresolved, and we therefore stick to the narrow conventional definition. The Bank of Jamaica is the source for money supply and government expenditure as well. The expenditure covers both current and capital account.

Capital inflows and exports are taken from the Statistics Department publication. Exports consist of visible items only; total receipts from abroad would have been preferable, but this series is not available monthly. There is a possible source of bias here, since the seasonal fluctuations in invisible earnings (tourism) follow a pattern somewhat different from that of the visible items². In subsequent analysis some proxy for tourist earnings (for example, arrivals data) might be tried, but the available proxies are not very good³, so this modification is not introduced into our explanatory equation.

Imports of capital goods is the proxy used for capital inflows. The two sources of error to which this proxy is vulnerable derive from (a) the fact that there may be lags between the inflow of capital and its deployment to purchase imports and (b) not all capital inflows will be used to buy imports

¹ See Nugent Miller, Commercial Banking in Jamaica, I.S.E.R., U.W.I. (mimeo) 1970.

² See Chapter Two.

³ For example, tourist expenditure does not follow the trend of tourist arrivals closely, because average expenditures differ at different times during the year.

directly or indirectly, and not all imports so purchased will be capital goods. A further problem is how "capital goods" are defined; we use selected categories at a fairly aggregate level¹.

In view of the data limitations on these last two variables we may ask whether the particular formulation of our explanatory equation can in fact be useful to policy makers. If the data requirements are beyond the system's capacity to produce, the model cannot be made to work. I think it is true to say that the required data, though not currently available in published form, can be generated by the authorities using existing mechanisms, in particular the Exchange Control system. Since all legitimate foreign currency transactions are now monitored by the Bank of Jamaica's Exchange Control Department the Bank should be able to generate an up-to-date series for receipts from abroad and capital inflows on a monthly basis using information currently being collected. Thus, in practice, policy makers need not be hamstrung by data limitations as we are in this exercise.

The Department of Statistics' National Income and Product publications are the source for the annual time series. We can obtain information on total foreign exchange receipts and payments on an annual basis, and these are the definitions used for "exports" and "imports" respectively in equation 6-5. A consistent series is available for these variables, as well as national income, domestic saving and domestic investment, from 1960 through 1972. The data are all given in current prices, however, and if we are to estimate real opportunity costs we ought to apply price corrections. Unfortunately the only index of price changes available is that for retail

¹ Section 7 "Machinery and Transport equipment" plus 81 "prefabricated buildings, plumbing, heating and fixtures".

prices, and its limitations as a general price deflator have already been mentioned (Chapter Two). It is used nevertheless in the absence of other price deflators.

Estimating the Parameters of the Cost Equation

(1) The Regression Equation for Net Foreign Exchange Earnings.

The estimating equation for the net reserve demand is derived from the expression for reserve changes given in Chapter Four:

$$7-1. \quad \Delta R = R(\Delta MS, X, K, G)$$

Assuming that the relationship is linear, the exact expression for any time period (t) becomes

$$7-2. \quad \Delta R_t = \alpha_0 - \alpha_1 \Delta MS_t + \alpha_2 X_t + \alpha_3 K_t - \alpha_4 G_t.$$

The rationale for the signs of the coefficients (α_i) is given in Chapter Five; they represent the most likely outcomes, though we saw there that there may be factors making for "perverse" influences in some cases. However, apart from such influences, we would expect increases in money supply and increases in government spending to lead to loss of reserves, while increasing capital inflows and exports should lead to accumulation of reserves.

Since we wish to arrive at reserve levels at any chosen time, it is more convenient to express 7-2 as

$$7-3. \quad R_t = \alpha_0 - \alpha_1 \Delta MS_t + \alpha_2 X_t + \alpha_3 K_t - \alpha_4 G_t + R_{t-1}.$$

We will estimate the parameters of this equation from

$$7-4. \quad R_t = \beta_0 - \beta_1 \Delta MS_t + \beta_2 X_t + \beta_3 K_t - \beta_4 G_t + \beta_5 R_{t-1} + \epsilon$$

where we expect the coefficients to have the following properties:

(a) β_1 and β_4 : negative;

(b) β_2 and β_3 : positive;

(c) $\beta_5 = 1$

The results of this regression are given in Table 7-1. Only the coefficients of exports and R_{t-1} are significant at the 1% level, and of these, R_{t-1} is significantly different from unity, which is the value we expect a priori. If we reduce the rigour of our test, the coefficients associated with government expenditure and capital inflows become significant at the 10% level, but the coefficient of money supply changes remains insignificant. The coefficient of capital inflows has the expected sign, but government spending and money supply changes show up with positive coefficients where negative ones were expected. (There is, we may recall from Chapter Six, one set of circumstances which might lead us to expect this result for government expenditure).

The coefficients were expected to put in a rather indifferent performance because we have strong reason to suspect multicollinearity between the explanatory variables. Multicollinearity leads to a loss of precision in estimation, with the probability of large errors in the estimates, large variances for the estimates and highly correlated errors. It follows that a great deal of insight into the causal links between explanatory and dependent variables cannot be gleaned from our results. Nevertheless, as we noted earlier, this factor, though disappointing, does not pose a difficulty for predictions, so long as the essential features of the system remain the same. Since the explanatory power of our equation is as high as 94.8%, as measured by R^2 (the conventional statistic, not to be confused with reserves R_t), we have some basis for making predictions.

Table 7-1. Estimation of Reserve Movements

Explanatory Variable	Intercept	MS_t	X_t	K_t	G_t	R_{t-1}
Value of associated coefficient	\$12.51m.	0.01	0.79	0.36	0.20	0.72
t-ratio	2.53	0.04	3.17	1.50	1.41	12.93

No. of observations: 46

For 40df, $t(.1) = 1.303$, $t(.05) = 1.684$ and $t(.01) = 2.423$

Standard error of the estimate = \$4.49 m.

$R^2 = 0.948$

Large sample test for serial correlation with lagged dependent variables:

$h = 1.387$

(Durbin - Watson Statistic = 1.63)

Prediction for June 1972: Expected value of $R = \$155.8m.$

Standard error of the prediction = \$4.87m.

Another potential problem we face in using the equation for prediction arises from the presence of lagged values of the dependent variable. We can get around this problem if the residuals from the equation can be shown still to possess the usual independent normal distribution. If they do, then estimates should not be significantly biased for samples as large as ours. We apply a recently-suggested test for serial correlation in equations with lagged variables (the h-statistic of Table 7-1)¹. h is standard normal, and the hypothesis of zero autocorrelation may be accepted at the 5% level with an h-value of 1.387.

Our estimation procedures require the usual assumptions that the explanatory variables be non-stochastic and error free. We satisfy the first condition insofar as the variables are policy instruments or deterministic in some sense. The second condition is more problematic, as is evident from our description of the data employed.

We also require further assumptions on the behaviour of the residuals,

¹ See J. Johnston, Econometric Methods, (2nd edition) p. 312. The test is for large samples (Johnston suggests over thirty observations); it is based on the first order correlation coefficient, defined as

$$r = \frac{\sum_{t=2}^n e_t e_{t-1}}{\sqrt{\sum_{t=1}^{n-1} e_t^2}}$$

where e_t are the residuals computed from OLS estimates. If we form

$$h = r \sqrt{\frac{n}{1 - n \hat{v}(b_1)}}$$

where $\hat{v}(b)$ is the estimate of the sampling variance of the coefficient of R_{t-1} , the lagged value of the dependent variable, then R is tested as a standard normal deviate.

which should be normally distributed with zero means and constant variances. The fact that the residuals are uncorrelated in an equation which has good explanatory power would suggest that the assumption of zero means is not unrealistic; the assumption of at least an approximately normal distribution is made more plausible by the fact that we have a reasonably large number of observations; and we may now test the results we obtain to see whether the assumption of constant variance can be supported.

Our test leads to the rejection of the homoscedastic hypothesis. The test is based on the hypothesis of homogeneous variances for the dependent variable, but it is argued that with a 'well-specified regression function' the variation around the mean of the dependent variable will be 'very close to the variation about that function'.¹ The R-observations are arranged in ascending order and divided into six classes. A ratio is computed which has, as its numerator, the product of the variances of each class (weighted by the size of the class), and as its denominator, the variance of the whole series (weighted by the total number of observations). Twice the negative of the logarithm of this ratio yields a χ^2 variable whose value turns out to be 78.93, a value which leads to the rejection of the hypothesis of homoscedasticity at the one percent level (χ^2 for five degrees of freedom at 1% is 15.09)².

¹ J. Johnston, opt. cit., p. 218.

² The formula may be written as follows:

$$\lambda = \prod_{i=1}^m \left(\frac{s_i}{n_i} \right)^{n_i/2} \left(\frac{\sum s_i / \sum n_i}{\sum n_i} \right)^{\sum n_i/2}$$

where m is the number of classes, n_i the number of observations in the i^{th} class and

$$s_i = \sum_{j=1}^{n_i} (y_{ij} - \bar{y}_i)^2$$

$\mu = -2 \log \lambda$
is distributed as χ^2 with $(m-1)$ degrees of freedom.

Alternative Forms of the Regression

We tried a number of alternative formulations of the regression equation. The details are given in Appendix C. Two of the alternatives are based on different economic approaches to reserve determination, another is a purely statistical specification, others introduce lagged explanatory variables, one concentrates on the most significant variables only, and there are two which neglect the lagged dependent variable. The specific forms are presented in Appendix C, together with their results.

The overall level of significance (measured by R^2) remained high throughout, though there was a substantial difference between those equations where R_{t-1} was excluded and the rest. However, even when R_{t-1} is excluded, the lowest value of R^2 is still a significant 73.5%. There is evidently a purely statistical element in the regression, represented by R_{t-1} . However, the economic variables on their own have significant explanatory power.

The coefficients of the individual variables are in general no more reliable than for our first equation. The coefficients of R_{t-1} and X_t are always significant, and these variables alone give an R^2 of 94.3%. The coefficient of G always has the wrong sign and is not usually significant; the money supply is another poor performer, with wrong signs and insignificant coefficients for the most part, but money supply levels do a little better than money supply changes. K shows up in most cases with a coefficient significant only at the 10% level. However, when R_{t-1} is dropped, its level of significance rises considerably.

The standard error of the estimate records a maximum value of \$10.1 million, a value which occurs when R_{t-1} is dropped. This is over twice the error in our preferred equation, and the equations in which it occurs are hard to support on a priori grounds.

We determined on the form of the equation which was first described for the following reasons. First, we feel it has the strongest a priori justification, as established by our analysis in Chapter Five. Secondly, this equation as estimated fits the data well, and the comparison with alternative formulations suggests that this fit does not arise from trivial reasons. Thirdly, none of the alternative equations offers a solution to the problems of multicollinearity and heteroscedasticity, which are the main problems of the original formulation.

(2) The Variance of Net Foreign Exchange Earnings

The regression equation of Sub-section One is needed to provide us with an estimate of the variance of net foreign exchange earnings. In previous studies of foreign exchange reserves several variables have been used to represent the variation in foreign transactions. The more common ones are the coefficients of variation (or the standard deviation) of reserves, of exports, of imports, or of the balance of visible trade¹. The difficulty with exports, imports and visible trade is that they represent only a part of total external transactions and are therefore an inadequate reflection of transactions variation. Reserves, the mirror image of net foreign transactions, is the variable to be preferred.

However, simply to take the coefficient of variation of reserves is to imply that the movement of reserves is entirely stochastic. The burden of our analysis in Chapter Five is that reserve variation is due to systematic influences as well as stochastic factors. This has been recognised in the

¹ There is a list of variables which have been used in previous studies in John Williamson, 'International Liquidity: A Survey', Economic Journal, Sept. 1973, p. 695.

literature by Kenen and Yudin and by Archibald and Richmond¹; both studies derived their estimate of reserve variation after allowing for systematic influences on the reserve series by using the estimated standard deviation of the residuals in an equation in which reserves are regressed against predetermined variables. In the two cases mentioned, however, the explanation of systematic reserve movements is purely statistical. Reserves are given as a function of time (in one case) and their lagged value (in both cases). We have extended the argument by attempting to explain systematic variation in reserves as a function of economic forces rather than simply as a statistical function (although we have estimated the statistical function for comparative purposes; see Appendix C).

Formally, our model (and those of Kenen-Yudin and Archibald-Richmond) substitutes the estimate of

$$V(R | X_i) \quad i = 1, 2, \dots$$

for the estimate of $V(R)$. ($V(R)$ stands for the variance of R : $V(R | X_i)$ is the variance of R , given the values of predetermined variables X_i). If it is accepted that net foreign transactions (and hence reserves) are subject to systematic influences, then this is clearly an improvement. Furthermore, an economic explanation of reserve movements is preferable to a purely statistical one. Unless the economic logic of the model is flawed, it will reduce the area of ignorance and hence the degree of uncertainty.

¹ P.B.Kenen and E.Yudin, 'The Demand for International Reserves', Review of Economics and Statistics, Aug. 1975; G.C.Archibald and J.Richmond, 'On the Theory of Foreign Exchange Reserve Requirements', Review of Economic Studies, April 1971.

Following this line of argument, the variance of net foreign exchange earnings is estimated from the variance of the randomly distributed residuals (ξ) in our regression equation. Now the variance of ξ in Equation 7-4 is estimated simply by σ_e^2 , the (square of the) standard error of the estimate. If there were no added sources of error due to the explanatory variables, this would also be the variance of expected reserves, six months hence (measuring time from December 1971)¹. We may however allow for errors arising from the explanatory variables, using the standard error of the prediction as (the square root of) our estimate of the variance of reserves. This gives a value for the estimate of the standard deviation of reserves of \$4.87 million; the values of R and D in Equation 4-1 are standardised by this value in order to produce a standard normal variable.

(3) Estimating the Parameters of the Cost Equation.²

The equation which is used to determine the growth-cost of particular levels of reserves (c_1) is given in Chapter Six. Two versions are presented, together with the reasons why we use the trade-gap version instead of the savings-investment version. The parameters to be estimated for these equations are the propensity to import (m), the propensity to save (α), the incremental capital-output ratio (k) and the growth rate of exports (x). k is estimated in Chapter Six, the estimates of the other parameters are derived by performing regressions on equations 6-3 (for m), 6-10 (for α) and 6-18 (for x).

¹ See Carl Christ, Econometric Models and Methods, John Wiley, 1968, p. 550; the variance of the prediction is the sum of the variances of the intercept, the coefficients of the independent variables and the residuals.

² The estimates relate to c_1 only; c_2 is assumed constant (see following section).

The regression equations are as follows (t-ratios in brackets)¹:

$$7-5. \quad M_t = 194.5 + 0.80 (Y_t - Y_0), \quad \bar{R}^2 = 0.977, D-W = 3.01. \\ (19.36) \quad (21.83)$$

$$7-6. \quad S_t = 86.1 + 0.20 (Y_t - Y_0), \quad \bar{R}^2 = 0.839, D-W = 1.81. \\ (12.01) \quad (7.69)$$

$$7-7. \quad \log X_t = 2.31 + 0.0199 t, \quad \bar{R}^2 = 0.936, D-W = 1.60. \\ (219.61) \quad (12.79)$$

These equations yield values of 0.8, 0.2, and 0.047 for m , α and x respectively.

These estimates are the bases of Equations 6-19 and 6-20. It is 6-19 which we use to determine the cost of the reserve stock. We express the expected reserve level $(R-D)$ as a ratio to base period income (Y_0) and replace F_t/Y_0 with this variable. By this we imply that the stock of reserves represented by $(R-D)/Y_0$ will have growth effects given by 6-19 if it were used to expand productive capacity. The notation $c_1(R-D)$ stands for a variable g (the rate of growth which has to be sacrificed) which is a function of $(R-D)$. This variable is derived directly from 6-19 (see Appendix A).

The Cost Curve

The graph on which we plot the growth-cost of different levels of foreign reserve holding lies at the core of our model. It is shown as Figure 7-1, where the level of reserves is measured along the horizontal axis and the growth rate associated with each reserve level is plotted vertically. The curve is derived from equation 4-1, which has to be solved

¹ D-W stands for the value of the Durbin-Watson statistic; it reveals negative autocorrelation in equation 7-5 (the values of D-W in 7-6 and 7-7 are consistent with the hypothesis of zero autocorrelation). The presence of autocorrelation does not bias the estimate of m , though it makes the associated value of t an unreliable guide to its significance.

and evaluated for the relevant range of values of R .

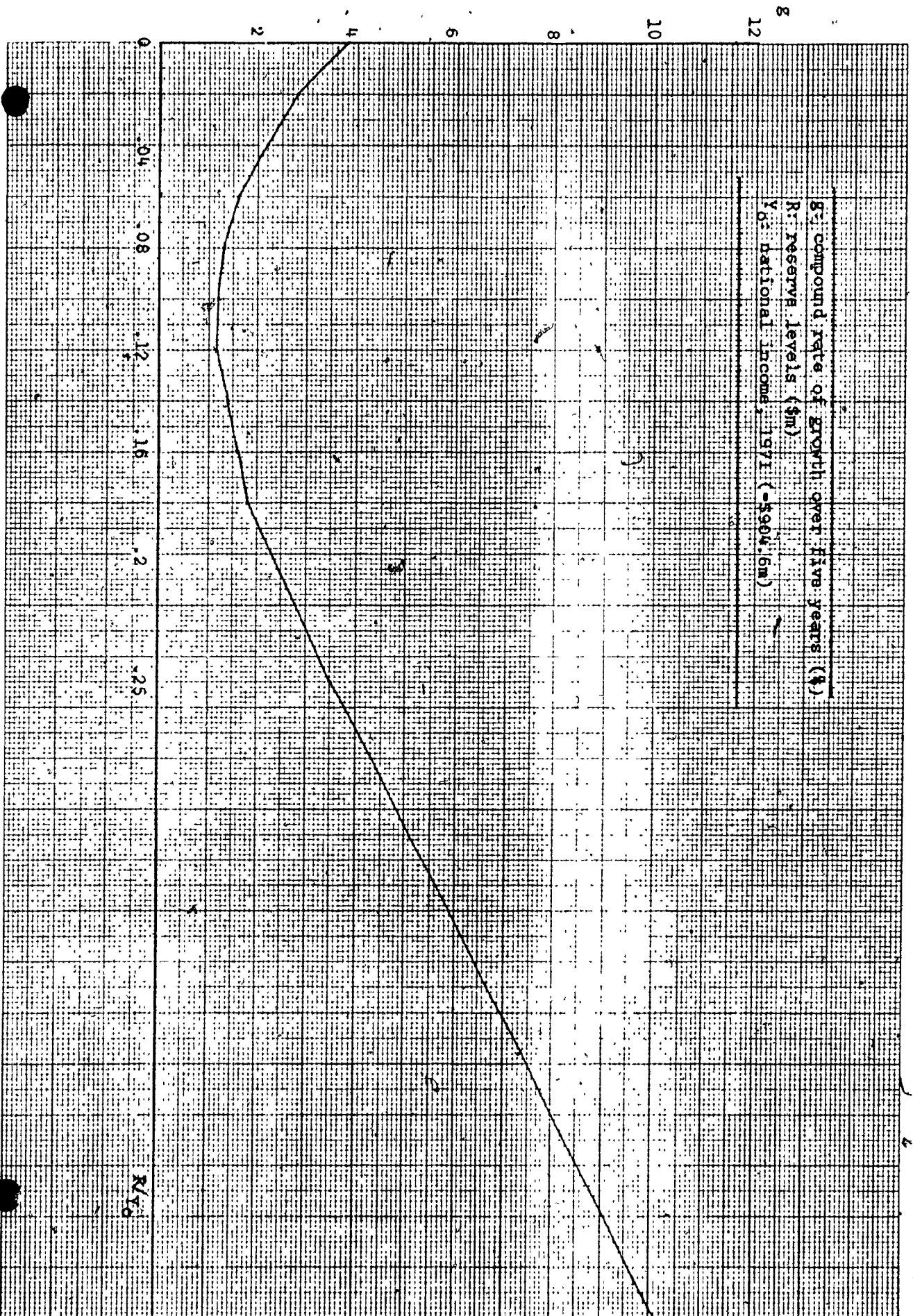
A method of solving Equation 4-1 is developed in Appendix A. The prior information required is the value of the parameters both of the cost functions and of the distribution function of D . These have all been developed earlier. As far as c_1 (the cost of the reserve stock) is concerned, the relevant parameters (the import coefficients (m) and the rate of growth of exports (x)) are given by the calculations of the last section. As for c_2 (the cost of adjustment), we noted in Chapter Six the difficulty of determining quantitatively and in general terms what this cost would be. We have therefore taken the simplest assumption, of constant unit costs¹, as a working hypothesis, always bearing in mind that we must qualify the results of the analysis to take account of this. The standard deviation of the precautionary demand was derived in the section before the last. The value obtained is used to standardise the values used in the cost equations so that in subsequent manipulations we have a random variable which is standard normal. As is evident from Appendix A, this eases the computation considerably.

One or two comments about the evaluation of 4-1 are in order. The problem of the integration limits forced the use of numerical methods. The equation had to be solved for values of R one at a time. Thus, in the initial manipulations R is a constant and we can evaluate the integral for one particular value of R . Because R is an integration limit, this procedure yields an expression in terms of R , and the expression is then valued at different R -levels.

¹ The integer-value of c_2 was set at unity for want of justification for any other specific value. However, in order to obtain the correct order of magnitude for growth rates (i.e. between 0.1% and 10% rather than 10% to 1000%), the actual value of 0.01 (in absolute terms) was used; also, because we have specified c_2 as a function of $(R-D)$ rather than $(D-R)$, c_2 must be negative.

Metric

Figure 7-1. The Opportunity Cost of Reserves in Jamaica, Measured in Terms of Cumulative Growth Rates over Five Years.



The calculations in Appendix A refer to only one year, year five of the planning period. In line with our earlier discussion we would prefer to look at the growth cost of reserves over the entire planning period. The more elegant method of accomplishing this is to sum equation 6-5 over all values of t by treating the elements of that equation as a geometric progression¹. However, this procedure prevents integration by the method of Appendix A because a "g" now appears in the denominator of A-2. As a result, we are forced to use the more cumbersome method of repeating the calculation of Appendix A for values of t from one to five. The costs for any value of R (say R_0) are accumulated and plotted against the value of $5R_0$. In effect, the total cost of reserves equal to $5R_0$ over five years is seen as the sum of the opportunity costs of reserves equal to R_0 in each of the five years.

The curve of Figure 7-1 gives the cumulative growth rate (over five years) associated with each level of reserves. Reserve levels are measured on the horizontal axis as ratios to national income in 1971, which is taken to be the base year of the planning period. The rates of growth, measured on the vertical axis, are compounded from the rate obtained for each of the five years, as explained in the last paragraph and demonstrated in Appendix A. Thus we can deduce, for example, that the opportunity cost of a reserve level of \$36.2 million (= 0.04 on the horizontal scale) is a growth sacrifice of 2.2% over the five years of the plan period (This is the total growth sacrifice over the period, not the per annum average). The cost of any reserve level may be derived in similar fashion.

¹ This yields the following equation:

$$\sum_{t=0}^T F_t / Y_0 = (t-1)(m_0 - m) + \frac{m}{g} \left[(1+g)^{t+1} - 1 \right] - X_0 / Y_0 \left[\frac{(1+x)^{t+1} - 1}{x} \right]$$

The optimum level of reserves can be found by inspection at $R/Y_0 = 0.12$, with an opportunity cost of 1.2%. This gives us a value of \$108.6 million for the optimum. The cost of this level of reserves may be regarded as the cost of maintaining any or all of the economic structures and policies which establish the parameters of the cost equation. This follows from the fact that it is possible, in theory, to obtain a value of zero for $R/Y_0 = 0.12$ if there are changes in the values of the exchange rate, the propensity to import, the growth rate of exports, the variability of reserves and policies of balance of payments adjustment.

However, our main concern is to examine the implications of the calculated optimum reserve level for reserve holdings at December 1971 and reserve policy during the ensuing six months¹. The actual value of reserves at December 1971 was \$139.0 million, equivalent to an R/Y_0 value of 0.15 and yielding an opportunity-cost of 1.6% over five years. The expected value of reserves for June 1972, projecting from December 1971, was \$155.8 million ($R/Y_0 = 0.17$). The opportunity cost of this level of reserves was 2.0% over five years.

The rule of thumb which is often applied to reserve management is to set the target level of reserves at the equivalent of three-to-four months' imports. Using the average monthly imports for 1971, this would have given a range from \$114.9 million to \$153.2 million for reserves. The lower limit is close enough to the optimum to have the same opportunity cost (1.2% growth sacrifice), but the upper limit would imply a sacrifice of 2.0% growth.

¹ Although we will draw inferences from Figure 7-1 only for six months, information on policies to the end of 1972 is provided in order to present a complete picture of exchange reserve policies in Jamaica.

Guidelines for the management of reserves can be derived from the cost curve, and these are to be contrasted with the implications of the rule of thumb in the last paragraph. In the first place, there is a range of values of reserves from \$50.7 million ($R/Y_0 = 0.056$) to \$140.2 million ($R/Y_0 = 0.155$) within which the cost of reserves is never more than 0.5% above the cost of the optimum level. This suggests that, under the conditions prevailing in Jamaica at the end of 1971, the authorities could be relatively complacent when confronted with any level of reserves in this range. The policy which might follow from a curve such as Figure 7-1 would be to set thresholds for adjustment at the limiting values of this range¹. Within the range reserves would find their own level; outside it, there would be corrective policy adjustment. This suggestion is developed in the next chapter.

As we saw above, the rule of thumb also gives a range, which partly overlaps that derived from our calculations. However, this rule leads, by and large, to higher reserve levels and the possibility of costs in excess of the 0.5% threshold. Moreover, since the optimum reserve level is outside this range, there would be a tendency to maintain "excessive" reserves.

Our second management guideline is derived from the slope of the cost curve. The slopes at various points on the curve are steeper for values less than 0.06 and greater than 0.14 than they are for the values in between. If

¹ There is nothing sacrosanct about the choice of 0.5% growth for defining the threshold. A less conservative authority, or one that was more confident of its ability to make reliable predictions and institute policies with measurable effects, might impose a closer limit in an attempt to make marginal gains in growth.

we take the value 0.01 as our marginal unit for R/y_0 , the marginal cost of the fifth unit, for example, is -0.4%, as compared with a marginal cost of -0.05% for the ninth unit. On the other side of the optimum, the marginal cost doubles from 0.1% for the thirteenth unit to 0.2% for the sixteenth. In fact it can be readily seen that marginal costs decline more and more gently as R/y_0 rises to 0.12. Beyond 0.12, marginal costs rise, slowly (but not so slowly as in the final declining phase) and then a little more quickly (but not so quickly as in the earlier phase of their decline).

These features suggest guidelines for the speed of adjustment in response to discrepancies between optimum and expected levels of reserves. In the area where marginal costs are low, adjustment might be slow and in moderate amounts. As marginal costs increase, it becomes necessary to adjust fully and more quickly. Furthermore, because the rate of increase in costs (moving from right to left) is greater for very low reserve levels than the rate of increase (moving from left to right) for very high levels, especial care must be taken to avoid a stock-out. This is another issue which is taken up in Chapter Eight.

We turn now to an examination of Jamaican monetary and international reserves policy during 1972 to see whether our model gives any insight into actual events. Reserves rose rapidly during the first quarter of 1972 to reach a peak of \$163.5 million at the end of March. This was achieved without any changes in monetary and fiscal policy. The high levels of reserves were seen by the authorities rather as a matter for congratulation than for concern, an attitude which probably reflects the opinion that the costs of high levels of reserves is not great. The opportunity cost turns out to be 2.2% growth over five years, fully one percent above the optimal cost.

The Jamaican authorities may have been guided by the rule of thumb

for reserve management. By this yardstick reserves would still be excessive, but not significantly so, if the upper limit were used as a guide.

Alternatively, it may be that there was no productive means of employing the excess reserves in the short run and no long run projects could be put into effect at short notice. Finally, the authorities may have had reason to expect the change in the country's trading fortunes which soon followed.

The remainder of 1972 was in contrast to the first quarter. Reserve levels declined with increasing rapidity from the end of April onwards. By November, when they reached their minimum for the year, they stood at \$115.7 million, a fall of \$47.8 million over eight months. The Jamaican authorities clearly held a more conservative view of required reserve levels than our results indicate, for they considered that this situation required remedial action, even though the November reserve level was a little higher than our optimum.

The Bank of Jamaica felt that adjustment measures were required as early as June, when reserves stood at \$138.6 million, still \$30.6 million too high, by our reckoning. The measures introduced at the end of June were both monetary and fiscal and included¹:-

- (i) an initiative to reduce Bank of Jamaica lending to commercial banks;
- (ii) an increase (from 5% to 6%) in the Bank Rate;
- (iii) increases in stipulated deposit and lending rates;
- (iv) an increase in statutory liquid assets requirements;
- (v) intensification of exchange control measures; and
- (vi) selected import restrictions.

¹ Bank of Jamaica Report for Year Ended 31 December, 1972, p.4.

The extensiveness of these measures indicates the degree of concern about the reserve situation even at this stage. It is not surprising, therefore, that the continuing decline in reserves elicited further adjustment measures in November when quantitative restrictions were placed on commercial bank advances.

Conclusion.

Chapter Seven contains the kernel of the study. Here we have brought together all the elements of the model, provided empirical specification and given a method of solution for obtaining the optimum level of reserves. The stages we went through in order to arrive at the solution reflect the important features of the model. First, the estimate of the variance of net foreign exchange reserves is derived after accounting for the systematic effects of economic policy and state variables; then the cost of stockpiling reserves is measured in terms of growth sacrificed, as is the cost of adjusting to a reserve stock-out; and finally, the growth cost, weighted by the probability distribution of net reserves, is minimised to determine the optimum reserve level.

The model is feasible and yields results which do not appear unreasonable in the light of developments subsequent to the period of the test. Furthermore, it provides a means of critically evaluating the foreign exchange policies of the Jamaican authorities. It has been necessary, however, to make a number of simplifying assumptions. Some of these are examined in the next chapter which deals with modifications and extensions which might be worthy of attention in future work designed to advance the theory of foreign exchange reserves.

CHAPTER 8

Modifications and Extensions

In this chapter we relax some of the assumptions which were made in the empirical work. We wish to discover whether the model remains feasible under slightly less restrictive conditions. In the process, we suggest directions in which further development of reserve theory might proceed.

The assumptions which are modified or removed have to do with the cost equations, the nature of the adjustment process, and the exchange rate. Up to this point the parameters of the equations giving the growth-costs of reserves and adjustment have been kept fixed. The first section of this chapter discusses whether this assumption is realistic and suggests ways of treating non-constant parameters. In the second section, we remove the assumption that there is no adjustment to balance of payments disturbances until reserves run out. We suggest alternative decision rules and ways of implementing them. The third section deals briefly with the implications of the floating exchange rate regime; hitherto the exchange rate has been assumed fixed.

Changes in the Parameters of the Cost Functions

We begin with the " c_1 " cost of reserves, the opportunity cost of maintaining a stock of reserves. The parameters on which this cost depends are the marginal propensity to import (m), the growth rate of exports (x) and the standard deviation of the reserve series (σ_D). So far we have assumed all three to be constant. What happens if they are not?

Both the propensity to import and the growth rate of exports may vary over the plan horizon, and both are to some degree unpredictable.

Exports perhaps presents the greater difficulty, since the principal determining factors here are exogenous. For example, in 1974 Jamaica's agricultural exports benefited from a significant rise in sugar prices which could not have been foreseen in 1971.¹ There is some scope for determining export growth where new products, new markets or new resources are to be introduced or exploited in accordance with specific policy guidelines. Similarly, greater determinism may be had if the government proposes such guidelines for existing activities. Some modification to the projection of export growth can be made to take account of these and other policies which will affect export growth in a determinate way, but the basic estimation still has to be done on the basis of extrapolation from past trends, which is what we have done.

The propensity to import may be less unpredictable, since it depends on domestic factors. The reliability of our estimate depends on our understanding and explanation of the factors which determine import levels. Our estimating equation specifies imports as a function of income alone, which is a simplification. In theory, anyway, imports ought also to respond to changes in import prices relative to domestic prices, to political and sociological factors, to income distribution changes, to changes in the community's real assets, and so on. In practice, if the other factors have a negligible effect on imports (relative to the impact of income) over the time period of our interest,

1. The "Free Market" price for sugar (which applies to supplies which are not marketed under bilateral agreements) rose to £320 per ton (August 23, 1974) from levels of about £75 for most of 1973. However, much of the Jamaican output was supplied to the U.K. under the Commonwealth Sugar Agreement; the negotiated price under this Agreement increased a mere 22 per ton to 83.

then reliable results will be had from our equation. Whether this is so might be a question for empirical investigation in another context.

However, here again projections ought to be modified in the light of official policy. Import substitution activities are the obvious case in point. Typically, there is little import saving during the establishment phase of import competing activities, but it ought to be possible to project the import saving in future years of the plan period and to adjust m accordingly.

Changes in the values of m and x will alter the shape of the cost curve and the solution for the optimal level of reserves. An increase in m will cause the c_1 curve to shift downwards; a given amount of foreign resources will now secure a lower rate of growth, and therefore, the opportunity cost of the equivalent amount of reserves is lower.¹ Increases in x have the opposite effect. The additional foreign exchange earnings replace part of the previous requirement for foreign resources on capital account. Lower foreign resource requirements for any growth rate mean that the opportunity cost of the equivalent reserve stock is higher.

1. This may be demonstrated using Equation 6-5. Write

$$R - D = M_0 + mY_0[(1+g)^t - 1] - X_0(1+x)^t$$

$$mY_0[(1+g)^t - 1] = (R - D) - M_0 + X_0(1+x)^t$$

$$(1+g)^t = \frac{1}{mY_0} [(R - D) - M_0 + X_0(1+x)^t] + 1$$

An increase in m will reduce the value of the expression on the right-hand side. Put $RHS = q$; then

$$g = (q)^{1/t} - 1,$$

and g decreases with q .

The effects of an increase in x may be traced in analogous fashion.

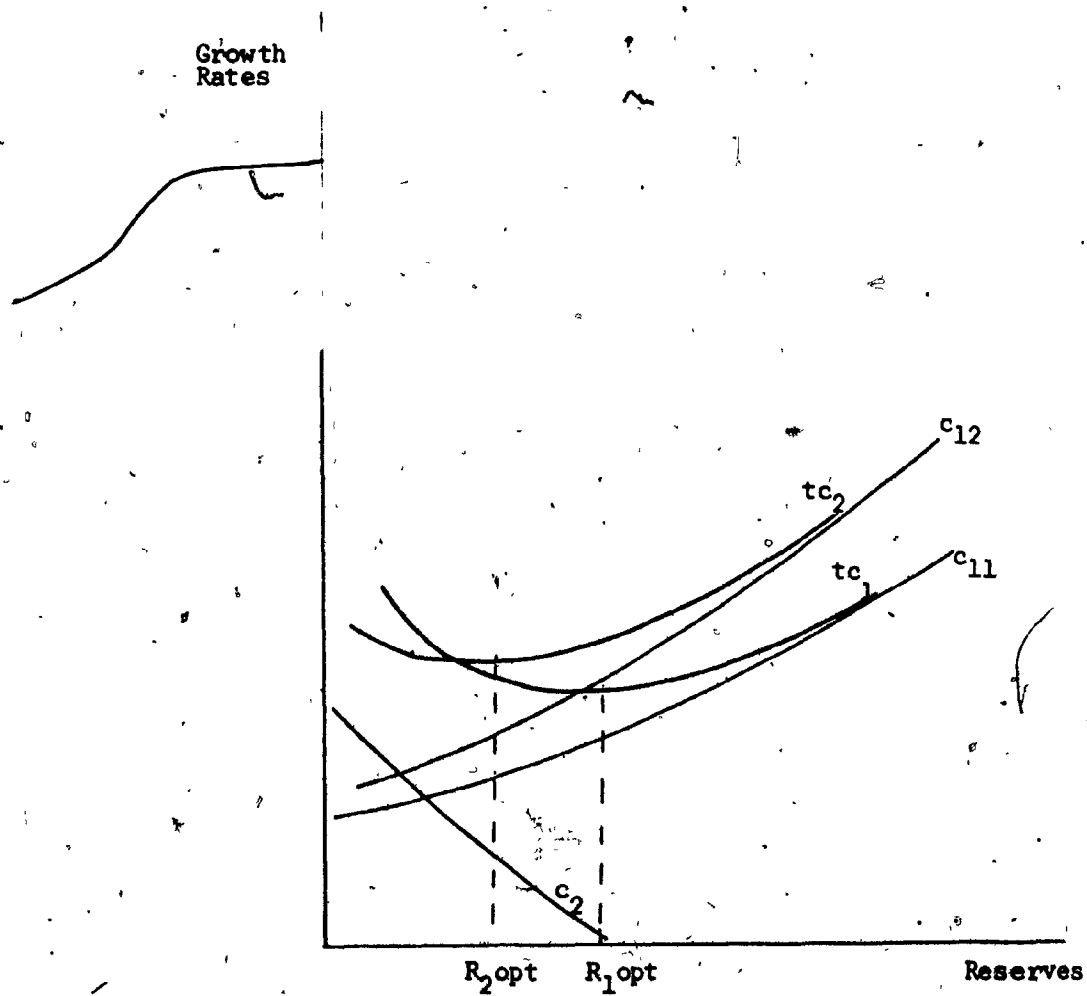
Both m and x will cause the c_1 curve to change its shape as well as its position, because c_1 is a non-linear function of each.¹ This is one reason why the point of minimum cost will no longer be the same. However, even if the shift in c_1 were parallel along its entire length, the effect of adding c_2 would be to change the shape of the total cost curve, so that even in this case the optimum might change. The "favourable" changes, that is, increases in x and decreases in m , would tend to lower the optimum reserve level. Refer to Figure 8-1. The c_1 -cost is shifted from c_{11} to c_{12} by an increase in x , a decrease in m or a combination of the two. This moves the aggregate cost curve (with unchanged costs of adjustment (c_2)) from tc_1 to tc_2 . The minimum point on the latter curve lies to the left of the minimum for tc_1 and the corresponding value for optimal reserves (R_2^{opt}) is lower than the initial value (R_1^{opt}). Note, however, that now the cost of reserves is higher, even at the optimal level. This need not always be the case, depending on the way in which c_1 changes. Reserves are now more valuable; therefore, the total cost of the optimal level will be reduced only if that level falls more than enough to compensate for the increase in the value of reserves.

Moving now to the standard deviation of reserves, we have assumed that its value does not vary with the level of reserves. This assumption, which has appeared elsewhere in the literature, might be challenged over the long period.² Even if fluctuations in the volume of transactions remained the same, increases in their dollar value would increase the amplitude of reserve variations. Tests reported in Chapter Six indicate

1. See Appendix A.

2. G.C. Archibald and J. Richmond, op . cit. addressed this problem.

Figure 8-1. Changes in c_1 and the reserve optimum.



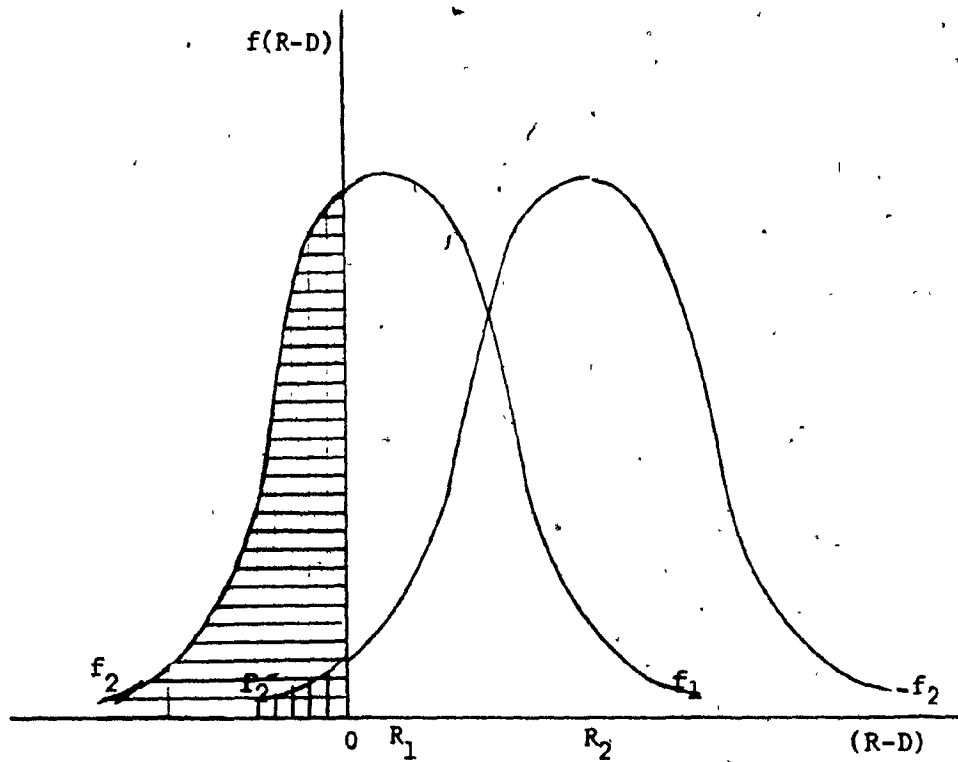
the presence of heteroskedasticity; an important task for future empirical research is to determine the precise way in which the variance changes over time.

In view of the analysis of Chapter Six it may be necessary in practice to replace the continuous c_2 -function with one which is specified at particular values of $(R - D)$. The suggestion made in Chapter Six was that the marginal cost of each additional unit of adjustment (each such unit consisting of a discrete portion of foreign exchange demand to be eliminated) be computed empirically by evaluating the cost and availability of each adjustment mechanism. There can be no general rules for the behaviour of this function. Each point would represent a discrete step, and there would not necessarily be a smooth progression in any one direction. When we specify $(R - D)$ rather than an amount to be adjusted as the variable whose cost is to be measured, probability weights must be applied, and it is these which account for the fall in c_2 . As we move further and further away from the origin, the probability of a given amount of adjustment decreases, and is finally zero. The rate at which it decreases, and the point at which it goes to zero depends on the standard deviation of the net demand for reserves (σ_D).¹ Because this decline depends on σ_D only, it can be postulated whether the marginal cost of a unit of adjustment rises or falls.

Figure 8-2 illustrates the last point. When reserves have the value R_1 , the distribution function of the net demand for reserves

1. If, as we state, D has the normal distribution, it is more accurate to say that c_2 tends to zero, since all values of $(R - D)$ have some probability of occurrence and therefore some cost. This cost is however negligible outside a central range of values.

Figure 8-2. The Distribution Function of $(R-D)$.



is situated at f_1 . The probability weight assigned to the prospect of running out of reserves is represented by that part of the area under the f_1 curve which lies to the left of the origin (0). When reserves are increased to R_2 , the distribution function (which is identical in shape with f_1) moves to f_2 , yielding a probability which is much lower than in the first instance. When the reserve levels become so high that there is no discernible area to the left of the origin, c_2 reduces to zero. Nevertheless, because we cannot be sure that c_2 is a well-behaved function of the number of units of adjustment, we cannot maintain that the second part of Equation 4-1 will decline in a regular fashion.

The parameter changes do not create any conceptual difficulty. So long as some firm information is available on the changes, the appropriate values can be put into the optimising equation. The difficulty of course is to get reliable estimates of these changing parameters. The importance of this problem should not be underplayed, but our main focus here must be on the question whether or not the integrity of the model is compromised by the changes. It seems true to say that it is not.

Adjustment Costs for Positive Expected Reserve Levels

We may bring the model of reserve optimisation a step closer to reality by making allowance for adjustment when $(R - D)$ is positive. It is unlikely that the monetary authorities will wish to wait until reserves are completely used up before they institute any policies to protect the net foreign payments position. Rather, they will wish to lay down guidelines for making policy changes so as to secure the

maintenance of a target level of reserves, in the face of the actual and expected changes in net foreign exchange earnings from month to month. We turn now to examine some of the issues which arise in establishing such guidelines. In doing so we identify another area into which future work should be extended.

The difference between the case we are to look at now, and our earlier analysis is that formerly we assumed there would be no adjustment costs until the expected reserves fell to zero; now we establish a target level of reserves to which adjustment policies are linked. That is to say, adjustment costs may be incurred whenever there is a discrepancy between the expected reserve levels and the reserve target. In what follows we set the target level of reserves equal to the optimum level of reserves, but, as we shall see, this leads to some difficulty, and alternative suggestions are offered at the end of the section.

We may begin by taking the situation of the monetary authority which, at time t , faces an expected level of reserves at time $(t+n)$ given by $\hat{R}$; suppose that the optimal level of reserves has been calculated as R_{opt} , which is different from $\hat{R}$. The question which arises is, what decision rules should be followed in adjusting reserves (and over what period) in order to achieve the optimal level.

Even before we go on to examine what alternative decision rules are possible, it is evident that any active reserve management whatever will require us to adjust the second part of our integral at Equation 4-1. The expression for the cost of adjustment which has been employed to date,

$$\int_R c_2 (R - D) \phi(D) dD$$

must now be revised to take account of (a) the fact that the adjustment needed is no longer equal to $(R - D)$ and (b) the costs of adjustment for positive as well as negative values of $(R - D)$.

Let us begin by assuming that the policy of the competent authorities is that the entire discrepancy between the expected and optimal reserve levels be eliminated. The value of the adjustment required (A) is then given by

$$8-1. \quad A = R_{\text{opt}} - \hat{R}.$$

A new functional relationship for the cost per unit of adjustment must be defined. Replace c_2 by c_2^1 . Furthermore, the integration limits must be set at minus and plus infinity, since adjustment may be required irrespective of the value of net foreign exchange earnings.¹ The expression for the cost of adjustment becomes

$$8-2. \quad \int_{-\infty}^{\infty} c_2^1 A \phi(D) dD = c_2^1 A \int_{-\infty}^{\infty} \phi(D) dD \\ = c_2^1 A,$$

since the value of the cumulative distribution function of the random variable is necessarily equal to unity.

There is an adjustment cost now which is independent of the distribution of D ; we can support this with intuitive argument. In our previous formulation, the weighting given to the cost of a given reserve level R_1 depended on the portion of the $\phi(D)$ curve which lay in the adjustment range (See Figure 8-1). Now the weighting given to the cost of each R_1 is identically equal to one, because the whole of the $\phi(D)$ curve is now within the adjustment range.

The one case in which adjustment is not needed is, of course, when the value of D is such that $\hat{R} - D = R_{\text{opt}}$.

However, one should expect the nature of the cost function to change with the sign of A . That is to say, the unit costs of reducing reserves which are expected to be higher than the optimum ("excess" reserves) may well be different from the unit costs of increasing reserves which are suboptimal ("deficient" reserves). Thus, the c_2^1 function may be discontinuous at $A = 0$.

In principle, the adjustment to the cost function which we have just outlined creates only one problem for the reserve optimisation model, but it is a crucial problem. The fact is that "excess" or "deficient" reserves can be defined only in relation to the optimal level, but the optimal level is itself derived from the cost functions. In equation 8-1, therefore, we could not determine A beforehand because we could not know the optimum level of reserves. In practice, the decision rule that might be followed would be that authorities pick a reserve target R^* without reference to the unknown reserve optimum and then calculate optimal reserves based on the cost schedules derived from this.¹ This calculated reserve optimum could then be used to revise the reserve target; the calculation would then be repeated. This process could be reiterated several times, and, if the series for the calculated reserve optimum were convergent, this value could then be derived to the desired degree of accuracy. The properties of the series would have to be established with reference to particular cases, and this is one area where the development of reserve management theory might reward further investigation.

1. An arbitrary choice of reserve targets is the method used to deal with this problem elsewhere in the literature. See, for example, Kelly, op. cit., p. 658 and Britt and Heller, op. cit., p. 184.

We turn now to the matter of fixing decision rules for adjusting foreign receipts and payments so as to secure any given reserve target. The principles underlying these rules might be that (a) very large adjustments should not be made in a single time period and (b) changes in the direction of adjustment should be minimised. The reasons for these guidelines are that large adjustments are more costly than small, and a reversal of direction, however small, is more costly than the equivalent change in the same direction. The first proposition may be deduced from our existing cost function (c_2 or any of its variants); the second is intuitively acceptable, but would require concrete proof in further development of the method.

The actual decision rules for adjustment might operate somewhat along the following lines. Let us introduce an adjustment parameter γ such that

$$8-4. \quad A = \gamma (R^* - \hat{R}),$$

where R^* is the target level of reserves.¹ The problem then is to specify γ in such a way as to fulfill the conditions set out in the preceding paragraph.

We will do no more than suggest one or two possibilities. For one thing, since costs are expected to be asymmetrical as between excess reserves and reserve deficits, we might specify different magnitudes (or functional relationships) for γ , depending on the sign of $(R^* - \hat{R})$.

1. The parameter γ plays a crucial role in Clark's model; cf 'Optimum International Reserves and the Speed of Adjustment', Journal of Political Economy, March/April 1970.

In this way the total cost incurred in a particular period could be the same for excesses as for deficits; the greater unit cost of any deficit adjustment would be compensated for by a diminished response for deficit adjustment as opposed to adjustment to excess reserves. To take a concrete example, the cost of making up a reserve deficiency of \$10 million might be twice the cost of eliminating \$10 million of excess reserves; but we compensate for this by only making half the adjustment for the reserve deficit per time period.

As to the specific nature of γ , it may be a single parameter with values between zero and unity, or it may be variable, allowing for a smaller proportion of adjustment, the greater the difference between R^* and $\hat{R}$. The value of this latter suggestion would be to impose some limits on the dollar value of A in any period. Another alternative would be to combine any of the suggestions so far with an absolute limit on the amount of adjustment to be permitted in any one period.

While these suggestions would serve to limit the amount of adjustment to be undertaken in one time period, they would not prevent frequent alternation in the direction of adjustment. One way of taking care of this problem would be to specify a lower threshold for any adjustment. That is to say, there would be no action if A were less than a specified amount. This rule would reduce the incidence of switches in the direction of adjustment by eliminating all cases where $\hat{R}_{t+i}$ fluctuated in a narrow range around R^* for successive i . There would be changes to and fro only if $\hat{R}_{t+i}$ fluctuated very widely in successive time periods. In such a case the adjustments would be much more violent and disruptive. It is reasonable to assume, however, that such an eventuality is unlikely

and that it would indicate either (a) the need for review of the forecasting model or (b) the need for other policies of domestic stabilisation, rather than the need for new rules of reserve management.

There is also the question of the definition of the time period and the related question of the speed of adjustment. Recall that the projections ($\hat{R}$) from which optimal reserves are derived are made for several time periods ahead. We may re-define γ as follows

$$B-5. \quad A_1 = \gamma (R^* - \hat{R})$$

where A_1 is the amount of adjustment in the month following the end of the current period. Clearly, the larger is γ , the faster the economy will adjust to the desired level of reserves. The adjustment process may now be thought of as a dynamic process. $\hat{R}$ will alter from month to month, even though R^* may be maintained constant for some time; there will therefore be a series of partial adjustments each month, with the discrepancy between R^* and $\hat{R}$ never being completely eliminated.

We may now summarise the observations of this section. The one problem which these guidelines for reserve management present for our theory of optimum reserves is the question of whether the iterative procedure for establishing the reserve target will work. In effect, what we wish to do, as compared with what was outlined earlier, is to shift the origin from which we measure our adjustment costs from $R=0$ to $R=R^*$. Our dilemma is that this shift in origin will affect the overall cost curve (the sum of c_1 and c_2) even if it leaves each of its two elements unchanged.

In fact, we may wish to change the shape of c_2 as well as its position, for two reasons. The first we have already seen derives from the need to allow for adjustment to excesses as well as deficiencies. The second would arise from the limitations to the adjustment process imposed by the introduction of γ . By reducing the extent of adjustment we would reduce the cost. However, so long as we can find an acceptable method of determining R^* , these changes create no further difficulty. None of the other considerations as to the speed and limitations on adjustment will affect the computation of the optimum reserve level. This follows from the fact that none of these changes will alter the other parameters of the cost curves, viz., the propensity to import, the rate of growth of exports and the standard deviation of reserves (which, by assumption, does not vary with the reserve level).

Optimum Reserves and Floating Exchange Rates

In Chapter Three we established the model on the basis of a fixed exchange rate. We pointed out, at that time, that the procedures for computing optimum reserves would not be invalidated by a floating exchange rate regime. However, one would expect results rather dissimilar in the two cases. We have to investigate the possibility that, for part of the period from which we draw our data, the exchange rate in Jamaica was changing as a result of changes in the value of the pound sterling, to which the value of the Jamaica dollar was tied.

During the period of our analysis the Jamaican dollar was maintained at a fixed rate of parity with the pound sterling. In a world of fixed exchange rates, we can infer that Jamaica operated on a fixed exchange rate. However, once the rates of exchange between the pound

and other major currencies began to vary, the effective rate of exchange for Jamaica was no longer constant. In practical terms, this resulted mainly from the changes in the UK - US rate, and the extent of Jamaica's trade with the US. Alterations in the US - UK rate meant that the US - Jamaica rate changed pari passu. This phenomenon became significant as of August 1971. Until July 1971, the US - UK rate remained centred on the value of US \$2.40 per pound sterling; in August the rate rose to US \$2.4525 per pound, and continued rising steadily to the end of the year.

In fact, the change in the effective exchange rate for Jamaica vis-à-vis the rest of the world did not change significantly, except for the last month of our series, December 1971. Jamaica's main trading partners are the US, the UK and countries whose parities are fixed to one or other of these currencies. Countries in these categories account for 80% of Jamaica's total trade.¹ A trade weighted exchange rate index was computed for Jamaica for January 1968 to December 1971; the average value of this index for the period is 1.6192 Jamaican dollars for a basket of trading currencies. The deviation from this value was less than 2.0%, except for December 1971, when it rose to 5.6%.

We indicated earlier that exchange rate changes could be accommodated in our analysis either by including the exchange rate explicitly as an

1. Canada is included; although not actually fixed to the U.S. dollar, the value of the Canadian dollar in fact generally follows the movements in the currency of its larger neighbour. Since Canada accounts for only about 8% of Jamaica's trade, no significant error is introduced by treating it as part of the dollar area.

explanatory variable, or by splitting the regression into separate parts, divided at the point where the exchange parity or the exchange rate regime changes. This was not thought necessary in our case since only one observation is involved. However, even more significant exchange rate changes have taken place since December 1971. Apart from the continuing variation in the value of the pound, there have been devaluations of the Jamaican dollar and a switch from the pound to the U.S. dollar as the basis of valuing the Jamaican currency. Undoubtedly, one of our earlier suggestions for dealing with floating rates would have to be employed in any updated analysis.

Conclusions

This chapter has brought to light one modification to the model of the preceding chapter. This modification is in regard to the adjustment process when reserves are managed so as to secure a given target level. Apart from this, our analysis suggests the following areas of theoretical and empirical interest which would complement and extend the model. First, explicit specification of a system of simultaneous equations to determine the relationship between reserves and major economic variables; second, development of a planning framework from which estimates may be derived of expected systematic changes in the cost functions; third, thorough investigation by the competent authorities of alternative balance of payments short-run adjustment policies and a quantification of the availability and growth costs (derived from the planning framework) of each; and fourth, a discontinuity in the series (for any update) to take account of the world of floating exchange rates.

CHAPTER 9

Conclusion

Synopsis of the Argument

The model of exchange reserve optimisation which has been presented in this study evolves from two main premises, one a feature common to most recent models, the other less common, addressed to the special concerns of developing countries. The first premise is that reserves are held as insurance against short-term fluctuations in net foreign exchange earnings, the second that the promotion of economic development is the overriding concern of the class of countries for which the model is appropriate.

Certain structural characteristics of countries in this category (i.e. developing countries) are built into the model. In particular, the main constraint on the growth of national income and employment is the scarcity of foreign resources. Secondly, because these countries have a relatively small stock of capital and low capacity to produce, the rate of investment per year will usually generate a significant increase in that productive capacity. The joint effect of these two structural characteristics is that any addition to the available foreign resources will have a marked effect on the rate of growth which is possible. This is important, because the model focuses on foreign exchange reserves as a potential foreign resource.

If reserves are held as a precaution against fluctuations in net foreign exchange receipts, the first question to be resolved is what risk there is that any given amount of reserves will be needed to meet unexpected shortages in earnings of foreign exchange? The risk is assessed by looking at the past behaviour of net foreign reserves, determining how much of the behaviour of the series can be attributed

to certain exogenous economic variables and then deducing the risk which derives from purely random elements.

Once the degree of risk has been determined, the authorities must decide how great a precaution should be taken. Here there are two considerations to be taken account of: the cost of the precaution (which is the cost associated with any stock of reserves) and the cost of a 'stock-out' (which is the cost of economic adjustment measures to be taken to eliminate a deficiency in net foreign exchange earnings if no reserves are available to finance the deficiency). The precautionary reserve is determined, finally, by establishing what reserve level incurs the least cost to the country, when the risks of 'stock-out' and the availability and costs of reserves and of all adjustment mechanisms have been taken into account.

Review of the Study

In this section we recapitulate briefly on the way in which the above argument has been developed in the course of the preceding eight chapters.

The first chapter introduces the problem, says why it is of interest and defines a number of terms to be used in the course of the study. Chapter Two provides a brief background sketch of the Jamaican economy and in Chapter Three there is a review of the literature. A complete outline of the model is given in Chapter Four.

The next four chapters provide the main analysis and testing of the model. Chapters Five and Six, which deal respectively with the determination of risk and the specification of costs, lead up to Chapter Seven, where the model is evaluated and solved to determine the optimum

reserve level for Jamaica. Chapter Eight deals with extensions, qualifications and further thoughts on the model.

We present here a brief review of the content of four central chapters (Five to Eight), before proceeding to the conclusions to be drawn from the analysis. The risk of running out of reserves (Chapter Five) and therefore of having to resort to adjustment measures depends on the random element in the variation in net foreign exchange receipts. We argue that these receipts are subject to systematic influences which derive from monetary and fiscal policies (represented by the money supply and government expenditures) and from the two principle exogenous factors which influence the level of economic activity in Jamaica (exports and capital inflows). Above and beyond these systematic influences (which determine the transactions level of reserves) there is purely stochastic variation. If this stochastic element is represented by a random variable, then the degree of risk is deduced from the variance of that random variable. The residual variation about a regression of reserves on money supplies, government expenditures, exports and capital inflows reflects the influence of the random variable and therefore gives an estimate of the risk of running out of reserves.

In order to determine the cost of reserve stockholding (Chapter Six) we consider the need for and the availability of foreign exchange over a (five-year) planning period. Available foreign resources are exogenously determined, but the requirements depend on the projected rate of growth over the period. The foreign resource requirement associated with any chosen rate of growth is the amount

required to make up any deficiency between the total foreign resources needed for that rate of growth and the resources available. Reserves are regarded as a potential foreign resource which might be used to supply this deficiency, and hence by substituting any value of reserves in the equation linking resource needs and growth rates we determine the potential growth which is sacrificed by holding reserves instead of using them. This is the opportunity cost of reserves.

The cost of meeting deficiencies in net foreign earnings when there are no means of financing is the cost of adjusting domestic expenditures so as to eliminate the deficiency. The ways in which this adjustment affects potential growth, by introducing waste and inefficiency, are also explored in Chapter Five.

At this point we have established the basis for determining the optimum level of reserves. Starting at any given point in time, we consider a six-month prediction. There is a central expected value, but our interest is in the range of values surrounding it. Each has a probability of occurrence given by the random residual variation and each has a cost of stockholding (for positive values) or of adjustment (for negative values). Weighting the costs by their associated probability gives us a schedule from which we can determine the value of reserves which minimises the total cost. This is the optimal level of reserves.

The results

The calculated optimal reserve level for Jamaica (at December 1971) lies below the range within which Jamaican authorities attempted

to maintain reserve levels in 1972. It is also below the range which the familiar rule of thumb for the management of reserves would have indicated, being less than the equivalent of three months imports. Actual reserve management in Jamaica seems to have operated on slightly more conservative principles than our results would imply, and measures were taken to protect reserves at levels which are, on our calculations, above the optimum. (The measures were not noticeably successful).

The results on tests of various sections of the model were uneven. The regression from which we determine the variance of net foreign exchange earnings fits the data well, but suffers from multicollinearity among the variables (which does not invalidate the results) and heteroscedastic residual variation (which remains an unresolved problem). Trials with a number of alternative formulations failed to eliminate these problems.

The costs of the reserve stock were measured under the assumption that the parameters involved (the propensity to import, the growth rate of exports, the capital-output ratio, the savings ratio) all remain fixed. If the economy is in the process of structural change, this assumption must be modified, and the costs equations restructured to reflect whatever systematic changes have been programmed for these parameters.

On the empirical level there is need for a more adequate specification of the costs of adjustment. We have been forced to make an arbitrary specification of the nature of these costs. What is needed is the complete list of options, each with a measure of the implied growth sacrifice. At the moment we lack both the list of options and the mechanism for computing their costs. For the list of options, what is missing is the total amount of foreign financing available; to compute the costs of adjustment, we need a more explicit description of the production process than is at present available. Both these requirements could be satisfied by empirical studies of the sort which would be carried out in the course of drawing up a development plan.¹

On the theoretical level, the model of the determinants of exchange reserve variation needs to be refined. What we have used is, in effect, the reduced form of a structural model which we have specified implicitly rather than explicitly in Chapter Five. In order to deal with the multicollinearity problem and to improve our understanding of the adjustment processes at work, further research into the model is required.

Assessment of the Model

The model we have studied is based on a conceptual framework which already existed. The idea that optimal reserves should depend on the degree of security afforded by each reserve level and on the comparative costs of adjustment and of reserve stocks is a feature of most recent studies of reserve optimisation. Within this basic

1. The reason they are not now available is that development planning seems rather in abeyance in Jamaica. This is in effect an appeal for a renewal of emphasis on such planning.

frame these studies have differed in the way they have determined risk, the way costs are computed and the economic objectives specified.

The present study is, however, rather more than a synthesis of existing work with an empirical test. We have extended the theory, introduced factors relevant to developing countries, incorporated future considerations and provided a model which the policy makers of an individual country can apply directly to the determination of optimal reserve levels for that country at any time.

The theory has been extended by providing an economic explanation (as opposed to a purely statistical one) for the variation in net foreign exchange earnings. This is a novel feature which links the determination of reserves more closely to monetary and fiscal policy and to externally induced disturbances, which are the main determinants of economic performance and hence, of foreign transactions. This innovation has led to encouraging results from empirical testing; such qualifications as may be inferred from these results would suggest the need for further exploration of this facet of the model, rather than a reversion to previous specifications which were all purely statistical.

The specific features of developing countries which we have considered relevant to the determination of optimum reserves are (a) the foreign exchange constraint on development and (b) the impact of new investment on the expansion of capacity and hence on the rate of growth. These considerations led us into an area which, though very familiar, had not previously been incorporated into the theory of foreign exchange reserves: that is, the relationship between foreign resources and growth and, as a result, the measurement of costs in

terms of growth rates¹ over a planning period. This provides us with measures of the cost of reserves and adjustment which are unique in the literature and which seem to us to be particularly suited to the circumstances of developing countries.²

Finally, our model is operational. Policy makers in any country, once they have gathered the necessary information to quantify the equations of the model, can determine uniquely the level of reserves which is optimal for that country. This is a feature not shared by many sophisticated models of reserve optimisation. The absence of such a feature may conceivably be partly responsible for the persistence of rules of thumb in day-to-day reserve management by the competent authorities in many countries. We demonstrate that our model is feasible and yields reasonable results in an empirical test which uses the Jamaican economy as an illustration.

Conclusion

This study offers an extension of the existing theory of reserve optimisation, one that has particular relevance to countries where the rate of development is constrained by scarcity of foreign resources. We have provided justification for this approach and a demonstration of its merits. This effort is to be seen rather as a suggestion that here is a fruitful path for further exploration than as a definitive statement and resolution of the theory of optimum reserves. In any

1. From a theoretical standpoint, rates of development would have been more appropriate, but because of measurement difficulties with this concept, we have adopted the usual compromise of using growth rates, with all the well-known caveats.

2. There have, of course, been studies of reserve behaviour directed specifically to developing countries, but their approach was rather different.

case, we do not claim perfectly general application. Each case would have to be examined to see whether the premises and the structural specifications fit. Our hope therefore is that we will have generated sufficient interest to encourage others to develop, criticise and refine the ideas we have presented here.

BIBLIOGRAPHY

The following references are cited in the text:-

Nassau Adams, "An Analysis of Food Consumption and Food Import Trends in Jamaica", Social and Economic Studies, March 1968.

Nassau Adams, "Import Structure and Economic Growth in Jamaica, 1954-67", Social and Economic Studies, September 1971.

J.P. Agarwal, "Optimal Monetary Reserves for Developing Countries", Weltwirtschaftliches Archiv, 107 (1), 1971.

G.C. Archibald & J. Richmond, "On the Theory of Foreign Exchange Requirements", Review of Economic Studies, April 1971.

Bank of Jamaica, Annual Reports, 1961 - 1972.

Bank of Jamaica, Research Department, The Balance of Payments of Jamaica, 1964 - 70, 1971, 1972.

Bank of Jamaica, Statistical Digest (Monthly).

H. Brewster and A. Brown, "A Review of the Study of Economics in the English Speaking Caribbean", Social and Economic Studies, March 1974.

R. Caves and H. Johnson (eds), Readings in International Economics, published for the American Economic Association by Richard D. Irwin, Inc., 1968.

H. Chenery, "The Role of Industrialisation in Development Programs", American Economic Association, Papers and Proceedings, May 1955.

H. Chenery and O. Bruno, "Development Alternatives in the Open Economy: The Case of Israel", Economic Journal, March 1962.

H. Chenery and A. MacEwan, "Optimal Patterns of Growth and Aid: The Case of Pakistan", Pakistan Development Review, Summer 1966.

Carl Christ, Econometric Models and Methods, John Wiley and Sons.

P.B. Clark, "Optimum International Reserves and the Speed of Adjustment", Journal of Political Economy, March 1970.

R.W. Clower and R.G. Lipsey, "The Present State of International Liquidity Theory", American Economic Review, May 1968.

George Cumper, "Tourist Expenditure in Jamaica", Social and Economic Studies, September 1959.

M.J. Flanders, The Demand for International Reserves, Princeton Studies in International Finance, No. 27, 1971.

H.G. Grubel, "The Demand for International Reserves", Journal of Economic Literature, December 1971.

D.J. Harris, "Saving and Foreign Trade as Constraints on Economic Growth", Social and Economic Studies, June 1970.

H.R. Heller, "Optimum International Reserves", Economic Journal, June 1966.

International Monetary Fund, International Financial Statistics.

International Monetary Fund, International Reserves: Needs and Availability, IMF 1970.

M.A. Iyoha, "Optimal Balance of Payments Strategy by Stochastic Dynamic Programming", Western Economic Journal, December 1971.

Jamaica, Department of Statistics, National Income and Product 1970, 1971.

Jamaica, National Planning Agency, Economic Surveys 1960 - 1972.

Owen Jefferson, The Post-War Economic Development of Jamaica, Institute of Social and Economic Studies, University of the West Indies, 1972.

J. Johnston, Econometric Methods (2nd edition), McGraw-Hill, 1973.

M.G. Kelly, "The Demand for International Reserves", American Economic Review, September 1970.

P. Kenen and E. Yudin, "The Demand for International Reserves". Review of Economics and Statistics, August 1965.

Fritz Machlup, International Payments, Debts and Gold, Charles Scribner's Sons, 1964.

Wendell McClean, Money and Banking in the East Caribbean Currency Authority Area, Institute of Social and Economic Studies, University of the West Indies (mimeo) 1971.

Nugent Miller, Commercial Banking in Jamaica, Institute of Social and Economic Studies, University of the West Indies (mimeo) 1971.

Ragnar Nurkse, International Currency Experience, League of Nations, Geneva, 1944.

J.H.G. Olivera, "A Note on the Optimal Growth Rate of International Reserves", Journal of Political Economy, March 1969.

J.H.G. Olivera, "The Square-Root Law of Precautionary Reserves", Journal of Political Economy, September - October 1971.

Danny Otchere, "The Reserve Holding Behaviour of Developing Countries", Unpublished Ph.D. thesis, McGill University, 1972.

J.J. Polak, "Monetary Analysis of Income Formation and Payments Problems", IMF Staff Papers, 1957 - 58, pp. 1 - 50.

Erich Streissler, "A Stochastic Model of International Reserve Requirements During Growth of World Trade", Leitschrift fur Nationalokonomie, December 1969.

Leroy Taylor, "Money, The Balance of Payments and Income Determination in Jamaica", Social and Economic Studies, June 1972.

C.Y. Thomas, "Monetary and Financial Arrangements in a Dependent Monetary Economy", Social and Economic Studies, December 1965 (Supplement).

UNCTAD, Trade Prospects and Capital Needs of Developing Countries, United Nations, 1968.

J. Williamson, "International Liquidity: A Survey", Economic Journal, September 1973.

Appendix A. Solution of the Cost Function.¹

Standardise Equation 4-1 by dividing through by the standard deviation of the reserve projection:

$$A-1. \quad E(C/R) = \int_{-\infty}^R c_1 \frac{(R-D)}{\sigma} \phi(D) dD + \int_R^{\infty} c_2 \frac{(R-D)}{\sigma} \phi(D) dD$$

$$\text{Put } E(C/R) \equiv I = I_1 + I_2$$

where I_1 and I_2 are the expressions on the RHS of A-1.

Solution for I_1 .

$$A-2. \quad c_1 \frac{(R-D)}{\sigma} \equiv \frac{R-D}{\sigma} = m_0 + m \left[(1+g)^t - 1 \right] - x_0(1+x)^t.$$

Solve for g :

$$A-3. \quad g = \left(\frac{1}{m\sigma} (\chi - D) \right)^{1/t} - 1,$$

$$\text{where } \chi = R + \sigma [m + x_0(1+x)^t - m_0]$$

To solve $(\chi - D)^{1/t}$, put

$$A-4. \quad (\chi - D)^{1/t} = (\chi)^{1/t} (1 - D/\chi)^{1/t}$$

$$A-5. \quad (1 - D/\chi)^{1/t} = 1 - \binom{1/t}{1} (D/\chi) - \binom{1/t}{2} (D/\chi)^2 - \dots - \binom{1/t}{r} (D/\chi)^r - \dots$$

By choosing an appropriate number of terms this expression can be approximated to any desired degree of accuracy.

¹ We acknowledge the invaluable assistance of Mr. Clyde Drayton, post-graduate student of the Department of Mathematics, St. Augustine, University of the West Indies, in devising this solution.

$$\begin{aligned}
 \text{A-6. } I_1 &= \frac{1}{(2\pi)^{1/2}} \int_{-\infty}^R \left(\frac{1}{m\sigma}\right)^{1/t} (\chi - D)^{1/t} e^{-\frac{D^2}{2}} dD - \frac{1}{(2\pi)^{1/2}} \int_{-\infty}^R e^{-\frac{D^2}{2}} dD \\
 &= I_{11} - I_{12}
 \end{aligned}$$

where

$$\text{A-7. } I_{12} = \frac{1}{(2\pi)^{1/2}} \int_{-\infty}^R e^{-\frac{D^2}{2}} dD = \phi(R);$$

where $\phi(R)$ is the cumulative standard normal distribution function to R ;

and

$$\text{A-8. } I_{11} = \frac{1}{(2\pi)^{1/2}} \left(\frac{1}{m\sigma}\right)^{1/t} \int_{-\infty}^R (\chi - D)^{1/t} e^{-\frac{D^2}{2}} dD$$

$$\text{Put } N = \frac{1}{(2\pi)^{1/2}} \left(\frac{1}{m\sigma}\right)^{1/t}$$

$$\begin{aligned}
 \text{A-9. } I_{11} &= N \int_{-\infty}^R (\chi)^{1/t} (1 - D/\chi)^{1/t} e^{-\frac{D^2}{2}} dD \\
 &= N(\chi)^{1/t} \int_{-\infty}^R e^{-\frac{D^2}{2}} dD - N \binom{1/t}{1} (\chi)^{1/t-1} \int_{-\infty}^R D e^{-\frac{D^2}{2}} dD \\
 &\quad - N \binom{1/t}{2} (\chi)^{1/t-2} \int_{-\infty}^R D^2 e^{-\frac{D^2}{2}} dD - \dots \\
 &\quad - N \binom{1/t}{r} (\chi)^{1/t-r} \int_{-\infty}^R D^r e^{-\frac{D^2}{2}} dD
 \end{aligned}$$

Integrate I_{11} term by term

$$\text{A-10. } I_{111} = N(\chi)^{1/t} \int_{-\infty}^R e^{-\frac{D^2}{2}} dD = (2\pi)^{1/2} N(\chi)^{1/t} \phi(R)$$

$$\text{A-11. } I_{112} = -N \binom{1/t}{1} (\chi)^{1/t-1} \int_{-\infty}^R D e^{-\frac{D^2}{2}} dD = N \binom{1/t}{1} (\chi)^{1/t-1} e^{-\frac{R^2}{2}}$$

$$\text{A-12. } I_{11r} = -N \binom{1/t}{r} (\chi)^{1/t-r} \int_{-\infty}^R D^r e^{-\frac{D^2}{2}} dD = -\left[D^{r-1} e^{-\frac{D^2}{2}} \right]_{-\infty}^R (r-1) \int_{-\infty}^R D^{r-2} e^{-\frac{D^2}{2}} dD$$

By repeated integration I_{11n} reduces to either I_{111} (for odd numbers) or I_{112} (for even numbers).

I_{11} is therefore evaluated as a function of χ and R ; but recall that χ is itself a function of R . Therefore we may write

$$A-13. \quad I_{11} = I_{11}(R).$$

The solution for I_1 is

$$A-14. \quad I_1 = I_{11}(R) - (R)$$

Solution for I_2

$$\begin{aligned} I_2 &= \frac{1}{(2\pi)^{\frac{1}{2}}} \int_R^{\infty} c_2 \frac{(R-D)}{\sigma} e^{-\frac{D^2}{2}} dD \\ &= \frac{1}{(2\pi)^{\frac{1}{2}}} \frac{c_2 R}{\sigma} \int_R^{\infty} e^{-\frac{D^2}{2}} dD - \frac{c_2}{\sigma(2\pi)^{\frac{1}{2}}} \int_R^{\infty} D e^{-\frac{D^2}{2}} dD \\ &= \frac{c_2 R}{\sigma(2\pi)^{\frac{1}{2}}} \left[1 - \Phi(R) \right] + \frac{c_2}{\sigma(2\pi)^{\frac{1}{2}}} \left[e^{-\frac{D^2}{2}} \right]_R^{\infty} \\ &= \frac{c_2 R}{\sigma(2\pi)^{\frac{1}{2}}} \left[1 - \Phi(R) \right] - \frac{c_2}{\sigma(2\pi)^{\frac{1}{2}}} e^{-\frac{R^2}{2}} \end{aligned}$$

The complete solution is therefore

$$E(C/R) = I_{11}(R) - \phi(R) + \frac{c_2 R}{\sigma(2\pi)^{\frac{1}{2}}} \left[1 - \Phi(R) \right] - \frac{c_2}{\sigma(2\pi)^{\frac{1}{2}}} e^{-\frac{R^2}{2}}$$

which is the equation of the curve of Figure 7-1.

Appendix B. The Data.

Table B-1. Estimation of Reserve Variation.

t	R_t	R_{t-1}	ΔMS	MS_{t-1}	CR	X_t	K_t	$X_t + K_t$	G_t
1.	86.6	70.4	1.3	85.8	10.5	4.3	25.9	12.0	
2.	97.6	86.6	-1.5	102.3	16.7	4.7	21.4	5.1	
3.	95.7	97.6	-1.2	97.5	16.1	4.1	20.2	6.5	
4.	99.3	95.7	-2.5	99.6	16.3	5.0	21.3	6.9	
5.	99.5	99.3	5.1	99.7	12.8	5.1	17.9	9.5	
6.	97.8	99.5	1.6	100.6	13.1	5.8	18.9	8.0	
7.	98.1	97.8	3.7	108.3	14.0	4.1	14.4	6.5	
8.	101.7	98.1	1.0	108.8	15.1	5.2	21.3	8.3	
9.	98.4	101.7	0.4	104.2	14.4	4.3	18.7	12.1	
10.	102.9	98.4	7.4	108.7	14.9	4.0	18.9	15.1	
11.	107.3	102.9	7.2	131.2	14.4	4.3	18.7	19.1	
12.	111.0	107.3	-4.9	116.8	16.8	4.6	21.3	12.7	
13.	116.9	111.0	8.3	104.0	15.5	8.0	23.6	24.0	
14.	109.0	116.9	0.4	131.8	20.6	4.5	25.1	15.1	
15.	106.2	109.0	-5.6	124.4	20.5	10.8	31.3	9.2	
16.	103.1	106.2	6.5	119.6	18.9	4.5	23.4	15.5	
17.	100.1	103.1	-5.0	130.2	17.8	4.9	22.7	18.7	
18.	103.4	100.1	-0.1	127.3	15.8	4.4	20.2	17.1	
19.	100.0	103.4	4.1	120.9	18.8	4.8	23.6	11.7	
20.	94.6	100.0	4.6	133.5	15.7	6.1	21.7	15.5	
21.	96.9	94.6	-4.6	137.5	13.0	5.4	18.4	15.7	
22.	100.8	96.9	8.2	133.3	21.2	6.5	27.7	18.5	
23.	105.9	100.8	5.0	138.0	18.1	13.0	31.1	16.5	
24.	108.4	105.9	-6.9	131.7	19.8	9.6	29.4	17.8	
25.	125.0	108.4	-0.3	110.1	20.2	13.9	34.1	28.2	
26.	129.7	125.0	9.5	129.6	23.3	16.1	39.4	23.6	
27.	132.8	129.7	-4.7	137.1	20.6	11.9	32.5	7.6	
28.	133.6	132.8	1.7	134.4	20.9	18.6	39.6	14.4	
29.	133.7	133.6	-3.7	148.9	21.0	19.0	40.0	16.5	
30.	133.8	133.7	5.2	133.5	22.7	10.3	33.0	21.0	
31.	134.3	133.8	3.2	137.3	21.9	15.1	37.0	17.7	
32.	129.3	134.3	-3.8	153.9	16.6	15.0	31.6	21.1	
33.	124.8	129.3	0.3	139.7	17.2	15.7	32.9	22.6	
34.	121.7	124.8	7.2	150.8	20.5	13.4	33.9	28.3	
35.	128.2	121.7	11.7	148.7	21.7	13.8	35.5	22.5	
36.	127.8	128.2	-9.8	149.4	20.9	12.1	33.0	13.9	
37.	143.6	127.8	8.6	136.6	28.1	14.4	42.5	31.1	
38.	147.1	143.6	-1.5	158.9	28.3	14.9	43.2	22.1	
39.	148.2	147.1	-3.0	149.7	26.9	13.0	39.9	15.9	
40.	150.0	148.2	1.9	161.4	25.0	13.4	38.4	19.1	
41.	152.6	150.0	0.3	161.4	22.0	13.6	35.5	25.0	
42.	149.4	152.6	11.0	159.4	23.3	13.4	36.7	26.7	
43.	145.5	149.4	-5.7	166.2	19.4	11.0	30.3	20.7	
44.	151.5	145.5	4.5	163.2	20.9	11.8	32.6	25.6	
45.	144.1	151.5	1.1	165.6	20.8	11.8	32.6	19.4	
46.	139.0	144.1	8.8	177.4	19.3	15.1	34.4	34.3	

Table B-2. The Cost of the Reserve Stock.

M_t	$I_t - Y_0$	S_t	$\log X_t$	t
221.2	25.1	95.5	2.3487	1.
228.0	44.0	94.3	2.3485	2.
236.3	69.8	105.3	2.3530	3.
287.4	106.4	90.7	2.3856	4.
298.1	146.7	108.6	2.4053	5.
352.4	182.6	122.9	2.4208	6.
378.7	235.7	130.5	2.4789	7.
440.8	296.6	158.5	2.4790	8.
503.4	366.2	169.3	2.4986	9.
515.2	457.3	196.9	2.5219	10.
632.0	521.5	163.8	2.5074	11.

Appendix C. Alternative Equations for Estimating the Variance of Precautionary Reserves.

The variance of precautionary reserves was estimated from a number of equations in which the combination of explanatory variables was rather different from that of the equation in Chapter Six. A comparison between that equation and some alternatives was suggested by the fact that the results of our estimation in Chapter Six were not wholly satisfactory. The results presented below are derived from simple models, one based on non-monetary income determinants and the other in the 'monetary' tradition associated with the International Monetary Fund and the name of J.J.Polak in particular¹. We have also used a statistical description of reserves along the lines developed by Archibald and Richmond². Estimates based on these equations, together with the equation in Chapter Six (and some variants of these equations) constitute the first set of results, presented in Table C-1.

The results of the estimates in this first set suggested tests to determine the explanatory power of particular variables which are significant throughout. We therefore tried equations which contained only significant variables and other which did not include the lagged dependent variable (Table C-2). The third test set of results were derived from equations which included one-period lags (Table C-3).

¹ See J.J.Polak, 'Monetary Analysis of Income Formation and Payments Problems', International Monetary Fund Staff Papers, v.6 (1957-58), p.1.

² See Chapter Three, p. 69.

The non-monetary model is derived from a conventional set of equations:

$$C-1. \quad Y = C + I + G + X - M;$$

$$C-2. \quad C = C(Y);$$

$$C-3. \quad M = M(Y);$$

and from one unusual equation which reflects the fact that investment (I) in Caribbean economics is determined, not so much by considerations of marginal efficiency, the interest rate and the demand for liquidity, but rather by the available capital inflow (K) and the absorptive capacity of the country. This gives an equation such as

$$C-4. \quad I = I_1(K) + I_2(Y),$$

where income (Y) is used to represent absorptive capacity. The other symbols are familiar: C stands for consumption; G, government expenditure; X, exports; and M, imports.

From this equation system we can deduce imports in terms of X, K and G. Using

$$C-5. \quad R = X - M + K$$

we get a relationship for reserves which may be written as

$$C-6. \quad R = R(X, K, G).$$

The results of this estimate appear as Equation Three of Table C-1.

A simple version of the Polak model which was devised for testing on the Jamaican economy¹ can be written as follows:

¹ Leroy Taylor, 'Money, the Balance of Payments and Income Determination in Jamaica', Social and Economic Studies, June 1972.

$$C-7. \quad Y = vMS$$

$$C-8. \quad M = M(Y)$$

$$C-9. \quad MS = MS_{t-1} + \Delta CR + \Delta R,$$

where MS is the money supply and CR the increase in domestic credit.

Using C-5 we get

$$C-10. \quad R = R^1(X, K, (MS_{t-1} + \Delta CR))$$

This is Equation Four of Table C-1.

The other equations of Table C-1 are as follows:

1. The equation of Chapter Six.
2. The same equation using money supply levels rather than money supply changes.
5. Equation Four, replacing money supply levels with changes.
6. The Archibald-Richmond equation.

Equation One has been analysed in Chapter Six. Equation Two yields a marginal improvement in the already high explanatory power (as measured by R^2). Also the money supply levels have significant coefficients (at the 5% level of t) with the expected sign, whereas money supply changes (Eqn.1) are insignificant with the wrong sign.

If we drop the money supply altogether from Equation One, the results are virtually unchanged (Eqn.3). Nor does Equation One suffer much from the omission of G , which has the wrong sign throughout the estimation and is usually significant, if at all, only at the less stringent 5% and 10% levels. Equations Four and Five, without G , retain an R^2 around 95%. As with Equations One and Two, money supply levels do rather better than changes, with the former significant, however, only at the 10% level. The coefficient of X is always significant and varies little from one equation to another.

Table C-1.

Estimates of Reserve Variance Based on Alternative Formulations of the Explanatory Equation.

Eqn. No.	Intercept (\$m.)	Explanatory Variables							$\bar{R}^2$ (%)
		t	R_{t-1}	ΔMS_t	$MS_{t-1} + \Delta CR_t$	X_t	K_t	G_t	
1.	12.51 (2.53)		0.72 (12.93)	0.01 (0.04)		0.79 (3.17)	0.36 (1.50)	0.20 (1.41)	94.8 4.49
2.	16.54 (3.23)		0.83 (11.75)		-0.13 (-2.25)	0.75 (3.21)	0.36 (1.60)	0.30 (2.41)	95.3 4.23
3.	12.52 (2.57)		0.72 (13.39)			0.79 (3.22)	0.36 (1.55)	0.21 (1.68)	94.9 4.43
4.	14.61 (2.82)		0.81 (10.98)		-0.09 (-1.46)	0.81 (3.31)	0.48 (2.06)		94.8 4.47
5.	11.98 (2.40)		0.74 (13.79)	0.11 (0.88)		0.80 (3.21)	0.45 (1.90)		94.6 4.54
6.	22.31 (2.85)	0.24 (1.72)	0.77 (8.49)						92.7 5.30

Notes: 1. For each explanatory variable the estimate of its coefficient is given, together with the associated t - ratio (in brackets).

2. The critical values of t (for 40 degrees of freedom) are: 1.303 (10%); 1.684 (5%) and 2.423 (1%).

The coefficient of K is significant only at the 10% level, except when G is excluded, but even then its significance level does not improve beyond 5% (Eqns. 4 and 5). For these equations the K coefficient is substantially different from its value in the first three equations.

Equation Six, which neglects the economic variables, retains explanatory power not much lower than the high levels of the first five equations. The variable which bears the burden of the explanation is clearly R_{t-1} . The fact that economic variables do not improve the explanation very much suggests that there has been a stable pattern of reserve growth with few disturbances. The result should not distress us in view of the high levels of significance obtained. However, we must discount the possibility that the explanation is purely statistical. To do this, we exclude R_{t-1} to obtain the results of Equations Seven and Eight. Although R^2 is now considerably lower, its values are still in a very acceptable range. We have significant coefficients for X and K , but money supply changes remain insignificant and money supply levels have the wrong sign, as does G . What these equations demonstrate is that the economic variables are not to be neglected. Should their values become highly volatile, Equations One to Five would yield results more obviously superior to those of Equation Six.

Equations One to Nine assume instantaneous reaction to disturbances in the explanatory variables. For a period of analysis as short as one month, this seems a little unrealistic, since the full effects of any current economic activity should hardly have exhausted themselves within the month. What is usually assumed,

though, is that the largest impact takes place in the current period, with diminishing effects as we move further into the past. In other words, the coefficients of the explanatory variables are inversely proportional to the length of the lags and eventually become insignificant. In view of this, we begin with one-period lags. The results, presented in Table C-3, suggest that the assumption of instantaneous adjustment does little violence to the facts. The only lagged exogenous variable significant at the 1% level of t is X in Equation Eleven. It appears that if we drop R_{t-1} as an explanatory variable, X_{t-1} acts in part as a proxy for that variable. Apart from this, the lagged variables are of little interest.

The equation in the text is retained mainly because it has the strongest a priori justification. Its explanatory power is not inferior to the alternatives we have tried, and, except for the equations where R_{t-1} is excluded, the estimate of the variance of reserves (needed for determining the reserve optimum) is not significantly altered by re-specifying the equation in the ways we have attempted. The empirical results suggest that our equation, though in need of further development, is neither spurious nor perverse.

Tables C-2 and C-3. Modifications of the Estimating Equations.

Table C-2. Modification of Equations One and Two of Table C-1.

Eqn. No.	Intercept (\$m.)	Explanatory Variables						$\bar{R}^2(\%)$ S.E. (\$m.)
		R_{t-1}	MS_t	$MS_{t-1} + \Delta CR_t$	X_t	K_t	G_t	
7.	55.49 (6.75)		-0.41 (-1.24)		1.75 (3.25)	1.82 (3.80)	0.75 (2.41)	73.5 (10.1)
8.	28.98 (2.86)			0.35 (3.83)	1.47 (3.12)	1.34 (3.06)	0.19 (0.73)	79.7 8.82
9.	6.53 (1.57)	0.80 (17.86)			0.98 (4.01)			94.3 4.67

Table C-3. Lagged Explanatory Variables

Eqn. No.	Intercept (\$m.)	Explanatory Variables									$\bar{R}^2(\%)$ S.E. (\$m.)
		R_{t-1}	MS_t	MS_{t-1}	X_t	X_{t-1}	K_t	K_{t-1}	G_t	G_{t-1}	
10.	10.74 (1.89)	0.73 (9.45)	0.03 (0.19)	-0.21 (-1.09)	0.39 (1.36)	0.42 (1.23)	0.48 (1.62)	-0.22 (-0.79)	0.15 (0.91)	0.12 (0.62)	94.3 4.58
11.	46.28		0.30 (1.00)	- (-0.01)	0.64 (1.23)	1.72 (2.96)	1.19 (2.22)	0.40 (0.77)	0.39 (1.29)	0.33 (0.97)	80.3 8.51
12.	10.04 (1.79)	0.76 (10.17)	0.12 (0.81)	-0.16 (-1.02)	0.46 (1.64)	0.37 (1.10)	0.56 (1.93)	-0.19 (-0.65)			94.3 4.59
13.	10.24 (1.82)	0.73 (9.63)			0.46 (1.69)	0.39 (1.18)	0.53 (1.79)	-0.25 (-0.89)	0.25 (1.87)	-0.02 (-0.14)	94.4 4.56