

ABSTRACT

Some Problems of Exchange-Rate Policy and Stabilization in an Open Economy

M.M. Courtney

St John's College

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The immediate objectives of exchange-rate policy should be stability of output, stability of the rate of inflation and stability of the exchange rate itself. Moreover, exchange-rate policy is likely to be of some use in achieving these aims, as the modifications to the rational expectations theory which make monetary policy effective do so for exchange-rate policy as well, and additional channels of effectiveness operate in an open economy.

There are various explanations for the volatility of exchange rates under free floating, but a more realistic picture of the reaction to external disturbances is obtained if step changes in interest rates are allowed for by considering the term structure of interest rates and the influence of the terms of trade on the demand for money.

Capital is not in fact perfectly mobile internationally, which widens the range of policy options, and some modifications of the theory are required to study the determinants of capital flows in an imperfect world.

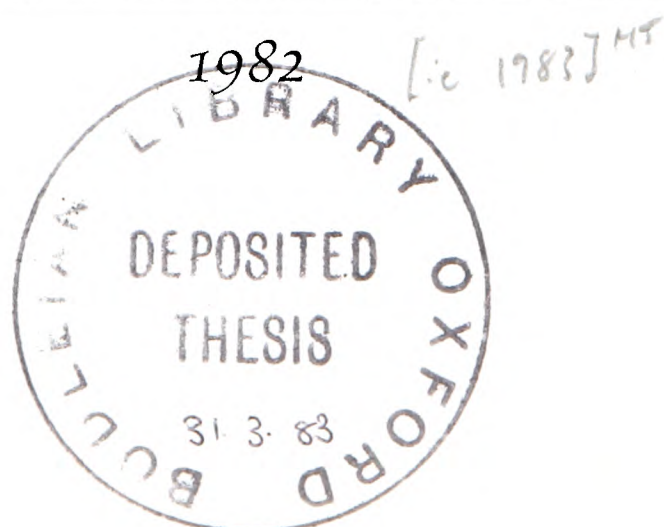
One can use the correlation between deviations of output and inflation from trend to study the origin of disturbances. This is illustrated by a study of eighteen sub-Saharan African countries. Furthermore, the type and origin of disturbances have implications for whether some sort of dual exchange-rate or dual interest-rate system is desirable.

Finally, a model of an open economy is presented in which exchange-rate policy can be analyzed whether specified in terms of exchange-rate targets or the degree of intervention, and with the possibility of a restricted forward foreign-exchange market. A variant of the model is estimated for South Africa for the period 1974-1981 and various exchange-rate policies are simulated.

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M. M. COURTNEY

OXFORD



PREFACE AND ACKNOWLEDGEMENTS

This thesis is in part an extension of the topic of my 1973 University of Oxford B.Phil. thesis, which was entitled "International Capital Movements and the Exchange Rate Regime". Apart from Ch. 3 section (iv), I have been at pains not to cover the same ground again, but in three places reference is made to relevant parts of the earlier work. The changing focus of ideas in this area is evident in the titles : from preoccupation with a once and for all choice of the optimum currency area or degree of exchange-rate flexibility, to an investigation of how to make the best of managed floating.

A slightly altered version of Part Two of Chapter One has already been published under the title "The Effectiveness of Exchange-Rate Policy under Rational Expectations", in *Studies in Economics and Econometrics*, No. 11, July 1981, pp. 54-66.

I would like to express my thanks to Peter Oppenheimer for his supervision of the thesis, both for his detailed advice on a number of points and for helping me to see the broader perspectives to which my arguments were leading. I would also like to thank Professor Amartya Sen for his comments on section (xi) of Chapter One; Brian Dollery for suggesting a consideration of market structure in section (ix) of Chapter One; Philip Black for some stylistic suggestions in Chapter Two; and Professor Victor Argy for his encouraging reception of some earlier, crude estimates, which emboldened me to undertake the simulations presented in Chapter Five, Part Two. Needless to say, they are all absolved from any responsibility for remaining errors or the use or misuse I have made of their advice.

A preface of this kind is also a suitable place to record the debt I owe to my former teachers : to Martin Brett, who first showed me the value of the academic life; to Professor Edward Tower, who stimulated my interest in international monetary economics; and to Professor Max Corden, who demonstrated, against some current practice, that the most lucid economics is usually also the best.

I would also like to record my appreciation of the thoroughly professional typing of the manuscript by Mrs H. Wells, and of the notable generosity of the Institute for International Economic Studies of the University of Stockholm in the provision of their research publications.

Finally, I would like to express my indebtedness to my late uncle, Fr. Francis Courtney, S.J., and to the Hon. Mr Justice George Wynne, who separately persuaded me to cast my research in this form. To them this thesis is dedicated.

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CHAPTER ONE
MACRO-ECONOMIC STABILITY AND THE OBJECTIVES
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(i)

This thesis sets out to assess the scope and applicability of exchange-rate policy in general and the contribution that it can make to macro-economic stability in particular. Several recent developments have made a reassessment of this area appropriate. There has been a marked acceleration of inflation in the past decade and a large increase in the volume of private and official international capital movements, and, perhaps not unconnected with these changes, the widespread floating of the world's major currencies. In the realm of ideas, economists since the 1960's have frequently assumed that flexible exchange-rates are best,¹ and this view has achieved much more general acceptance, notwithstanding recent experiences and the definite if partial revolt against free floating by central bankers since 1978. More widely, there has been disillusionment with activist macro-economic policy in general, connected theoretically with the monetarist and rational-expectations views and empirically with the persistence of stagflation. In these circumstances a careful analysis of the contribution which exchange-rate management can make to a desirable stabilisation of the economic climate is likely to be of some interest.

To start with, section (ii) of this chapter defines what is meant by exchange-rate policy. The remainder of the first part of the chapter deals with the objectives of macro-economic policy as a whole and

1. e.g. Samuel Brittan, "The Price of Economic Freedom, A Guide to Flexible Rates", London, Macmillan, 1970.

especially with those aspects of the economy which exchange-rate policy can hope to influence and which should appropriately be its immediate targets. The second part of the chapter, accepting that there are some objectives which it might be desirable to achieve by means of exchange-rate policy, assesses the minimum conditions necessary for exchange-rate policy to have any effect on them, in the light of the recent "ineffectiveness of monetary policy" debate.

(ii)

I define exchange-rate policy as the rule or set of rules that a country uses for determining its exchange rate. These can take the form of any of the familiar range, from leaving the rate to be determined freely in the foreign exchange market, through having a target range based on past price or balance of payments experience, to adopting a rate rigidly fixed to another currency or basket of currencies. This definition takes less for granted about the working of the economy than the alternative of defining exchange-rate policy as the time pattern of exchange rates desired by the authorities. (It is rather as if one were defining tax policy as the set of rules or rates under which tax is collected rather than as the amounts of tax which the government desires to collect in each of the time periods in question.)

The advantage of this procedure is that it enables one to distinguish those rules or aspects of policy which are particularly directed towards altering the exchange rate from those policies which have a merely incidental affect on the exchange rate, perhaps altering the variables which are arguments in the exchange rate rule. One could, therefore, conduct a completely *ceteris paribus* study, investigating how the economy would perform with different exchange rate rules with all other policies being constant. In some cases such a *ceteris paribus* assumption is

appropriate and will be used. But it is often interesting to see how other policies should best be co-ordinated with any given exchange rate rule so that the best overall impact is made both on the time pattern of exchange rates and on other economic variables. One can then judge the desirability of the rule in question according to its impact on one's chosen criteria of economic welfare when all other policy measures have been adjusted in harmony with it.

(iii)

At a very abstract level one would like to be able to judge any economic policy according to its impact, when all its ramifications have been allowed for, on one's ultimate economic objectives. At the most general level these might be defined as efficiency and equity, or one might consider the conventional goals of full employment, price stability and growth. In practice, most economic policies are not aimed directly at these final ends but at narrower and more immediate objectives, through which are transmitted their effects on economic welfare. And it is according to their success in attaining these proximate ends that they are judged.

In the case of the exchange rate it is true that at any moment of time the level of the exchange rate (and its expected level in the future) is likely to exert an influence on the level of output and the price level. However, provided other macro-economic policies are unchanged, the form of the exchange rate rule is unlikely to have much direct influence on the average level or trend of the exchange rate over time, but rather will affect the time pattern of the exchange rate about the trend. The extent and type of fluctuations about the trend might in their turn influence the level of the exchange rate if, for example, violent fluctuations in the exchange rate alter political resolve or if a reduction

in the public's money illusion as a result of exchange-rate instability induces the authorities to alter their policy stance: but this would represent only an indirect effect of the exchange-rate rule on the trend of the exchange rate via its effect on stability about the trend. Consequently, in the first instance the success of the exchange-rate rules can best be judged in terms of their effect not on the levels but on the stability of output, the stability of the rate of inflation and the stability of the exchange rate itself.¹

This choice of the objectives for exchange-rate policy can be justified in two ways. Firstly, the objectives can be shown to be desirable in themselves; secondly, securing these immediate objectives can be shown as leading to the attainment of the conventional final ends of economic policy and as being the main channel through which exchange-rate policy influences these final ends.

(iv)

Let us consider first the stability of output. There are two ways in which a level of output which fluctuates about its trend brings disadvantages. Firstly, there are problems which arise because a fluctuating level of output is more difficult to predict than one which fluctuates less; secondly, there are the channels through which a more fluctuating level of output imposes disutility even when forecasts of output are no less accurate.

Given that in practice it is hard to disentangle a trend from fluctuations about the trend, a more variable level of output will make it more difficult for firms to predict future levels of aggregate demand.

1. By the stability of a variable we refer to the amplitude, length and regularity of its fluctuations about a trend.

This may lead to incorrect decisions about the short term level of production; more significantly, it may lead to inappropriate investment decisions with a consequent waste of productive resources. There is, of course, the contrary opinion, that from the point of view of the individual firm all that matters are predictions about the prices of its own outputs and inputs and that it need not concern itself with aggregate demand. However, many firms are not perfectly competitive and expectations about the level of demand are relevant to their level of output; and for all firms in a world of uncertainty, knowledge of what is happening to aggregate demand is of use to them in distinguishing the degree to which particular price changes are in fact relative price changes or part of a general movement of prices.¹ In addition there will be difficulties for government policy, especially in adjusting the future money supply and credit conditions to future levels of output. To the extent that incorrect predictions are made by the government, there will be greater uncertainty about the future price level, which again will make it more difficult for firms to plan correct output levels.

(v)

But even if the future levels of output are as accurately predicted when there are greater fluctuations as when there are lesser, there will be disadvantages. Fluctuations in output entail fluctuations in the use of resources; and it is probable that for the same average level of output there will be a greater average use of resources, so that they are

1. A similar point is made in "International Trade 1978/79", by the General Agreement on Tariffs and Trade, Geneva, 1979, where the decreased information conveyed by observed relative prices in periods of high inflation and the consequent lack of coordination of economic activity are identified as the major cost of inflation and a notable cause of stagflation.

being used less efficiently. To see this, consider the case where there is an input which cannot be costlessly and continuously varied in amount; the fluctuating level of output must then be achieved by altering more than proportionately to this relatively fixed factor the amounts of the variable factors employed. If there is diminishing marginal productivity of the variable factors, then increases of output above trend require more of these factors than are released by equal decreases of output below trend, so that the average requirement of the variable factors rises, even though the average level of output remains constant. To some extent this loss might be mitigated by keeping the amount of the relatively fixed factors slightly above what their level would be if output were constant, but that simply entails trading off lower productivity of one factor for lower productivity of another.

A similar situation arises even if all factors are continuously and costlessly (but not instantaneously) variable, if there is any asymmetry in the costs of having factors below or above the optimum level (so that producers prefer, on average, say, to have unused capacity rather than be unable to meet demand) and if there is uncertainty about the timing of the fluctuations of output (the variance of output about its mean might be the same say, as when output fluctuates less, but the third moment might be higher, reflecting a greater possibility of extreme peaks and troughs). Here again, there will be a higher average factor requirement, since there will be a desire to have factors available so that the firm can more nearly meet peak demand when it occurs.

To some extent, government services will also suffer from reduced productivity. Many pure government services, as distinct from state-owned industries, need not respond to the business cycle, but there are some, such as the social security services and those dealing with the unemployed, which do. To the extent that resources cannot be shifted

costlessly from one employment to another, and to the extent that peaks and troughs for these services cannot be perfectly predicted, this fluctuation in the administrative workload will impose a cost in resources.

(vi)

So much for what might be called the production losses associated with a fluctuating level of output. There are likely to be losses on the consumption side too. Leaving aside the ownership of foreign assets, a country's real income fluctuates with its level of output. This need not give rise to fluctuations in consumption provided that these fluctuations in income are perfectly foreseen, or foreseen as well when there are greater as when there are lesser fluctuations, and provided that either all types of consumables can be costlessly stored or else at least some consumables can be costlessly stored and production can be costlessly switched from one type of consumable to another. Failing this, there will be greater fluctuations in consumption, and, given a constant average level of aggregate consumption and assuming diminishing marginal utility of consumption, this will result in lower utility from consumption. (This assumes no change in the distribution of average consumption, and also that greater fluctuations in aggregate consumption do not lead to smaller fluctuations in the consumption of a sub-group to whose welfare one attaches extraordinary importance.)

Whatever may be society's success in smoothing out consumption over time, there will be one good whose consumption is bound to fluctuate when output fluctuates, namely leisure. When the change in labour employed takes the form of changes in the hours worked, such as by variations in overtime, fluctuations in leisure about the same average weekly level are likely to lead to a loss of utility according

to the diminishing marginal utility of leisure. When the change in labour employed takes the form of changes in the number employed, judgments about a welfare loss depend on interpersonal comparisons of the utility or disutility of the leisure that comes from unemployment. But it seems plausible to assume that those who are hired only when unemployment is very low derive less utility from working and more from leisure than do those who are in work except when unemployment is very high.

It is true that fluctuations in the utility derived from leisure (unless one rates the leisure that comes from unemployment as a negative good) will in general offset fluctuations in the utility derived from consuming produced goods, but it is unlikely that substitutability between the two is so great, or their coincidence for individual families sufficiently close, to overturn the general presumption that greater fluctuations in output, even about the same average level, will lead to lower utility from consumption.

(vii)

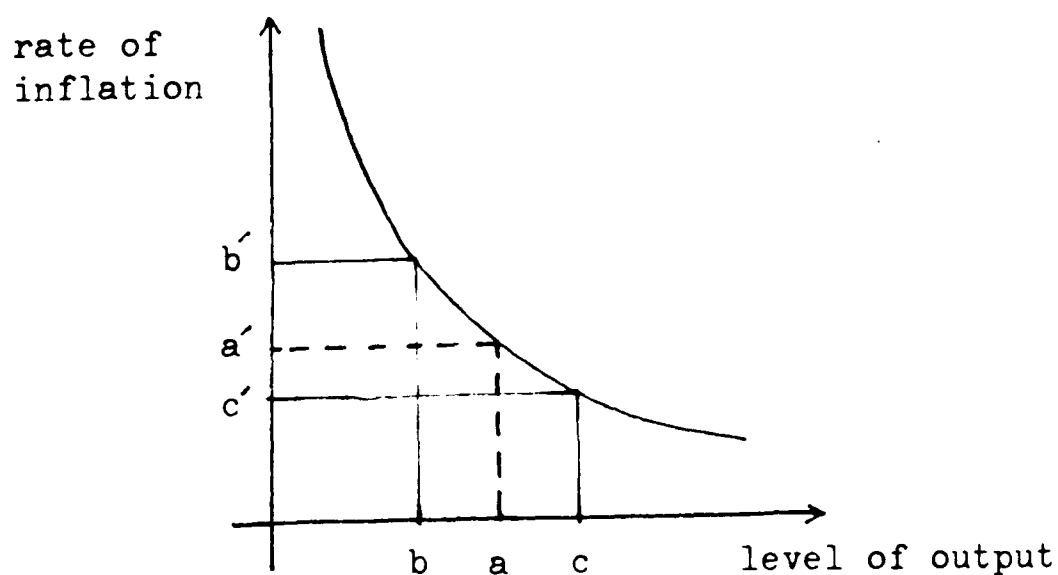
We now have to consider what has sometimes been seen as a major economic cost of fluctuations in output, namely that they lead to a higher average rate of inflation.

There is a distinction to be made here between two lines of argument. The first is that greater variability of output leads directly to a higher average rate of inflation because of the non-linear nature of the static Phillips curve trade-off between the level of output and the rate of inflation. The second line of argument is that a greater variability of output leads to a greater variability of the rate of inflation and that this in turn leads to a higher average rate of inflation (because, for example, it leads to a more rapid shifting up-

ward of the Phillips curve). This second line of argument, exploring the links between the variability of output and the variability of the rate of inflation, is an interesting one which will be examined briefly in the next section and in more detail in the body of the thesis.

But since we have chosen stability of the rate of inflation as one of our objectives, this cannot be an independent argument in favour of stability of the level of output: rather it explores the link between two of the objectives we have chosen and the extent to which attaining one will help or hinder the achievement of the other.

But if there is a direct link between the variability of output and the average level of the inflation rate, and if a high rate of inflation is undesirable, then this does constitute another reason for wanting a low variability of output. Such a link will exist if there is a static short-run Phillips curve which is concave outwards (as the majority of estimated Phillips curves seem to be), so that a given decrease in the level of output leads to a small decline in the rate of inflation compared to the rise in the rate of inflation that is brought about by a comparable increase in the level of output.



In terms of the diagram above, a symmetrical distribution of the level of output between b and c leads to an average rate of inflation above a', the rate which would result if output were stable at its

average level, a .

(viii)

In general, any disturbances in the economy will move both output and prices away from their trend level, so that in the absence of any stabilisation policy, a higher variability of output is associated with a higher variability of the rate of inflation. But from a policy point of view, the nature of the link between the two must be more closely specified. It may be that policies which reduce the variability of output will increase the variability of prices, or the two might be improved simultaneously.

One approach¹ is to consider whether deviations from the trend levels of output and prices are caused predominantly by disturbances on the supply side or the demand side of the economy. In the case of a disturbance on the supply side, one would expect an increase in output above trend to be associated with a decrease in the rate of inflation, as the price level dips below its trend to equilibrate the goods market. However, if demand disturbances predominate, one would expect a positive correlation between the deviations from trend in output and prices, since a temporary increase in demand would elicit both output and price increases, while a decrease in demand would tend to depress both output and prices.

Ideally, any stabilisation policy would meet disturbances in supply with offsetting changes in supply, and perturbations in demand with countervailing changes in demand. Very often, however, the only policies available are ones which act on the level of aggregate demand. If aggregate demand is varied so as to offset exogenous changes in supply

1. c.f. John B. Taylor, "Output and Price Stability", Journal of Economic Dynamics and Control, vol. 2, 1980, pp.109-132.

and thus stabilise output, then the deviations in price will tend to increase. For example, if supply is below trend and aggregate demand is increased in order to stimulate output to nearer the trend level, this will reinforce the upward pressure on prices resulting from the original deficiency in aggregate supply. On the other hand, if aggregate demand is decreased to match the exogenous drop in aggregate supply, with the aim of stabilising prices, then the initial decrease in output will be reinforced. In such circumstances there exists a policy trade-off between the stability of output and the stability of the inflation rate. If, on the contrary, demand disturbances predominate, aggregate demand policies which increase the stability of output should improve price stability, too.¹

Exchange rate changes operate through changes in aggregate demand (for tradeables) rather than through changing aggregate supply directly, so that the distinction between disturbances to demand and to supply is quite important and in fact includes the better known distinction between external and internal disturbances. So far as the home country is concerned, any external disturbances are demand disturbances (i.e. do not affect domestic supply directly) and exchange-rate changes in reaction to them under a freely-floating exchange rate system will move both output and prices in the same, and most likely a stabilising, direction.²

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1. John B. Taylor, op.cit., finds that for eight out of ten industrial countries during the period 1954-1976 there was a negative correlation between deviations of output and prices from their trend levels, implying a predominance of supply shocks. This is contrary to what has often been supposed.
 2. This assumes that a drop in the demand for a country's exports, for example, which under a fixed exchange rate would lead to a lower price and/or a lower output, will cause a depreciation of the domestic currency under a freely-floating exchange rate, tending to increase both domestic prices and output again, and thus counteracting the effects of the initial disturbance. This does not rule out the possibility of the exchange rate overshooting or of unfavourable speculation moving the exchange rate in the wrong direction.

Demand disturbances can also arise from fluctuations in domestic aggregate demand and, again, exchange rate changes will move output and prices together (most likely in a destabilizing direction). In the case of a supply disturbance we might have a lowering of output and a consequent tendency for prices to rise - as the result, for example of an industrial dispute in an export industry - and a depreciation would tend to increase output back towards the trend level, but would raise prices even further beyond their trend.

Of course, exchange rate changes, besides affecting prices through altering aggregate demand, have direct price effects on tradeable goods as well. These effects go in the same direction, since a depreciation increases aggregate demand at the same time as it gives rise to an increase in the domestic price of tradeables, and an appreciation decreases aggregate demand for domestically-produced goods while it decreases the price of tradeables.

However, in looking only at the direct price effects of exchange rate changes, there may be a danger of neglecting the cause of these changes. Thus R.I. McKinnon¹ maintains that it is precisely in the cases where a flexible exchange rate would stabilise output that it would destabilise prices. His chief reason is that the sort of economy where a flexible rate would stabilise output would be a very open one, where most disturbances would be external and export production would dominate the generation of national income. But in an economy of this type a flexible rate would peg the prices of non-tradeable goods in domestic currency and allow the prices of tradeable goods to vary in proportion to the exchange-rate changes. Since the latter goods make up a large

1. R.I. McKinnon, "Optimum Currency Areas", American Economic Review, 1963, p.722.

proportion of output and consumption, the overall price level would also fluctuate considerably.

McKinnon's argument depends, however, on rather special assumptions concerning the nature of the disturbance. More usually, if, for example, a depreciation stabilises output by counteracting a drop in foreign demand, the resultant increase in prices (from direct "law of one price" effects and also as a result of greater aggregate demand) will tend to offset the lower price level likely to have resulted from the initial decrease in foreign demand. Of course the depreciation may over-compensate, so that prices for the period in question actually lie above their trend level. That possibility depends among other things on the various price elasticities involved,¹ but at least the initial movement is in a stabilising direction for both prices and output.

(ix)

So far we have considered only the possible advantages of a more stable level of output. But it can be argued that some measure of instability will be beneficial, because it might increase investment, or stimulate innovation, or improve competition, or lead people to derive greater utility from given amounts of material and non-material goods.

Alisdair MacBean² has suggested that greater instability of income might lead to a higher level of investment. He reverses the capacity argument, which was put forward above to show that there would be a less efficient use of factors of production if output fluctuated more.

1. c.f. M.M. Courtney, "International Capital Movements and the Exchange Rate Regime", University of Oxford B.Phil Thesis, 1973, pp.50-53.

2. Alisdair MacBean, "Export Instability and Economic Development", London, George Allen & Unwin, 1966.

Since a fluctuating level of output is in any case less certain, and even if certain implies a higher peak level of output, firms might install capacity to meet peak demand, thus maintaining a higher level of investment. Hence the proportion of national income invested would be higher and growth would therefore be faster. Furthermore, if the level of savings is a constraint on growth, then this constraint is likely to be eased as well: because income is less certain, precautionary saving will be higher. Professor MacBean cites evidence from Chile consistent with this argument.¹ There may be some truth in this chain of reasoning, but it does imply some inefficiencies in the economy: that the level of investment and hence the rate of growth that would be chosen under certainty or with a higher average use of capacity is somehow not the socially desirable rate of growth. That may or may not be the case, but increasing the rate of growth by causing or allowing a more unstable level of output can be only a second-best procedure.

There is a long established argument that stability, if too complete, will lead to stagnation and decay. "Unless and until society acquires a complete technical control over the explosive forces of industrial progress, it may well be that the ultimate interest even of the wage-earning class as a whole is best served by a measure of industrial instability."² The reason lies partly in the fact that there will always be changes in real operating costs, or the desire for various goods, which should appropriately be met by variations in output; but more important is the fact that industrial progress comes in discrete

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1. A. MacBean, "Export Instability and Economic Development", p.182, referring to Clark W. Reynolds, "Development Problems of an Export Economy", Ph.D. thesis, University of California, Berkeley, 1962.
 2. D.H. Robertson, "Banking Policy and the Price Level", London, P.S. King, third impression 1932, p.22.

steps. In Joseph Schumpeter's words, "the recurring periods of prosperity of the cyclical movement are the form progress takes in capitalistic society."¹ By its nature this is a difficult argument to confirm or to refute. That cyclical movements should follow particular inventions is no very strong reason for tolerating fluctuations in output but if innovations only take place as a result of the confidence engendered by a boom or the hungry inventiveness of a slump, then it might well be shortsighted to eliminate boom and slump. Nevertheless, even those who argue for some measure of instability recognise that any benefits in faster economic progress must be weighed against the disadvantages in efficiency and equity associated with instability, and that in any case the usual fluctuations in economic activity probably exceed those necessary to prevent a stagnation of inventiveness.² In any case, it is not too optimistic to suppose that some economically less expensive way might be found to encourage innovation other than periodic booms and slumps.

Greater fluctuations in output might also have an influence on market structure. There are two conflicting arguments: on the one hand, greater instability and, particularly, periodic recessions are likely to make price collusion and various forms of market leadership more difficult.³ On the other hand, smaller firms with less well-established banking connexions and more restricted access to financial markets are

1. Joseph Schumpeter, "The Explanation of the Business Cycle", *Economica*, December 1927, (vol. 7), pp.286-311.

2. D.H. Robertson, "Banking Policy and the Price Level", p.34.
 "...the actual fluctuations in industrial output tend greatly to exceed the rational or appropriate fluctuations hitherto examined."

3. F.M. Scherer, "Industrial Market Structure and Economic Performance", 2nd edn., Rand McNally, Chicago, 1980, p.227.

more likely than larger firms to fail in recessions or be driven into mergers, thus increasing industry concentration. On balance one might suppose that with greater output fluctuations, industry will become more concentrated but make less use of this greater market power than it would have in more stable circumstances.

If output instability did lead to increased competition this might in itself represent a self-stabilising feature of the economy, since such empirical evidence as exists seems to show that less concentrated industries have more flexible prices and a more stable level of employment. But because it applies across industries, it does not necessarily follow that for the economy as a whole, lowered concentration would lead to greater price flexibility and a faster recovery from recessions or a faster end to booms; and in any case the statistical evidence for a link from lower concentration to more stable output is very weak at best.¹ And the basic premise - that output instability lessens industry concentration - is not even weakly established, so that a concern with market structure does not seem to provide any strong argument against trying to stabilise the level of output.

There is, finally, a consumer² argument that fluctuations in output and consumption, even though they might lead to lowered utility with given tastes, actually improve people's welfare because they change their (cardinal) utility functions. Deprivation makes people appreciate more both the material goods of which they have been temporarily deprived and the non-material goods which they retain. Therefore, over the whole cycle of deprivation and abundance, the same total consumption of

1. Ibid., p.367.

2. I am grateful to M.R.N. Wetmore for suggesting this argument to me.

material and non-material goods affords them a higher utility if the cycle fluctuates widely than they would derive if their consumption was more stable. This takes us rather far from rational economic man who would presumably be arranging for an optimal fluctuation of deprivation and abundance in his own consumption; or if only involuntary fluctuations will do the job, arranging for the right degree of risk in his income without necessitating inefficient fluctuations in society's aggregate output. Of course this would not work if collective rather than individual fluctuations are necessary, but casual observation does not suggest that most societies become less greedy or more appreciative of non-material goods as a result of passing through a slump. However that may be, I shall assume that policies which increase the stability of output about a trend increase economic welfare on that account.

(x)

Our second objective is stability of the rate of inflation. We might instead have specified stability of the aggregate price level; but, firstly, many of the benefits of an inflation rate stable at zero inflation will accrue if the inflation rate is stable at some other constant level; and, secondly, it is unlikely that the form of the exchange rate rule will have much effect on the average aggregate price level except in so far as a more or less stable rate of inflation leads to a higher or lower average rate of inflation.

Of course, there is no unique aggregate rate of inflation that can serve as the government's target, just as there is no unique price index. But given the amplitude of the variations that are usually observed around the trend inflation rate, actions which stabilise the rate of inflation measured with one aggregate price index (such as the G.D.P.

deflator) are likely to stabilise it if a different aggregate price index is used (say, the consumer price index).¹ The choice of a particular aggregate index will depend on the customs of a particular country (which index is referred to in wage negotiations for example) and perhaps even on the statistics available.

There are two types of reason why one might want stability of the rate of inflation: because such stability is desirable in itself for reasons of equity and justice, and because it has favourable effects on output. We shall consider the latter argument first.

We have already seen that the stability of prices and the stability of output are likely to be related. In particular, if disturbances arise on the demand side of the economy, then policies which increase the stability of prices are likely to increase the stability of output also, because of their effects on the excess aggregate demand for goods and

1. The most important divergence comes with the treatment of imported inflation. Should one stabilise only the inflation associated with domestic production, or should one consider the prices of all goods consumed, including imported goods? There seems to be a consensus that in the present circumstances one should leave imported inflation out of the index that is stabilised, since a deterioration of the terms of trade represents a real cost to the community, and a once-for-all rise in the price level is a good way to spread that burden over the community. In principle a deterioration of the terms of trade could be achieved equally well by a fall in export prices with import prices constant, or by some combination of an export price fall and an import price rise: the preference for excluding imported goods from the index to be stabilised rests therefore on particular features of the economy. In countries where there is widespread indexation of wages one wants them to be related to the price of domestically produced goods only, otherwise the real loss or real gain of a change in the terms of trade falls only on the sector of the economy whose rewards are not indexed. Also, if one has reason to think that prices are sticky downwards, so that price falls cause greater dislocations than price rises, and if one expects deterioration in the terms of trade to put more strain on social and institutional arrangements and thus be harder to adjust to than improvements, then one might prefer a system which accommodates a terms-of-trade deterioration by a rise in the price of imports to one which relies on a fall in the price of exports.

services. A particularly strong form of this argument emerges if one supposes that the only reason output can deviate from its trend level is the presence of "price surprises". This is the basis of the supply function developed by Lucas¹ and since used by many models in the monetarist tradition. Of course, though this makes price stability all the more desirable, many of the models employing the Lucas supply function conclude that no stabilising policy is possible, reaching this conclusion by assuming that there are no information asymmetries between producers and the authorities (including knowledge about the authorities' own policies), nor inventories, nor fixed investments, nor multi-period contracts.² But one need not go as far as accepting the Lucas supply

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1. R.E. Lucas, Jr., "Expectations and the Neutrality of Money", Journal of Economic Theory, Vol.4, April 1972, pp.103-24, and "Some International Evidence on Output - Inflation Trade-offs", American Economic Review, Vol.63, No.3, April 1973, pp.326-334. Lucas supposes the supply function in market z to have the form:

$$\log Y_t(z) - \log Y_{nt}(z) = \gamma \{ P_t(z) - E [P_t/I_t(z)] \} + \{ \log Y_{t-1}(z) - \log Y_{n,t-1}(z) \}$$

Where $Y_t(z)$ is output in market (z) in period t , $Y_{nt}(z)$ is trend output in market (z) in period t , $P_t(z)$ is the actual price in market (z) in period t , and $E [P_t/I_t(z)]$ is the mean current, general price level, as estimated on the basis of $I_t(z)$, the information available in market z at time t . λ represents the effects of last period's deviation from trend, and $|\lambda| < 1$. Averaging over markets, he derives the aggregate supply function as $\log Y_t - \log Y_{nt} = \gamma (P_t - \bar{P}_t) + \lambda (\log Y_{t-1} - \log Y_{n,t-1})$. Where Y_t is aggregate output in period t , Y_{nt} is trend aggregate output in period t , $\bar{P}_t$ is the mean of the distribution of P_t (depending in a known way on the past history of prices, demand shifts, and deviation of output from trend).

2. The "rational expectations" literature is extensive. For a statement of the rational expectations approach see T.J. Sargent and N. Wallace, "Rational Expectations and the Theory of Economic Policy", Journal of Monetary Economics, April 1976, pp.169-183 and B.T. McCallum and J.K. Whitaker, "The Effectiveness of Fiscal Feedback Rules and Automatic Stabilizers under Rational Expectations", Journal of

function and supposing that only price surprises matter, in order to believe that price surprises have some effect on the deviation of output from its trend. And even acceptance of the Lucas supply function does not necessarily rule out monetary or fiscal policy being able to stabilise prices or make them more predictable. (The question of the effectiveness of macro-economic policy will be examined in more detail later. For the moment we are concerned only with its desirability.)

If price stability is a determinant of output stability, as I have argued above, it follows that economists who regard some output instability as a good thing may regard some price instability as necessary to achieve it. But in such a case price instability would be a necessary evil and not desirable in itself.¹

Granted that in some cases stability of the rate of inflation might be a means to our first objective, stability of output, this does not establish it as an independent objective. But it may be that there is some relationship between the rate of inflation and the level of output, such as predicted by the Phillips curve. In that case stability of the rate of inflation could have a direct effect on the level of output. As we have seen in the case of output, if the Phillips curve has the usual concave outwards shape, movements to and fro along it make for a worse trade-off between inflation and unemployment than results from stability at a chosen point on the curve: in the sense that for the

Monetary Economics, April 1979, pp.171-186. A critical summary is provided by W.H. Buiter, "The Macroeconomics of Dr Pangloss: A Critical Survey of the New Classical Macroeconomics", The Economic Journal, Vol.90, No.357, March 1980, pp.34-50.

1. Joseph Schumpeter, "The Explanation of the Business Cycle", *Economica*, Vol.7, Dec. 1927, p.307. "The cycle is not a simple 'evil', but maybe it does its work at very great costs. Perhaps stable prices would harm improvements but little, while reining in secondary, undesirable, phenomena."

same average level of output, greater instability of output leads to a higher average level of inflation; or, expressed the other way, for the same average rate of inflation, greater instability of the rate of inflation leads to a lower average level of output. (Conversely, if the trade-off were represented by a Phillips curve concave to the origin, instability of prices and output would improve the trade-off relative to any other chosen point of this Phillips curve other than a corner solution.)

There is a more dynamic sense in which greater instability of the rate of inflation might worsen the trade-off with output, namely that it would hasten any upward-shifting of the Phillips curve. We might suppose that the position of the next period's short-run Phillips curve depends on the inflationary experience this period. Specifically, if the amount by which the Phillips curve shifts upwards from this period to the next depends not on the average rate of inflation this period, but on the highest time rate of change of the aggregate price index experienced during this period, or at least on some weighted average of aggregate inflation rates within this period where the higher rates of inflation are given more prominence in people's expectations for next period, then a more unstable rate of aggregate inflation this period for any given average rate of inflation will lead to a faster movement upwards of the Phillips curve. A similar result occurs if one supposes that a more unstable aggregate price index gives rise to a wider dispersion of the rates of inflation of individual commodities and that the (temporarily) higher individual rates have a disproportionate effect on people's expectations and therefore on the next period's Phillips curve.¹

1. Robert E. Lucas, Jr., derives a similar result by supposing that when the aggregate rate of inflation has been relatively stable, producers interpret price surprises initially as relative price changes and hence there is a possible trade-off between inflation

(xi)

So far we have considered stability of the rate of inflation as being desirable only as an instrumental objective, to improve the output of the economy or lower the rate of inflation, but there are grounds on which it is desirable in itself. The chief reason is that a more stable rate of inflation will, in general, be a more predictable rate of inflation, and consequently one regarding which expectations are more nearly satisfied. If, as Henry Sidgwick maintains, "...Justice is generally, though somewhat vaguely held to prescribe the fulfilment of all such expectations (of services etc.) as arise naturally and normally out of the relations, voluntary or involuntary, in which we stand towards other human beings,"¹ then to achieve a more stable rate of inflation is, if not an act of justice by the State itself, at least the creation of a condition in which justice can more easily be practised by those who are subjects of the State.

The results of unanticipated inflation are well known. Quite apart from any effects on output, there are likely to be major effects on the distribution of income, in favour of debtors if the inflation exceeds expectations, or in favour of creditors if inflation is less than anticipated. This capricious redistribution is itself likely to strain the social fabric;² an additional strain arises from efforts to avoid it.

and output; but when the aggregate rate of inflation has been highly variable, price surprises are interpreted as changes in the aggregate rate of inflation and have little effect on real output.

1. Henry Sidgwick, "The Method of Ethics", sixth edition, London, Macmillan, 1901, p.269.
2. Not only the redistribution is resented, but the breach of justice that caused it; so that, even if it were possible, full compensation would be unable to repair the damage fully. Thus John Maynard Keynes ("A Tract on Monetary Reform", Macmillan, London, 1923, pp.25-26) on the subject of secular inflation: "No man of spirit

For either contracts will come to be indexed in some way or other, which is itself likely to be contentious, administratively costly and only a partial solution to uncertainty; or else there will be a disinclination to honour contracts once entered into. Nor would such a disinclination be altogether blameworthy, because it is generally held that promises or obligations become less strictly binding if the material conditions surrounding them alter substantially, so that the consequences of carrying them out are quite different from those foreseen when they were made. Commercial law may still enforce such contracts - except for occasional major changes involving currency or land reform, it is hard to see how it can do otherwise¹ - nevertheless mere legal obligation is a poor substitute for a willing compliance with reasonable obligations.

There is, then, a moral justification for seeking a stable rate of inflation, as promoting justice. There is also, though more weakly, an aesthetic reason; for the admiration accorded to Liberality, which is the graceful and generous exhibition of the power of wealth, is at least partly an aesthetic one. "There is," writes Sidgwick, "a certain border-ground between Justice and Benevolence where it [Liberality] is especially shown; namely in the full satisfaction of all customary expectations,

will consent to remain poor if he believes his betters to have gained their goods by lucky gambling. To convert the business man into the profiteer is to strike a blow at capitalism, because it destroys the psychological equilibrium which permits the perpetuance of unequal rewards." But see the discussion on p.27 for a contrary view which regards inflation as an adaptation by capitalist society to existing stresses.

1. Although the law is slowly making some allowances for the changing circumstances surrounding money contracts, for example the recent change in English law allowing judgement to be given in a foreign currency when appropriate, and not only in sterling. See Miliangos v. George Frank (Textiles) Ltd. [1976] A.C.443 (H.L. (E.)), which established the principle in the case of debt and The Despina R [1979] A.C.685, (H.L. (E.)), which confirmed it in the case of damages in tort and breach of contract.

even when indefinite and uncertain;... And again, since laws and promises and especially tacit understandings are sometimes doubtful and ambiguous, a liberal man will in such cases unhesitatingly adopt the interpretation which is least in his own favour, and pay the most that he can by any fairminded person he thought to owe; and exact the least that reasonably can be thought to be due to himself: that is, if the margin be, relative to his resources, not considerable."¹

It may well be supposed that when unanticipated inflation or deflation has greatly altered the anticipated outcome of a contract there is a much diminished scope for liberality. For the protagonists will either find themselves bound to pay much more than any fairminded person would have expected, or else they will have gathered a windfall which is more than merely marginal to the contract. In the latter case, certainly, there is an opportunity for generosity in redistributing the surplus, but there is not the same aesthetic satisfaction in the benevolence of the newly rich as in the smooth and liberal operation of a stable system of exchange. I do not wish to make too much of the relative merits of the virtues which could be brought into play: suffice it to say that an aesthetically pleasing or artistic dealing with money, like any artistic activity, benefits from a more stable and certain environment.²

Here, however, we must consider possible objections to the view which regards the maintenance of a stable rate of inflation as conducive to

1. H. Sidgwick, "The Method of Ethics", p.235.

2. This is not to maintain that a stable environment is the most important determinant of artistic achievement, only that it is one determinant. Thus, for example, Kenneth Clark in "Civilisation, a Personal View", London, 1969, B.B.C. and John Murray, p.34: "These changes [the twelfth century Renaissance] ...imply wealth, stability, technical skill and above all the confidence necessary to push through a long term project."

justice. In the first place, it might be admitted that no one can know with certainty what the rate of inflation will be for the next period, and that everyone must form some expectation of what the rate of inflation will be; but this estimate will not in general be a point estimate only, people will also form some idea of the possible range or distribution of the rate of inflation, based on an understanding of the economic system and the known reaction functions of the government authorities. To simplify the discussion, let us suppose that everyone forms an estimate of both the mean and the variance of the rate of inflation for the next period. Now, it may well be that if policy action can stabilise the rate of inflation, that is reduce its variance, then this will make peoples' predictions more accurate and improve the efficiency of the economy in the sense of producing a greater or more stable output; yet, it may be said, this is in no sense an expansion of justice. Everyone knew the past history of inflation and the riskiness of making any prediction about future inflation - in establishing contracts it is up to them to take account of the risks of an inaccurate prediction and, if they are rise-averse, to hedge or insure against them.

The answer to this objection is that at least in the present state of society the ability to predict the aggregate rate of inflation is not uniformly distributed, nor are there opportunities to hedge most transactions against variations in the rate of inflation.¹ Furthermore, the ability to predict and the power to hedge against inflation are not simple economic goods, types of information which can be acquired at a

1. This is not to suggest that the ability of the individual to hedge or insure against inflation would eliminate the costs of inflation to society. But it would mean that, at a cost, an individual could insulate himself against the effects of inflation, so that inequality in the distribution of knowledge about and power over inflation would pose no greater problem for justice in society than inequality in the distribution of other goods.

cost in a free market and sold in small amounts to meet the customers' needs and which just happen to have an unequal initial distribution. The reasons for this are complicated and some relate simply to inefficiencies and imperfections in the market system; but the main reason is that the aggregate rate of inflation depends crucially on government actions. And the ability to know or influence government policy, or, post hoc, to protect oneself against its consequences, is proportionate to political power and inherently indivisible. A less accurately predictable rate of inflation therefore tends to enhance the relative position of the politically powerful, which is seldom conducive to justice.¹ Moreover, even if we were to concede that knowledge about future inflation is equally available to everyone, so long as there are imperfect opportunities for hedging every contract there will be wider variations in the outcomes of contracts if the rate of inflation is more unstable; and, as I have already argued, this will reduce the display of Justice as it is manifested in Liberality.

The second objection would admit some moral obligations with regard to the aggregate rate of inflation, but would maintain that for the individual producer or consumer the aggregate rate of inflation is of little interest: the individual is concerned with a much narrower range of prices, with different weights attached to them - the prices of goods and services he actually buys or sells. Consequently, it might be maintained, it is the predictability of relative prices that concerns him

1. In special circumstances, when, for example, the politically powerful happen to be the relatively poor, one might applaud the redistributive consequences of unanticipated inflation and applaud even legislation enacted by the politically powerful to make it harder to hedge against inflation. Even so, such circumstances will be unjust in the sense of diminishing commutative justice as between partners in any civil contract, notwithstanding that distributive justice might be served by the implicit taxes and subsidies of unanticipated inflation.

and not the aggregate price level.

This objection can be answered, firstly, by pointing out that an uncertain aggregate rate of inflation is likely to make relative prices harder to predict. Not all prices change at exactly the same time: consequently, if one price does change and the aggregate rate of inflation is uncertain, it becomes more difficult to divide the observed price change into that part which is an element of the general inflation (soon to be matched by other prices) and that part which represents a reliable price change. Secondly, we can admit in the case of relative prices what we could not admit in the case of the aggregate price level. It is the business of every producer and consumer to predict the relative prices of what he buys and sells and to take the risks inherent in making such predictions and to use his specialist knowledge to make better predictions than his rivals. But, as we have seen, it is unreasonable to expect him to be able to allow for uncertainty of the aggregate rate of inflation. Consequently, if the government can stabilize the aggregate rate of inflation (or, better still, the aggregate price level) it has done all that can be expected of it (market imperfections aside).

The final objection draws on a sociological view of inflation and sees the underlying causes of inflation as being the conflicts and stresses within society over political power and particularly over the distribution of income.¹ So far from straining the social fabric, inflation may instead act as a mollifier or shock-absorber for conflicts that exist anyway, operating as a "vent for distributional strife, an escape hatch through which excess demands are automatically channelled."²

1. c.f. Fred Hirsch, "The Ideological Underlay of Inflation", in Fred Hirsch and John H. Goldthorpe (eds.), "The Political Economy of Inflation", Martin Robertson, London, 1978, pp.263-284.

2. Ibid., p.270.

Thus, particularly when there is an ideological struggle, inflation may be accepted as less painful or risky than a technically available alternative that appears ideologically threatening. Moreover, inflation is not simply an outcome in the struggle between different social groups, but an instrument which some groups can use in their struggle to achieve not just greater rewards, but power in a wider sense (e.g. trade unions can put forward political demands as the price of their co-operation in a social contract to reduce inflation). And so, on this view, a policy of reducing or even of stabilizing inflation is not necessarily ideologically neutral or unequivocally desirable.

That inflation, particularly unanticipated inflation, has distributional consequences is generally accepted. Whether one judges that these distributional consequences are or are not beneficial to the structure of society will depend on the particular features of the country concerned and on one's ideological point of view. But, strictly speaking, these distributional consequences are beside the point as far as the injustice of inflation is concerned; for inflation will only affect distribution, and perhaps have the mollifying effects on social conflict mentioned above, insofar as it is not fully anticipated.¹ This means that all sorts of contracts, especially between individuals but also between broad groups in society, will have outcomes different from those anticipated when the contracts were entered into. Even from the most utilitarian perspective it is hard to imagine the short-term gain to society from a favourable impact on distribution outweighing the long-term effects engendered by

1. As a purely technical matter, one might suppose that the continued use of inflation to cushion distributional conflicts would diminish money illusion and so make inflation less effective in this role or else require an ever accelerating rate of inflation.

the decreased confidence in money contracts and the grievances arising from the disappointment of legitimate expectations.

As to the ideological implications of curbing inflation: if one accepts that a policy of stabilizing the rate of inflation will harm the position of some social groups and benefit others and that therefore it might have ideological overtones, this does not mean that one has to adopt a relativist position and judge such a policy solely by its impact on the welfare of different social groups. There is an absolute standard about a stable, fully anticipated inflation as opposed to a more fluctuating one, namely that it provides the greatest certainty and the fullest information for the operation of the economy, and so is ideologically biased only inasmuch as the widest diffusion of knowledge is ideologically biased.

(xii)

So far our discussion has been in terms of stability of the rate of inflation, though I have mentioned that a more stable rate might lead to a lower rate of inflation, and have suggested that this would be a good thing. Is there, in fact, a case for preferring a lower rate of inflation to a higher one if both are equally stable? I shall not spend long on this question because it has already been discussed extensively elsewhere;¹ because one expects that exchange rate policy can have little influence on the average rate of inflation except through its effect on the stability of the rate of inflation; and because the drawbacks of a high rate of inflation are minor compared to those of a variable and unpredictable rate. Nevertheless, there are reasons for preferring a low to a high rate of inflation, which we can summarise briefly.

1. For example, Harry G. Johnson, "Is There an Optimal Money Supply?", *Journal of Finance*, Vol.25, No.2, May 1970, pp.435-42.

In the first place there are the purely administrative costs, by no means negligible: the more frequent revision of price lists, the more rapid revision of index-linked contracts. (And this is also the main justification for preferring a stable rate of inflation to an unstable one, even if both are perfectly foreseen.)

Related to this is a second reason. In the present set-up of society there are some contracts which cannot be completely hedged against even a perfectly foreseen inflation. And a low rate of inflation reduces the welfare losses associated with them. A particular case is the need to use money which is not index-linked. A high rate of inflation imposes a capital level on money balances and so will reduce the quantity held below the optimum which would minimize transactions costs.

Finally, it is an advantage if expectations of a stable inflation can coalesce around a universally held value (which is presumably the mean value of the stable inflation): in other words, for the expectations of inflation to be as little dispersed as possible. There may be no logical reason why expectations should more easily be focused on zero inflation than on inflation at say, four and a half per cent per annum: nevertheless, given past experience of accelerating inflation, it seems likely that if there were a stable rate of inflation it would be more rapidly accepted as stable if it were stable at zero or a low rate of inflation, than if it were stable at a higher rate.¹

I have argued for stability of the rate of inflation as more important in the context of exchange rate policy than a low rate of inflation

1. Edward Foster, "The Variability of Inflation", Review of Economics and Statistics, August 1978, pp.346-350, puts forward some evidence from Latin American data to indicate that a higher inflation rate might be a more variable one. And Dennis Logue and Thomas D. Willett, "A Note on the Relations Between the Rate and Variability of Inflation", Econometrica, Vol.43, No.70, May 1976, pp.151-158, find for a wide sample of countries a strong positive relationship between the rate and variability of inflation at inflation rates greater than "moderate" inflation (2 - 4%).

itself. Even though in principle one might be willing to accept a trade-off between a higher and more stable inflation rate on the one hand versus a lower but less stable one on the other, in general it seems as though achieving a more stable rate of inflation will, if it exerts any influence, exert only a favourable influence on the average rate of inflation itself, so that one can concentrate at least in the first instance on improving the stability of the rate of inflation.

(xiii)

Our third objective of exchange-rate policy is stability of the exchange-rate itself. The status of this objective is slightly different to that of the output and inflation objectives for two related reasons. In the first place, exchange-rate stability is desirable only for its results and not for any intrinsic virtue and, following on from this, a rather different interpretation has to be given to stability in this case.

It can hardly be maintained that a stable exchange rate in and of itself adds to a country's economic welfare. It is true that for some people a stable exchange rate might have a symbolic value. One thinks of the European Monetary System, where stability of the exchange rate (relative to a sub-set of world currencies in this case) might be taken as a symbol of a European commitment and a visible example of European co-operation. Even here the real, as opposed to the symbolic, benefit is presumably seen as the co-ordination of policy which a commitment to the E.M.S. entails and the increase in European at the expense of national sovereignty. But it certainly is the case that a visible stability of the exchange rate over time is seen as essential for such political dividends. Of course, what is a political gain for some is liable to be a political loss for others, and in any case the direct welfare effects

from the symbolic and political connotations of a stable exchange rate are probably very small. I shall therefore justify a concern with exchange-rate stability solely by looking at its economic consequences, in particular its effects on the efficiency of trade and of investment. But before they can be considered in more detail it is necessary to specify what is meant by stability of the exchange rate.

Where the rate of inflation was concerned, it was sufficient to define stability of the rate of inflation relative to the given average rate, equivalent to price stability being measured relative to an exponential trend. And in the case of output, too, one could measure instability by the amplitude and frequency of deviations from the long-term trend. But in the case of the exchange-rate it is not sufficient to consider stabilization of the exchange rate as consisting of smoothing the long-term trend of the exchange rate over time: rather, desirable stability of the exchange rate lies in its conformity to the equilibrium exchange rate - and the latter may have discontinuities over time.

The definition of the equilibrium exchange rate is bound up with the benefits to be expected from achieving it in the way of efficient trade and investment. In relatively simple two country barter models, the conditions have been worked out for the joint determination of trade and capital movements.¹ But when uncertainty, imperfect capital mobility and a monetary sector are introduced it becomes a very formidable undertaking indeed, since for example current capital flows depend on

1. For a survey of the models developed for this purpose, see W.M. Corden, "The Theory of International Trade", in J.H. Dunning (ed.), "Economic Analysis and the Multinational Enterprise", London, Allen & Unwin, 1974, pp.184-210. For the determination of comparative advantage in the presence of capital mobility see D.G. Ferguson, "International Capital Mobility and Comparative Advantage, the Two Country, Two Factor Case", Journal of International Economics, 1978, pp.373-96.

expected future exchange rates, which are themselves dependent on future trade levels, which will be partially determined by current capital flows. Nevertheless, one can form an idea of the meaning of the equilibrium exchange rate, if not its precise determination, by taking the real volume of trade, the real interest rates and real capital movements from a barter model, supposing that current price levels and the future rates of inflation are exogenously determined for each country, and deriving the equilibrium spot and future exchange rates from a balance of payments equilibrium condition.

Because of the difficulties involved in calculating an equilibrium exchange rate the usual procedure has been to regard as an equilibrium exchange rate that rate which preserves purchasing-power parity and/or the inflation-adjusted interest-rate parity relative to some supposedly "equilibrium" base year. One problem, of course, lies in choosing a suitable base year. A second, and more intractable problem arises from the fact that it may be impossible to preserve both purchasing-power and real interest-rate parity simultaneously. If interest rates and prices always moved towards their equilibrium levels (or trends) at the same speed, then it might be possible to adjust the exchange rate to maintain both parities simultaneously. But in general either prices or interest rates will adjust more rapidly. This is a matter which will be treated in more detail in the next chapter, which will examine the dynamics of a flexible exchange rate. For the moment we are concerned with the implications for measuring the departure from the ideal exchange rate. For completeness one would have to calculate the trade and production losses that would follow from an exchange rate different to the purchasing-power parity rate and the investment losses that would be the result of the exchange rate's differing from the real interest-rate parity level, and then devise a rule which set the exchange rate at a level which,

while probably satisfying neither parity exactly, would minimise the sum of the two types of loss. In the absence of such a calculation one might achieve an approximate measure of the deviation from the ideal exchange rate by looking only at that parity which is in any case less likely to be achieved. Thus, if interest rates generally react quickly to deviations in covered interest rates, whereas prices are comparatively sticky, the chief loss from an inappropriate exchange rate would probably be in deviations from purchasing-power parity. This is perhaps the more likely configuration for the advanced, industrial countries.¹ But it is possible to envisage economies which are relatively open to trade but where capital movements and domestic capital markets are heavily regulated, and in these cases the chief role of exchange rate changes could lie in minimizing losses due to deviations from real interest rate parity.

In practice, it may sometimes be necessary to look simply at deviations of the exchange rate from its long-term trend, perhaps making

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1. For a recent summary of the extensive literature and the empirical tests of the purchasing-power parity doctrine, See Louka K. Katseli-Papaefstratiou, "The Reemergence of the Purchasing Power Parity Doctrine in the 1970's", Princeton Special Paper in International Economics No.13, December 1979, and the references cited there. In addition see R.Z. Aliber, "The Firm Under Pegged and Floating Exchange Rates", Scandinavian Journal of Economics, vol.78, 1976, pp.309-322, and Clas Wihlborg, "Capital Market Integration and Monetary Policy under Different Exchange Rate Regimes", Stockholm Institute for International Economic Studies, Monograph No.7, 1976, and Clas Wihlborg, "Currency Risks in International Financial Markets", Princeton Study in International Finance, No.44, December 1978, section 4.4.

On interest-rate parity the general conclusion is that while capital is sufficiently mobile to maintain an approximation to covered interest-rate parity for short maturities, significant differentials persist at the long end. c.f. M. Feldstein and C. Horioka, "Domestic Saving and International Capital Flows", Economic Journal, vol.90, June 1980, pp.314-329; Michael G. Porter, "Capital Flows as an Offset to Monetary Policy: The German Experience", I.M.F. Staff Papers, vol.19, 1972, pp.395-424, and R.Z. Aliber, "Exchange Risk and Corporate International Finance", Macmillan, London, 1978, ch.6.

ad hoc assumptions regarding particular events which will markedly affect the country's real trading or investment position. This procedure requires the assumption that the long-term trend of the exchange rate follows the parities with some degree of congruence, at least compared to the often violent fluctuations in exchange rates which have been observed.

Part Two

The Effectiveness of Exchange-Rate Policy in the Light of the Rational Expectations Debate over Monetary Policy

(i)

So far we have concentrated our attention on whether greater stability of our chosen macroeconomic variables is desirable, and we have concluded that on the whole it is. But is greater stability possible? Specifically, will altering the form of the exchange-rate rule have any effect on the stability of output, of prices and of the exchange rate? There can be little doubt that there will be an effect on the time-pattern of the exchange rate and that in most cases different exchange-rate rules will lead to differences in the pattern of prices; so we shall concentrate our discussion on whether the exchange-rate rule can affect real variables, notably output. In doing this we are following the course marked out in the debate about the ineffectiveness of monetary policy, where attention has been concentrated on the proposition that under certain conditions systematic monetary policy is unable to affect output.¹

1. Obviously, systematic monetary policy can affect the level of prices, though some strong variants of the rational expectations

Let us be clear about what this proposition implies. It is not concerned with the long-run neutrality of money, in the sense that a once-and-for-all change in the level of the money stock has no real effects in the long run. Almost all models would yield this result. Nor is it concerned with "superneutrality", which posits the invariance of the real variables of the system to different proportionate rates of growth of the nominal money stock.¹ Such superneutrality is most unlikely, since changes in the rate of inflation alter the real rate of return on money balances whose nominal rate of return is fixed at zero. (This changes equilibrium portfolio composition and alters the rate of capital formation in the short run and the capital-labour ratio in the long run.²) Rather, the invariance proposition would deny any transitory effects on output of systematic (that is, non-random) changes in the money supply, and hence render monetary policy ineffective as a means of stabilizing output about a particular trend.

In terms of exchange-rate policy our concern would not be with the long-run equilibrium results of a once-and-for-all exchange-rate change; nor with whether an accelerated depreciation of the currency alters the portfolio composition as between domestic money, real assets

model would seem to deny its ability to affect the variance of prices. See Thomas J. Sargent and Neil Wallace, "'Rational' Expectations, the Optimal Monetary Instrument, and the Optimal Money Supply Rule", *Journal of Political Economy*, Vol.83, No.2, April 1975, p.249.

1. See Jeffrey Carmichael, "Money, Inflation and Economic Growth: Conditions for Superneutrality in a General Optimizing Framework," Princeton University, Econometrics Research Program, Research Memorandum No.244, May 1979.
2. Robert A. Mundell, "Monetary Theory", Goodyear, Pacific Pasilades, 1971, Ch.2 and Alvin L. Marty, "Gurley and Shaw on Money in a Theory of Finance," *Journal of Political Economy*, Vol.69, Feb. 1961, pp.56-62.

and foreign money; but rather with the question of whether non-random (and hence predictable) exchange-rate changes have any effect on real output.

It will turn out that in certain, unlikely circumstances exchange-rate policy will be without effect on real output. Nevertheless, this is no cause for despondency. As with monetary policy, we may rely on what I shall call the Principle of Sufficient Ignorance, which states that if stabilization policy is impossible, it will also be unnecessary. For stabilization policy will only be impossible if all prices are perfectly flexible and if all technically available information is being fully used by the private sector; and in such circumstances the private sector is already doing all that the most enlightened government intervention could do.¹

Moreover, the modifications to the model which serve to restore the effectiveness of exchange-rate changes are of some interest, as indicating the channels through which exchange-rate policy operates.

(ii)

Before proceeding to a consideration of exchange-rate policy, let us look at how the Principle of Sufficient Ignorance operates in the case of monetary policy, for which the ineffectiveness proposition was originally developed. The model set out below has been selected to exhibit the possibility of an ineffective monetary policy for a fairly plausible, simple specification. It is, of course, not the only possible

1. Robert J. Gordon, "What can Stabilization Policy Achieve?", American Economic Review, Papers and Proceedings, 1978, pp.335-341, remarks on the lack of a need for stabilization policy with sufficiently flexible prices.

specification, but is designed to show how various modifications can restore the effectiveness of monetary policy even if the initial model is that in which it performs least well.¹

The supply function, crucial for the ineffectiveness proposition, is of the "only price surprises matter" type:²

$$1) \quad y_t = a (p_t - E_{t-1} p_t)$$

The demand function has the demand for goods depending on the real interest rate and the previous period's income:

$$2) \quad q_t = -c (R_t - E_{t-1} p_{t+1} + E_{t-1} p_t) + b y_{t-1}$$

The goods market equilibrium condition is:

$$3) \quad q_t = y_t$$

And the money market equilibrium condition is:

$$4) \quad m_t = p_t + q_t - x_t - \frac{1}{f} R_t$$

Where y_t = the logarithm of the deviation of output in period t from its trend value,

p_t = the logarithm of the deviation of the domestic price level in period t from its trend value,

R_t = the deviation of the nominal interest rate in period t from its trend value,

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1. The model expounded here is basically that of Sargent and Wallace, "'Rational' Expectations, the Optimal Monetary Instrument and the Optimal Money Supply Rule", Journal of Political Economy, Vol.83, No.2, April 1975, pp.241-254 and is solved by a method suggested by Patrick Minford and David Peel, "The Role of Monetary Stabilization Policy under Rational Expectations", S.S.R.C. - University of Liverpool Project on the International Transmission of Fluctuations in Economic Activity, Secular Growth and Inflation, Working Paper No.7804, based on the method used by John F. Muth, "Rational Expectations and the Theory of Price Movements", Econometrica, Vol.29, No.3, July 1961, pp.315-335.
 2. For a discussion of the basis of the Lucas supply function, see Patrick Minford and David Peel, "The Natural Rate Hypothesis and Rational Expectations - A Critique of Some Recent Developments", Oxford Economic Papers, March 1980, pp.71-81.

m_t = the logarithm of the deviation of the nominal money supply
in period t from its trend value,

x_t = a random disturbance in period t to the nominal money supply,

and E_t before a variable denotes the expected value of that variable,
the expectation being taken in period t on the basis of know-
ledge of the values of all the variables in period t .

The first step in solving the model is to obtain the reduced form
equation in prices and expected prices. In equation 2, substituting
from equation 3 for q_t and from equation 4 for R_t :

$$y_t = -c(fp_t + fy_t - fm_t - fx_t - E_{t-1} p_{t+1} + E_{t-1} p_t) + by_{t-1}$$

Substituting from equation 1 for y_t and y_{t-1} :

$$\begin{aligned} \{(1+cf)a + cf\} p_t - \{(1+cf)a - c\} E_{t-1} p_t - cE_{t-1} p_{t+1} - ab p_{t-1} \\ + ab E_{t-2} p_{t-1} - cf m_t - cf x_t = 0 \end{aligned}$$

Consider the situation where there is no attempt at a monetary stabil-
ization policy: assume $m_t = 0$ for all t . Look for a solution for p_t

of the form $p_t = \sum_{i=0}^{\infty} \pi_i x_{t-i}$, that is, deviations of the aggregate
price level from trend are a function of current and past monetary

disturbances. Since $E_t x_{t+j} = 0$ for j positive, $E_{t-k} p_{t-j} =$

$$\begin{aligned} \sum_{i=k-j}^{\infty} \pi_i x_{t-i-j} \text{ for all } j, k. \text{ Hence:} \\ \{(1+cf)a + cf\} \sum_{i=0}^{\infty} \pi_i x_{t-i} - \{(1+cf)a - c\} \sum_{i=1}^{\infty} \pi_i x_{t-i} \\ - c \sum_{i=2}^{\infty} \pi_i x_{t-i+1} - ab \sum_{i=0}^{\infty} \pi_i x_{t-i-1} + ab \sum_{i=1}^{\infty} \pi_i x_{t-i-1} \\ - cf x_t = 0 \end{aligned}$$

This equation must hold for all x_{t-i} ; hence, taking terms in x_t :

$$\{(1+cf)a + cf\} \pi_0 - cf = 0$$

Taking terms in x_{t-1} :

$$c(1+f) \pi_1 - c \pi_2 - ab \pi_0 = 0$$

Taking terms in X_{t-2} :

$$c(1+f) \pi_2 - c \pi_3 = 0$$

$$\text{Therefore: } \pi_3 = (1+f) \pi_2$$

Similarly, taking terms in X_{t-j} , where $j \geq 2$, implies

$$\pi_{j+1} = (1+f) \pi_j \quad \text{for all } j \geq 2.$$

But $f > 0$. Therefore, unless any monetary disturbance is to lead to a price explosion, $\pi_j = 0$ for all $j \geq 2$.

$$\text{Hence } p_t = \pi_0 X_t + \pi_1 X_{t-1}$$

$$\text{Where } \pi_0 = \frac{cf}{(1+cf)a + cf} \quad \text{and } \pi_1 = \frac{abf}{(1+f) \{ (1+cf)a + cf \}}$$

$$\begin{aligned} \text{And } y_t, \text{ which} &= a (p_t - E_{t-1} p_t) \\ &= a \pi_0 X_t \\ &= \frac{acf}{(1+cf)a + cf} X_t \end{aligned}$$

That is, output deviation from trend is a function only of current money supply disturbances and private behavioural functions (the values of a , c , f) related to current variables, and hence any monetary policy (value of m_t) based on past values of the variables or past monetary disturbances will be unable to stabilise current or future output. Therefore the ineffectiveness proposition holds for the particular model considered here. Any systematic monetary policy based on past values of the economy or on predictions based on its known structure will be anticipated by the private sector and incorporated into their price predictions and so, not being "surprises", will not affect current output. Any random component of monetary intervention will, of course, have an effect, but not being related to X_t cannot be used for systematic stabilisation,

and in fact by adding another random disturbance will on average destabilise output.

(iii)

There are two features of the model which are essential for the ineffectiveness proposition. One, as is well known, is the particular "only current price surprises matter" supply function. The other is the requirement that supply decisions and demand decisions be taken at the same time with the same price information.

Let us look first of all at an alternative supply function. We might suppose that supply reacts to price surprises relative not only to price expectations in the last period but to price expectations formed in earlier periods. This might be because some planning must proceed two periods ahead or because of price or wage contracts two periods in length, for example. With such a supply function monetary policy is no longer ineffective, since monetary policy formulated in period $t-1$ can react to differences in the forecasts for p_t made in periods $t-1$ and $t-2$. That is, public policy can use information not fully incorporated by the private sector into its actions.¹

Thus, let us suppose that a proportion $\frac{m}{a}$ of supply decisions are taken one period ahead and a proportion $\frac{n}{a}$ two periods ahead. $\frac{m}{a} + \frac{n}{a} = 1$. Then the supply function defined above as :

$$y_t = a (p_t - E_{t-1} p_t)$$

becomes

$$5) \quad y_t = m(p_t - E_{t-1} p_t) + n(p_t - E_{t-2} p_t)$$

where $m + n = a$.

1. For a discussion of the types of supply function compatible with the ineffectiveness proposition, see Bennett T. McCallum, American Economic Review, Papers and Proceedings, May 1979, pp.340-245.

The other equations of the model are unchanged:

$$6) \quad q_t = -c(R_t - E_{t-1} p_{t+1} + E_{t-1} p_t) + by_{t-1}$$

$$7) \quad q_t = y_t$$

$$8) \quad m_t = p_t + q_t - x_t - \frac{1}{f} R_t$$

The solution proceeds as before. The reduced form equation in prices and expected prices is:

$$\begin{aligned} & \{(1 + cf)(m+n) + cf\} p_t - \{m(1 + cf) - c\} E_{t-1} p_t \\ & - n(1 + cf) E_{t-2} p_t - cf m_t - cf x_t - cE_{t-1} p_{t+1} \\ & - b(m+n) p_{t-1} + mb E_{t-2} p_{t-1} + nb E_{t-3} p_{t-1} = 0 \end{aligned}$$

Assume initially a passive monetary policy, so $m_t = 0$ for all t . Look for a solution of the form $p_t = \sum_{i=0}^{\infty} \pi_i x_{t-i}$

Then:

$$\begin{aligned} 9) \quad & \{(1+cf)(m+n) + cf\} \sum_{i=0}^{\infty} \pi_i x_{t-i} - \{m(1+cf) - c\} \sum_{i=1}^{\infty} \pi_i x_{t-i} \\ & - n(1+cf) \sum_{i=2}^{\infty} \pi_i x_{t-i} - cf x_t - c \sum_{i=2}^{\infty} \pi_i x_{t-i+1} \\ & - b(m+n) \sum_{i=0}^{\infty} \pi_i x_{t-i-1} + mb \sum_{i=1}^{\infty} \pi_i x_{t-i-1} + nb \sum_{i=2}^{\infty} \pi_i x_{t-i-1} \\ & = 0 \end{aligned}$$

Taking terms in x_t :

$$10) \quad \{(1+cf)(m+n) + cf\} \pi_0 - cf = 0$$

Taking terms in x_{t-1} :

$$11) \quad \{n(1+cf) + c(1+f)\} \pi_1 - c\pi_2 - b(m+n) \pi_0 = 0$$

Taking terms in x_{t-2} :

$$12) \quad c(1+f) \pi_2 - c\pi_3 - nb\pi_1 = 0$$

Taking terms in x_{t-3} :

$$c(1+f) \pi_3 - c\pi_4 = 0$$

Therefore $\pi_4 = (1+f) \pi_3$

Similarly, taking terms in X_{t-j} with $j \geq 3$ implies:

$$\pi_{j+1} = (1+f) \pi_j \quad \text{for all } j \geq 3.$$

Hence, since $f > 0$, if monetary disturbances are not to give rise to an explosion of prices, $\pi_j = 0$ for $j \geq 3$

Therefore $p_t = \pi_0 X_t + \pi_1 X_{t-2} + \pi_2 X_{t-2}$

and y_t , which $= m(p_t - E_{t-1} p_t) + n(p_t - E_{t-2} p_t)$,

$$= (m+n) \pi_0 X_t + n \pi_1 X_{t-1}$$

Solving for π_0, π_1, π_2 in equations 10, 11, 12 and writing $m + n = a$, we get:

$$y_t = \frac{acf}{(1+cf)a+cf} X_t + \frac{ba(1+f)cf}{\{n(1+cf)(1+f)+c(1+f)^2-nb\}\{(1+cf)a+cf\}} X_{t-1}$$

Hence, compared to the solution obtained with the first supply function, y_t is affected exactly as before by X_t , and is in addition affected by X_{t-1} . Since X_t and X_{t-1} are random and uncorrelated, the variance of y_t will have increased. But monetary policy is now effective. Let us set as our monetary rule:

$$\begin{aligned} m_t &= -\frac{b}{cf} y_{t-1} \\ &= -\frac{b}{cf} \left\{ (m+n) p_{t-1} + m E_{t-2} p_{t-1} + n E_{t-3} p_{t-1} \right\} \\ &= -\frac{b}{cf} \left\{ (m+n) \sum_{i=0}^{\infty} \pi_i X_{t-i-1} + m \sum_{i=1}^{\infty} \pi_i X_{t-i-1} + n \sum_{i=2}^{\infty} \pi_i X_{t-i-1} \right\} \end{aligned}$$

Equation 9 now becomes:

$$\begin{aligned} &\{(1+cf)(m+n) + cf\} \sum_{i=0}^{\infty} \pi_i X_{t-i} - \{m(1+cf) - c\} \sum_{i=1}^{\infty} \pi_i X_{t-i} \\ &- n(1+cf) \sum_{i=2}^{\infty} \pi_i X_{t-i} - cf X_t - c \sum_{i=2}^{\infty} \pi_i X_{t-i+1} = 0 \end{aligned}$$

Taking terms in X_t :

$$13) \quad \{(1+cf) (m+n) + cf\} \pi_0 - cf = 0$$

Taking terms in X_{t-1} :

$$14) \quad \{n (1+cf) + c (1+f)\} \pi_1 - C\pi_2 = 0$$

Taking terms in X_{t-2} :

$$c (1+f) \pi_2 - c\pi_3 = 0$$

$$\text{i.e.} \quad \pi_3 = (1+f) \pi_2$$

$$\text{Similarly} \quad \pi_{j+1} = (1+f) \pi_j \quad \text{for all } j \geq 2$$

Hence, if any monetary disturbance is not to cause a price explosion,

$$\pi_j = 0 \text{ for all } j \geq 2. \text{ And so, from 14, } \pi_1 = 0.$$

$$\text{Therefore } p_t = \pi_0 X_t$$

$$\text{where } \pi_0 = \frac{cf}{(1+cf)a+cf}, \text{ from equation 13.}$$

$$\text{Hence } y_t, \text{ which} = m(p_t - E_{t-1} p_t) + n (p_t - E_{t-2} p_t),$$

$$= (m+n) \pi_0 X_t$$

$$= \frac{acf}{(1+cf)a+cf}$$

Thus the variance of y_t is reduced and in fact becomes the same as in the case where only the previous period's price predictions affected the supply function.

It is therefore established that in a situation where monetary stabilization becomes possible it can achieve as much as private action would, if private agents could both know and use the most recent information technically available. Two observations immediately suggest themselves. The first is that if the most recent information technically available can be acquired costlessly, then there really is nothing to choose between a situation in which private agents know and use such

information and the monetary authority is passive, and a situation in which the monetary authority has better information and pursues an optimal monetary rule. If, on the other hand, the gathering of information is a costly process, there may be economies of scale to having it gathered socially: what use was made of it would then depend on the relative costs of distributing it to private agents and to government institutions and the efficiency with which it would be used in either case, in modifying private production decisions or in pursuit of an active monetary policy.

The second observation is that we have shown that stabilisation policy can achieve as much as private action would if private agents could both know and use the most recent technically available information. But can it achieve only as much? Could the monetary authority not exploit the difference in information between itself and the private sector in order to reduce fluctuations below what they would have been if the private sector had possessed and acted on the information? And, as a corollary, would it then pay the authorities to increase the difference between their information and the public's?

In terms of the model above, the question becomes: could the monetary authority not reduce π_0 below the value it assumes in the case where there is no rigidity of contracts or planning? The answer to this last question is clearly "No", since π_0 is determined only by the parameters of the private behavioural functions as they relate to the current values of the variables. And one can generalise this result as well. In the case where the only reason for the effectiveness of monetary policy is that the monetary authorities have information which the private sector does not have or, because of fixed contracts is unable to use, then the monetary authority is unable to do more to stabilize the economy than the private sector would have done, had it been able to know and use that information. If, on the other hand, there are other, structural

features of the model which would lead to business cycles and make even anticipated monetary policy effective, features such as durable capital and inventories;¹ then the monetary authority might well want to establish an informational advantage for itself to give it greater leverage to combat cycles caused by such features, because in such circumstances it would be putting the information to a use different to that which the private sector would adopt.

A slightly different question has received some attention in the literature, namely whether diminishing both the public's and the government's information by introducing a random element to the money supply could ever serve the purpose of stabilization. The point has been made that adding an unpredictable, random term to the money supply rule would lead to effects on real variables, perhaps even to a change in the trend value of real variables, but that in general this non-neutrality of money could not be exploited for stabilisation purposes, since it would be impossible to link the value taken by such a random term to the state of the economic system at the time. (Indeed, adding a stochastic term to the money supply would usually increase the instability of output.²) However, where there are causes of non-neutralities of money other than differences in information, it is by no means obvious that diminishing the accuracy of the public's predictions of the money supply in this way might not improve the efficacy of government counter-cyclical policy.

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1. A good summary of these is provided by Stanley Fischer, "Anticipations and the Nonneutrality of Money", *Journal of Political Economy*, Vol.87, No.2, April 1979, pp.225-252.
 2. c.f. T.J. Sargent and N. Wallace, "Rational Expectations, the Optimal Monetary Instrument and the Optimal Money Supply Rule", *Journal of Political Economy*, Vol.83, No.2, April 1975, pp.249-50, and Robert J. Barro, "Rational Expectations and the Role of Monetary Policy", *Journal of Monetary Economics*, No.2, January 1976, pp.1-32.

Adding a random term to the money supply would alter private behaviour in a way that would not in itself be stabilizing, but it might possibly result in an increased impact for government monetary policy based on the structural non-neutralities.¹

The more important case remains that in which the government would put information to a different use to the private sector, and therefore desires an informational advantage to enhance its policies. But it is just possible that diminishing both government and private sector information by adding a random term to the money supply would in itself increase the impact of counter-cyclical policy. In this latter case, though, it would surely be possible instead for the government to reduce the public's information without diminishing its own, by, for example, withholding government-collected statistics.

(iv)

So far we have looked at one well-known condition for the ineffectiveness proposition, namely the particular "only current price surprises matter" supply function. But there is a second necessary assumption implicit in the model: that supply decisions and demand decisions are taken at the same time and with the same price information. This is a restrictive but not totally unreasonable condition in the closed economy model, but, as we shall see, its generalization into the open economy is much less reasonable, since some decisions depend on the exchange rate, which is generally known sooner than the aggregate price level.

1. For a different case, in which the deliberate generation of uncertainty improves the yield of a government's (implicit) inflation tax, see Harry G. Johnson, "A Note on the Dishonest Government and the Inflation Tax", *Journal of Monetary Economics*, 1977, pp.375-377.

Remaining for the moment in the context of a closed economy, let us see how non-neutrality of monetary policy can arise when demand decisions can be taken with a shorter lag than supply decisions. Let us modify our first model by assuming that demand is based on a real interest rate where the rate of inflation from period t to $t+1$ is predicted on the basis of information available in period t and not just on that available in period $t-1$.

$$15) \quad q_t = -c(R_t - E_t p_{t+1} + p_t) + by_{t-1}$$

The other equations of the model, including the "only current price surprises matter" supply function, are unchanged.

$$1) \quad y_t = a(p_t - E_{t-1} p_t)$$

$$3) \quad q_t = y_t$$

$$4) \quad m_t = p_t + q_t - X_t - \frac{1}{f} R_t$$

The reduced form equation in prices and expected prices is:

$$\begin{aligned} &\{(1+cf)a + c(1+f)\} p_t - (1+cf) a E_{t-1} p_t - cf m_t - cf X_t - c E_t p_{t+1} \\ &- ab p_{t-1} + ab E_{t-2} p_{t-1} = 0 \end{aligned}$$

Assuming initially a passive monetary policy, put $m_t = 0$ for all t .

Look for a solution of the form $p_t = \sum_{i=0}^{\infty} \pi_i X_{t-i}$. We obtain:

$$\begin{aligned} 16) \quad &\{(1+cf)a + c(1+f)\} \sum_{i=0}^{\infty} \pi_i X_{t-i} - (1+cf) a \sum_{i=1}^{\infty} \pi_i X_{t-i} - cf X_t \\ &- c \sum_{i=1}^{\infty} \pi_i X_{t-i+1} - ab \sum_{i=0}^{\infty} \pi_i X_{t-i-1} + ab \sum_{i=1}^{\infty} \pi_i X_{t-i-1} = 0 \end{aligned}$$

Taking terms in X_t :

$$17) \quad \{(1+cf)a + c(1+f)\} \pi_0 - cf - c \pi_1 = 0$$

Taking terms in X_{t-1} :

$$18) \quad c(1+f) \pi_1 - c \pi_2 - ab \pi_0 = 0$$

Taking terms in X_{t-2} :

$$19) \quad c(1+f) \pi_2 - c \pi_3 = 0$$

i.e. $\pi_3 = (1+f) \pi_2$

Similarly $\pi_{j+1} = (1+f) \pi_j$ for all $j \geq 2$.

Hence, by the boundary condition, $\pi_j = 0$ for all $j \geq 2$.

So, from equations 17 and 18:

$$\pi_1 = \frac{ab}{c(1+f)} \pi_0 \text{ and } \pi_0 = \frac{cf}{(1+cf)a + c(1+f) - \frac{ab}{1+f}}$$

Hence y_t , which $= a(p_t - E_{t-1} p_t)$,

$$= a(\pi_0 X_t + \pi_1 X_{t-1} - \pi_1 X_{t-1})$$

20) $= \frac{acf}{(1+cf)a + c(1+f) - \frac{ab}{1+f}} X_t$

Note that now π_0 , the responsiveness of prices to current disturbances, is also a function of b , which relates demand to past levels of output. Hence monetary policy based on past values of the variables, if anticipated by the public, will alter their behaviour and responsiveness to current disturbances, i.e. alter π_0 .

Assume an active monetary policy with the same monetary rule as before:

$$\begin{aligned} m_t &= \frac{-b}{cf} y_{t-1} \\ &= \frac{-ab}{cf} (p_{t-1} - E_{t-2} p_{t-1}) \\ &= \frac{-ab}{cf} \left\{ \sum_{i=0}^{\infty} \pi_i X_{t-i-1} - \sum_{i=1}^{\infty} \pi_i X_{t-i-1} \right\} \end{aligned}$$

Then equation 16 becomes:

$$\begin{aligned} &\{(1+cf)a + c(1+f)\} \sum_{i=0}^{\infty} \pi_i X_{t-i} - (1+cf)a \sum_{i=1}^{\infty} \pi_i X_{t-i} - cf X_t \\ &+ \left[ab \sum_{i=0}^{\infty} \pi_i X_{t-i-1} - ab \sum_{i=1}^{\infty} \pi_i X_{t-i-1} \right] - c \sum_{i=1}^{\infty} \pi_i X_{t-i+1} \\ &- ab \sum_{i=0}^{\infty} \pi_i X_{t-i-1} + ab \sum_{i=1}^{\infty} \pi_i X_{t-i-1} = 0 \end{aligned}$$

Taking terms in X_t :

$$\{(1+cf)a + c(1+f)\} \pi_0 - cf - c\pi_1 = 0$$

Taking terms in X_{t-1} :

$$c(1+f)\pi_1 - c\pi_2 = 0$$

$$\text{i.e.} \quad \pi_2 = (1+f)\pi_1$$

$$\text{Similarly} \quad \pi_{j+1} = (1+f)\pi_j \quad \text{for all } j \geq 1$$

So, by the boundary condition, $\pi_j = 0$ for all $j \geq 1$

$$\text{Hence} \quad \pi_0 = \frac{cf}{(1+cf)a + c(1+f)}$$

$$p_t = \pi_0 X_t$$

$$\text{And} \quad y_t = \frac{acf}{(1+cf)a + c(1+f)} X_t$$

Comparing this with the expression for y_t given by 20, there is a clear reduction in π_0 , and hence in the variance of y_t . Monetary policy has become effective. The economic reason for this change is that monetary policy in the current period can alter expectations about the inflation between the current and the next period, hence altering the real interest rate and hence demand decisions in the current period.

(v)

To demonstrate the possibility that exchange-rate policy might be ineffective, we develop a very simple extension of the previous, closed-economy model, adding to it an equation giving capital flows as a function of the covered interest-rate differential, an equation giving the current account balance as a function of the excess supply of goods, a balance-of-payments identity and a purchasing-power-parity condition. The model is then:

Supply of goods:

$$1) \quad y_t = a(p_t - E_{t-1} p_t)$$

Domestic demand for goods (domestically produced and imported):

$$2) \quad q_t = -c (R_t - E_{t-1} p_{t+1} + E_{t-1} p_t) + by_{t-1}$$

Domestic money-market equilibrium:

$$3) \quad m_t = p_t + q_t - \frac{1}{f} R_t$$

Purchasing-power-parity condition:

$$4) \quad e_t = h + p_t$$

Capital flows as a function of the covered interest rate differential:

$$K_t = k (E_{t-1} e_t - E_{t-1} e_{t+1} + R_t)$$

Current account balance as a function of the excess supply of goods:

$$S_t = g (y_t - q_t)$$

Balance of payments identity:

$$K_t + S_t + Z_t + W_t = 0$$

The last three equations reduce to:

$$5) \quad k (E_{t-1} e_t - E_{t-1} e_{t+1} + R_t) + gy_t - gq_t + Z_t + W_t = 0$$

Where: e_t = the logarithm of the deviation of the exchange rate,
measured as the domestic currency price of foreign
exchange, from its trend value in period t ,

K_t = net capital inflows in period t ,

S_t = current account surplus in period t ,

Z_t = a random disturbance on the foreign-exchange market in
period t ,

W_t = government intervention on the foreign-exchange market
in period t (net sales of foreign-exchange).

Note that we no longer have a disturbance term in the money supply, and we have not allowed capital flows to influence the money supply - doing so would not alter the qualitative conclusions of the model.

Since e_t and R_t are measured as deviations from trend it is not inappropriate to specify capital flows simply as a function of the covered interest differential rather than as the outcome of a stock-adjustment specification. And since the purchasing-power-parity condition means that domestic and foreign goods are perfect substitutes, there can be no relative price effect on the current account. Indeed, the current account equation might instead have been expressed as an identity with the current account equal to, rather than a function of the excess supply of goods, but the formulation used here allows for changes in domestic stocks absorbing some of the excess supply or demand.

The first step in solving the model is to obtain the reduced form equation in prices and expected prices. Writing equation 1 for Y_{t-1} and combining it with equations 2, 3, 4, 5, we have:

$$(gc + k)E_{t-1}p_{t+1} - \{gc + k - (1 + cf)ga\} E_{t-1}p_t - \{f(gc + k) + (1 + cf)ga\}p_t \\ + f(gc + k)m_t + ab(g - fk)p_{t-1} - ab(g - fk)E_{t-2}p_{t-1} - (1 + cf)(Z_t + W_t) = 0$$

Assume a passive monetary policy, so $m_t = 0$. Assume initially a passive exchange-rate policy, so $W_t = 0$. Look for a solution of the form

$$p_t = \sum_{i=0}^{\infty} \phi_i Z_{t-i}.$$

We have:

$$(gc + k) \sum_{i=2}^{\infty} \phi_i Z_{t-i+1} - \{gc + k - (1 + cf)ga\} \sum_{i=1}^{\infty} \phi_i Z_{t-i} \\ - \{f(gc + k) + (1 + cf)ga\} \sum_{i=0}^{\infty} \phi_i Z_{t-i} + ab(g - fk) \sum_{i=0}^{\infty} \phi_i Z_{t-i-1} \\ - ab(g - fk) \sum_{i=1}^{\infty} \phi_i Z_{t-i-1} - (1 + cf)Z_t = 0$$

This equation must hold for all Z_{t-j} ; hence, taking terms in Z_t :

$$6) \quad - \{f(gc + k) + (1 + cf)ga\} \phi_0 - (1 + cf) = 0$$

Taking terms in Z_{t-1} :

$$(gc + k)\phi_2 - (1 + f)(gc + k)\phi_1 + ab(g - fk)\phi_0 = 0$$

Taking terms in Z_{t-2} :

$$(gc + k)\phi_3 - (1 + f)(gc + k)\phi_2 = 0$$

Therefore: $\phi_3 = (1 + f)\phi_2$

Similarly, taking terms in Z_{t-j} , where $j \geq 2$ implies

$$\phi_{j+1} = (1 + f)\phi_j \text{ for all } j \geq 2.$$

But $f > 0$. Therefore, unless any exchange-market disturbance is to lead to a price explosion, $\phi_j = 0$ for all $j \geq 2$.

Hence $p_t = \phi_0 Z_t + \phi_1 Z_{t-1}$

And y_t , which $= a(p_t - E_{t-1}p_t)$,

$$= a \phi_0 Z_t$$

$$= \frac{-a(1 + cf)}{f(gc + k) + ga(1 + cf)} Z_t,$$

from equation 6. That is, output deviation from trend is a function only of current foreign-exchange market disturbances and private behavioural functions (the values of a, c, f, g, k) related to current variables, and hence any exchange-rate policy (value of W_t) based on past values of the variables or past exchange-market disturbances will be unable to stabilise current or future output.

(vi)

By analogy with monetary policy in a closed economy,¹ we may readily suppose that a different supply function, one incorporating more remote expectations, would restore the efficacy of exchange-market intervention.

Similarly, other modifications that would make monetary policy effective would also restore the effectiveness of exchange-rate policy.

1. Since the reduced form equations for p_t are so similar.

But in addition, in the case of an open economy we have to reckon with the fact that exchange-rates are usually known before the aggregate price level.¹ Consequently, it would be reasonable to replace our original equation for capital flows by:

$$7) \quad K_t = k(e_t - E_t e_{t+1} + R_t),$$

where capital flows in period t are now determined by the current exchange-rate e_t and current expectations about e_{t+1} , rather than by expectations formed using the information of period $t-1$ concerning e_t and e_{t+1} .

This now restores the effectiveness of anticipated exchange-rate policy, despite the retention of the original supply function: the known form of the exchange-rate rule as it will operate in period $t+1$ (based on the values of Z_t , Z_{t-1} etc.) will influence current expectations about e_{t+1} , and hence will modify the response of K_t to the current disturbances Z_t . In this way the form of the exchange-rate rule will influence capital flows and hence, via the exchange-rate and the interest rate, the value of real output. Let us see how this works.

Using 7) the foreign-exchange market equilibrium condition becomes:

$$k(e_t - E_t e_{t+1} + R_t) + gy_t - gq_t + Z_t + W_t = 0$$

Combining this with equations 1 to 4 of the original model, the reduced-form equation in prices and expected prices becomes:

$$\begin{aligned} & c(g - fk)E_{t-1}p_{t+1} - \{(k + ga)(1 + cf) + f(cg + k)\} p_t \\ & + f(cg + k)m_t + \{(1 + cf)ga - c(g - fk)\} E_{t-1}p_t \\ & + ab(g - fk)p_{t-1} - ab(g - fk)E_{t-2}p_{t-1} + k(1 + cf)E_t p_{t+1} \end{aligned}$$

1. This fact does not sit well with the assumption of instantaneous purchasing-power-parity, but most modifications of the purchasing-power-parity condition would not negate the renewed effectiveness of exchange-market intervention which results. (Putting $e_t = h + E_{t-1}p_t$ would do so.)

$$- (1 + cf) (Z_t + W_t) = 0$$

As before, assume a passive monetary policy, so $m_t = 0$. Assume initially a passive exchange-rate policy, so $W_t = 0$. Look for a solution of the form $p_t = \sum_{i=0}^{\infty} \phi_i Z_{t-i}$.

Then:

$$\begin{aligned} & c(g - fk) \sum_{i=2}^{\infty} \phi_i Z_{t-i+1} - \{(k + ga)(1 + cf) + f(cg + k)\} \sum_{i=0}^{\infty} \phi_i Z_{t-i} \\ & + \{(1 + cf)ga - c(g - fk)\} \sum_{i=1}^{\infty} \phi_i Z_{t-i} + ab(g - fk) \sum_{i=0}^{\infty} \phi_i Z_{t-i-1} \\ & - ab(g - fk) \sum_{i=1}^{\infty} \phi_i Z_{t-i-1} + k(1 + cf) \sum_{i=1}^{\infty} \phi_i Z_{t-i+1} - (1 + cf)Z_t = 0 \end{aligned}$$

Taking terms in Z_t :

$$8) \quad - \{(k + ga)(1 + cf) + f(cg + k)\} \phi_0 + k(1 + cf) \phi_1 - (1 + cf) = 0$$

Taking terms in Z_{t-1} :

$$9) \quad -(cg + k)(1 + f) \phi_1 + (cg + k) \phi_2 + ab(g - fk) \phi_0 = 0$$

Taking terms in Z_{t-2} :

$$-(cg + k)(1 + f) \phi_2 + (cg + k) \phi_3 = 0$$

$$\text{Therefore} \quad \phi_3 = (1 + f)\phi_2$$

Similarly, taking terms in Z_{t-j} for $j \geq 2$ gives

$$\phi_{j+1} = (1 + f)\phi_j \text{ for } j \geq 2, \text{ and so,}$$

if disturbances in the foreign-exchange market are not to give rise to price explosions, $\phi_j = 0$ for $j \geq 2$.

$$\text{So, from equation 9:} \quad \phi_1 = \frac{ab(g - fk)}{(cg + k)(1 + f)} \phi_0$$

Hence, from equation 8:

$$\phi_0 = \frac{-(1 + cf)}{f(gc + k) + (ga + k)(1 + cf) - \frac{k(1 + cf)ab(g - fk)}{(cg + k)(1 + f)}}$$

And y_t , which $= a(p_t - E_{t-1}p_t)$

$$10) \quad = a\phi_0 Z_t, \text{ with } \phi_0 \text{ as above.}$$

An active exchange-rate policy is now able to influence ϕ_0 . The optimal policy will depend on the values of the parameters: in the case where $(g - fk) > 0$, the following exchange-rate rule gives a clear reduction in the variance of y_t .

$$\begin{aligned} \text{Let } w_t &= \frac{b(g - fk)}{1 + cf} y_{t-1} \\ &= \frac{ab(g - fk)}{1 + cf} \left\{ \sum_{i=0}^{\infty} \phi_i z_{t-i-1} - \sum_{i=1}^{\infty} \phi_i z_{t-i-1} \right\} \end{aligned}$$

The reduced form in the z_{t-j} is now:

$$\begin{aligned} &c(g - fk) \sum_{i=2}^{\infty} \phi_i z_{t-i+1} - \{(k + ga)(1 + cf) + f(cg + k)\} \sum_{i=0}^{\infty} \phi_i z_{t-i} \\ &+ \{(1 + cf)ga - c(g - fk)\} \sum_{i=1}^{\infty} \phi_i z_{t-i} + k(1 + cf) \sum_{i=1}^{\infty} \phi_i z_{t-i+1} \\ &- (1 + cf)z_t = 0. \end{aligned}$$

Taking terms in z_t :

$$- \{(k + ga)(1 + cf) + f(cg + k)\} \phi_0 + k(1 + cf) \phi_1 - (1 + cf) = 0$$

Taking terms in z_{t-1} :

$$- (cg + k)(1 + f) \phi_1 + (cg + k) \phi_2 = 0$$

$$\text{Therefore } \phi_2 = (1 + f)\phi_1$$

$$\text{Similarly } \phi_{j+1} = (1 + f)\phi_j \text{ for all } j \geq 1.$$

Hence by the boundary condition, $\phi_j = 0$ for all $j \geq 1$.

$$\text{Therefore } \phi_0 = \frac{-(1 + cf)}{(k + ga)(1 + cf) + f(cg + k)}$$

$$\text{and } y_t = a\phi_0 z_t, \text{ with } \phi_0 \text{ as above.}$$

Comparing this with the expression for y_t given by 10, there is a clear reduction in ϕ_0 , and hence in the variance of y_t .

(vii)

We have shown that by making extreme assumptions about the flexibility of prices, the efficiency of goods arbitrage, and the efficiency of private sector use of all technically available information, it is possible to construct a model in which exchange-market intervention will be powerless to affect real variables. The modifications to the model already noted in the literature in the case of monetary policy will serve to restore the efficacy of exchange-rate policy also. In addition, once the transition is made from a closed to an open economy, the fact that exchange-rates are generally known before economy-wide information about prices is established, means that there is an additional opportunity for an active exchange-rate policy (or macro-economic policy generally) to play a part in stabilising output.¹

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1. We have concentrated on the possible effect of exchange-rate policy on real output, as being the most subject to question. W.H. Buiter, using a different model which retains the usual rational expectations assumption that information on all the state variables is known simultaneously, demonstrates that even in such circumstances there is a role for active exchange-rate policies in stabilizing prices and, if there are international financial flows, in affecting the balance of payments. See W.H. Buiter, "Optimal Foreign Exchange Market Intervention with Rational Expectations", pp.1-37 in J.P. Martin and A. Smith, "Trade and Payments Adjustment under Flexible Exchange Rates", London, Macmillan, 1979.

CHAPTER TWO

THE INTERNATIONAL TRANSMISSION OF DISTURBANCES

UNDER FLOATING EXCHANGE RATES

(i)

It was argued in the previous chapter that the main benefits to be hoped for from exchange-rate policy lay in the stabilization of a number of economic variables. Before considering the design of exchange-rate policy, it is therefore appropriate to trace out the ways in which those variables are affected by or insulated from foreign disturbances in the absence of all government intervention; in other words, to look at the international transmission of disturbances under freely floating rates.

Of course, the manner in which external disturbances are transmitted to the domestic economy is only one of the considerations behind any exchange-rate policy. Considerable attention has also been given to the question of whether disturbances are mainly internally generated or mainly external in origin. In a very simplified form, the argument has been that if the domestic economy is less stable than the outside world, then it would benefit from an exchange-rate arrangement which linked it closely to the outside world, so that the effects of disturbances generated at home would be dissipated quickly: whereas if the domestic economy were more stable than the world as a whole it would be better to implement an arrangement which insulated the home country from external disturbances, even if it then had to suffer the full effects of internally generated changes. And floating exchange rates have been supposed to provide such insulation, at least for monetary, as opposed to real disturbances.

As is well known, the argument is not in fact quite so simple. In the first place, one has to take account of the timing of disturbances

as well as their frequency and size. Even if by any overall measure of stability the domestic economy were more stable than the outside world, one might want to open it up to external influences if the timing and direction of disturbances from abroad were such that they tended to offset domestic disturbances. Thus, the covariance of internal and external disturbances must also be taken into account.

But even when full consideration has been given to the origin and timing of disturbances, the way in which they affect the domestic economy remains important - and this is likely to vary from country to country, just as the predominant source of disturbance will.¹ Without going into all the details of the Swiss economy, one might illustrate the issues involved by taking as an example a small, open economy like Switzerland, which in the 1970's was internally more stable than the rest of the world, and where most disturbances were external. Under a freely floating rate, external disturbances would show up first of all in changes in the exchange rate and perhaps in offsetting changes in the capital account and trade balance. Under a fixed rate the impact of external changes would be on changes in foreign exchange reserves and (unless these were fully sterilized) in the domestic money supply, as well as changes in the trade balance and the domestic prices of traded goods. On the whole, the conventional wisdom that a floating exchange rate would insulate the economy better under these circumstances would

1. For a survey of the issues behind the choice of exchange-rate policy, see E. Tower and T. Willett, "The Theory of Optimum Currency Areas and Exchange Rate Flexibility", Princeton Special Papers in International Finance, No.11, May 1976. For an analysis of countries' actual exchange-rate practices, see H.R. Heller, "Choosing an Exchange Rate System", Finance and Development, June 1977, pp.23-27; and P. Holden, M. Holden and E.C. Suss, "The Determinants of Exchange Rate Flexibility: An Empirical Investigation", Review of Economics and Statistics, Vol.61, August 1979, pp.327-333.

seem to apply, and Switzerland did in fact make use of a flexible rate. But the insulation argument depends on the exchange-rate changes being the "right" ones. If exchange rate movements in reaction to external disturbances are likely to be large and violent (both because of the nature of the external disturbances, such as capital flows which are not very sensitive to the exchange rate, and because the current account reacts slowly to deviations of the exchange rate from purchasing power parity), and if such fluctuating departures from the "equilibrium" exchange rate have swift consequences for the domestic economy (because of a low degree of exchange-rate illusion, for example), then some measure of exchange-rate intervention might be warranted. And Switzerland in recent years has adopted this course also.

Finally, posing the question of the choice of exchange-rate policy in terms of the effects on domestic stability does assume that one is dealing with a "small" economy. It might well be reasonable for a small country to consider the effect of its exchange-rate policy on its economic stability in isolation; but large countries have to consider the effect on the stability of the world economy as well.

(ii)

Quite apart from being a preliminary to any study of exchange-rate policy, the dynamics of a floating exchange-rate system are likely to be of some interest in themselves in view of recent experiences under floating, albeit heavily managed, exchange rates. One has observed quite large and swift changes in exchange rates, often in directions different to those predicted by purchasing power parity. And interest rates and rates of inflation have also fluctuated, often apparently as a result of external influences. Naturally, in any particular case

there will be special circumstances which apply, but one can get quite far in explaining the movements of exchange rates and other economic variables with the help of relatively simple models.

One popular explanation for the sharp movements in exchange rates and their apparent overshooting of equilibrium levels lies in the revision of expectations.¹ The current value of the exchange rate depends on expectations about its future value and expectations about interest rates. Consequently, if events occur which lead people to revise their expectations about future levels of the exchange rate and other economic variables, there can be abrupt changes in the current exchange rate. There is no doubt that such changes in expectations have occurred, as a result of extraneous, perhaps political, developments and as a result of changes in feelings concerning the economic situation. And one can trace some changes in exchange rates directly to such revisions of expectations. All the same, frequent revisions of expectations seem unlikely to be the sole cause of exchange rate volatility, and it seems worth investigating whether a floating rate system might not in itself permit the overshooting of exchange rates (and interest rates) in reaction to foreign disturbances.

One interesting approach to the dynamics of a floating exchange rate has been taken by a number of economists, notably P.J.K. Kouri,² and

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1. This explanation is emphasised by Peter Isard, "Exchange-Rate Determination: A Survey of Popular Views and Recent Models", Princeton Study in International Finance, No.42, May 1978, pp.32-34.
 2. Pentti J.K. Kouri, "Capital Flows and the Dynamics of the Exchange Rate", Institute for International Economic Studies, University of Stockholm, Seminar Paper No.67, December 1976; Pentti J.K. Kouri and Jorge Braga de Macedo, "Exchange Rates and the International Adjustment Process", Cowles Foundation Discussion Paper No.488, March 15th 1978.
A similar approach is taken by Russel S. Boyer, "Financial Policies in an Open Economy", *Economica*, Vol.45, February 1978, pp.39-57.

gives prominence to the wealth effects and to the changes in total asset supplies underlying a current account imbalance. Without going into the details, particularly in the modelling of expectations, one can get the flavour of this approach by considering the distinction which Kouri draws between momentary equilibrium, the medium run and the long run. In momentary equilibrium output remains constant and there are no capital movements; only the prices of assets and the exchange rate adjust so that the existing stock of foreign assets is willingly held. Thus, if at existing asset prices and exchange rates the stock of foreign assets held by domestic residents is too high, the exchange rate will appreciate: this increases domestic wealth and makes domestic residents willing to hold the stock of foreign assets which now represents a smaller proportion of their total wealth. In the medium run, output and the current account balance adjust, and in the long run general inflation or deflation have restored output and the domestic real interest rate to their long run equilibrium levels. Thus, for example, a tight monetary policy has different short run and long run effects. In the momentary period the exchange rate appreciates so that the existing mixture of foreign assets and domestic assets is willingly held. In the medium run there is a current account deficit in reaction to the appreciated exchange rate, and a corresponding capital account surplus implying a net decrease in domestic holdings of foreign assets. This change in asset holdings requires a depreciation of the exchange rate. In the long run, the level of net interest outpayments will have increased, and hence the trade surplus must increase, so that in the end the exchange rate must be depreciated below its initial level.

While the later models of Kouri, in particular, have much in common with the approach we shall adopt, we shall instead use the framework

provided by a model of R. Dornbusch¹ which focuses more explicitly on the short run and relative rates of return and less on the changes in wealth and asset supplies which require a longer time to produce their effects.

The next section summarises Dornbusch's model and its reaction to an internal disturbance, and the remaining sections of this chapter set out a model extended to provide a better explanation of the reaction to external disturbances. Even so, two major simplifications are retained. Firstly, we shall assume throughout that domestic real output is constant. It would be quite easy to allow the endogenous factors to have an effect on output, and Dornbusch, in the article which is the basis for the simple monetarist model summarised in the next section, goes on to make this extension on the assumption that domestic output responds only to changes in aggregate demand. But such an extension is unlikely to modify the results fundamentally for prices, interest rates and the exchange rate, the variables we shall be studying, all of which are likely to be more volatile than real output. (Since aggregate demand will vary, there will be temporary disequilibrium in the goods market. The process of adjustment is not modelled explicitly. Since prices change only slowly, one can imagine some combination of changes in stocks and the trade balance during periods of incipient disequilibrium, while capital is assumed sufficiently mobile to finance any trade imbalance with only very marginal changes in interest rates or the exchange rate.)

A more serious omission in any study of the dynamics of floating exchange rates as they have operated in recent years is the assumption

1. Rudiger Dornbusch, "Expectations and Exchange-Rate Dynamics", Journal of Political Economy, Vol.84, December 1976, pp.1161-1176.

that the domestic money supply is fixed (or at least exogenous). Of course, this would be true for a genuinely freely floating rate, but in reality transitory current account imbalances or capital flows frequently do give rise to exchange-market intervention, which generates overall balance of payments surpluses or deficits which are often incompletely sterilized, so that they do have an effect on the money supply. Within the terms of the model itself, the assumption of a fixed money supply can also be justified on the grounds that one is considering the changing conditions necessary for the existing portfolio of domestic and foreign assets to continue to be held. There is then no incentive to reshuffle these portfolios via capital movements. And since total international capital movements are small relative to total financial portfolios, this approach may capture the more important effects involved. Nevertheless, this is an area in which the model will be extended once government intervention in the foreign-exchange market is allowed for.

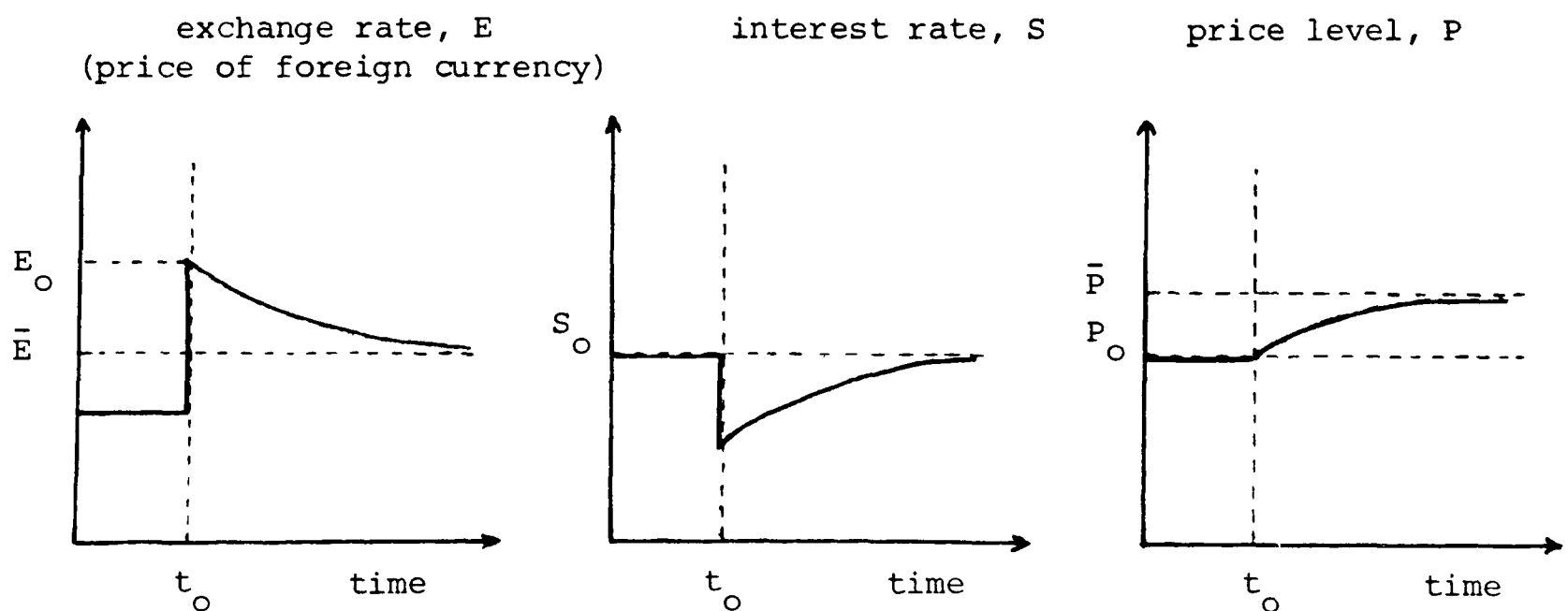
(iii)

The model which Dornbusch proposes generates its dynamics by assuming that the exchange-rate is completely flexible, free to adjust instantly; whereas domestic prices adjust only slowly in response to excess aggregate demand. The interest rate and the price level are tied together by a money market equation which has the velocity of circulation positively related to the nominal interest rate.

Consider a disturbance of the type analysed by Dornbusch, a sudden once and for all increase in the domestic money supply. If the money market is to stay in equilibrium there must be an immediate decrease in the nominal interest rate, as determined by the money market equation.

The covered interest rate arbitrage condition then requires that there be a forward premium on the domestic currency. Since the forward rate is equal to the expected future spot rate (there are speculators ready to move unlimited funds if it should diverge) and since the expected equilibrium (purchasing power parity) spot rate after a domestic monetary expansion will be depreciated from its present level, this means that when the spot exchange rate depreciates immediately after the initial shock, it does so not just to its future equilibrium level, but overshoots it and then slowly appreciates back up to its new equilibrium level. Meanwhile the depreciated exchange rate and the lowered nominal interest rate increase aggregate demand, which puts pressure on the domestic price level, which slowly rises to a level proportional to the new level of the money supply. As it does so the interest rate returns to its original level.

After an increase in the domestic money supply at t_0



So far, limited though its scope is, the model does a good job in explaining some features of the experience with floating rates: sharp fluctuations in exchange rates and interest rates, even with efficient forward markets and perfect capital mobility; temporary deviations of exchange rates from purchasing power parity; the possible co-existence of an appreciating exchange rate and an increasing price level.

(iv)

When one comes to consider the reaction of the economy to foreign disturbances, a weakness in the model becomes apparent. Since the interest rate is tied to the price level in the money market equation, it can adjust only as fast as the price level (if the domestic money supply is constant). And that seems counter-factual. The weakness is one not uncommon in monetarist models and stems from having money as the only financial asset.¹ The expanded model includes an equation representing expectations about the future course of the spot rate and one specifying the link between forward rates of two different maturities and hence, given covered interest arbitrage in both maturities, specifying the term structure of interest rates. In this way a foreign disturbance can call forth step reactions in the exchange rate and short-term interest rate, while long-term interest rates respond more slowly (the term structure of interest rates being twisted in the interim).

A second, less important addition involves including the terms of trade as one determinant of the demand for money. The reason for this is that the terms of trade affect not only the real value of cash balances but also real income. If the exchange rate depreciates, the command

1. F.H. Hahn, "The Monetary Approach to the Balance of Payments", *Journal of International Economics*, August 1977, pp.231-249.

of domestic income over foreign goods is less (the prices of domestic goods are already included in the demand for money equation) so that there is a lower demand for real cash balances; at the same time the increase in the domestic price of foreign goods has lowered the real value of existing cash balances. The net effect on the nominal demand for money can go either way. We are assuming that employment and physical output remain constant, so that one must see if the fall in the demand for real balances caused by the depreciation's reduction of real income is more or less than met by the proportionate fall in real balances caused by the rise in the domestic price of foreign goods. If the income elasticity of the demand for real balances is greater than one (money is a luxury good), the price change will not in itself have reduced the value of real cash balances sufficiently, and so a depreciation will lead to a reduction in the demand for nominal money; conversely, if the income elasticity of the demand for real balances is less than one (money is a necessity), a depreciation will increase the demand for nominal money.¹

(v)

The expanded model is set out below. The following conventions are used in the notation:

all upper case Roman letters are variables,

all lower case Roman letters (except "t") are the natural

logarithms of the variables,

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1. For completeness one should perhaps include the effect of an exchange-rate change on wealth as well as on real income, since this might also affect the demand for domestic real cash balances. If the country is a net debtor in foreign-currency denominated assets its net wealth, measured in domestic currency, will decrease with an unforeseen depreciation, but it will increase if the country is a net creditor.

lower case Greek letters are parameters,

a dash denotes a foreign variable, a star a foreign equilibrium value,

a bar denotes a domestic equilibrium value.

The symbols used are:

e	log of the spot exchange rate (price of foreign currency)
$\bar{e}$	equilibrium level of e
R'	short term foreign interest rate
R	short term home interest rate
S	medium term home interest rate
S'	medium term foreign interest rate
E_{fR}	forward exchange rate of maturity R
E	spot exchange rate
E_{fS}	forward exchange-rate of maturity S
m	log of the domestic money supply
p	log of the price level of domestic goods
y	log of real domestic income
D	domestic aggregate demand
p'	log of the foreign price level
Y	real domestic income
$\dot{p}$	differential of p with respect to time
p^*	foreign equilibrium price level
$\bar{p}$	log of the equilibrium domestic price level
t	calendar time

The model is constructed as follows.

Speculation: The expected rate of change of the exchange rate is given by:

$$E \left[\frac{de}{dt} \right] = \psi(\bar{e} - e)$$

Choosing units of time appropriately and assuming that the volume of speculative funds is sufficient so that the forward rate of maturity R is equal to the expected future value of the exchange rate at time R :

$$(i) \quad \frac{E_{fR} - E}{E} = \psi(\bar{e} - e)$$

$$(ii) \quad \text{Arbitrage of Maturity } R: \quad (1 + R) = \frac{E_{fR}}{E} (1 + R')$$

$$(iii) \quad \text{Arbitrage of Maturity } S: \quad (1 + S) = \frac{E_{fS}}{E} (1 + S')$$

$$(iv) \quad \text{Term Structure/Speculation:} \quad \frac{(E_{fS} - E_{fR})}{E} = \xi(\bar{e} - e)$$

From equations (i) and (ii), approximating (ii) by

$$R - R' = \frac{E_{fR} - E}{E}, \quad \text{we obtain the short term arbitrage/}$$

speculation equilibrium condition:

$$I \quad R - R' = \psi(\bar{e} - e)$$

From (ii), (iii) and (iv), the combined Arbitrage/Term Structure/Speculation equation is

$$II \quad \frac{(1 + S)}{(1 + S')} - \xi(\bar{e} - e) = \frac{(1 + R)}{(1 + R')}$$

$$III \quad \text{The Money Market:} \quad m - p = \phi y - \lambda S + \mu(e - \bar{e})$$

$$\text{The Goods Market:} \quad \log D = \epsilon + \delta(e + p' - p) + \gamma y - \sigma S$$

$$IV \quad \dot{p} = \pi \log \left(\frac{D}{Y} \right) = \pi \{ \epsilon + \delta(e + p' - p) + (\gamma - 1) y - \sigma S \}$$

(vi)

Case One : A Real Disturbance Abroad

We consider a sudden, once and for all increase in the foreign real interest rate from

$$S' = S'_0 \text{ to } S' = S^*$$

We assume the foreign term structure of interest rates is constant, so no generality is lost by taking $R'_0 = S'_0$ and $R^* = S^*$

We assume foreign prices remain constant at $p' = p^*$

The model then becomes:

$$(1) \text{ Short-term Financial Equilibrium: } \psi(\bar{e} - e) + S^* = R$$

Arbitrage/Term Structure/

$$\text{Speculation: } \frac{(1 + S)}{(1 + S^*)} - \xi(\bar{e} - e) = \frac{(1 + R)}{(1 + S^*)}$$

$$\text{Hence } (S - R) = \xi(1 + S^*)(\bar{e} - e)$$

$$(2) \text{ Which write as } (S - R) = \chi(\bar{e} - e)$$

$$(3) \text{ The Money Market: } m - p = \phi y - \lambda S + \mu(e - \bar{e})$$

$$\text{Goods Market: } \dot{p} = \pi \{ \epsilon + \delta(e - p^* - p) + (\gamma - 1)y - \sigma S \}$$

one may as well define units so $p^* = 1$ and $\therefore p^* = 0$

$$(4) \quad \dot{p} = \pi \{ \epsilon + \delta(e - p) + (\gamma - 1)y - \sigma S \}$$

From (1), the bond market and (2), arbitrage etc.; eliminating R:

$$S - S^* - \psi(\bar{e} - e) = \chi(\bar{e} - e)$$

$$(5) \quad \therefore (S - S^*) = (\chi + \psi)(\bar{e} - e)$$

And from (3), the money market: $p = m - \phi y + \lambda S - \mu(e - \bar{e})$.

In equilibrium, when $e = \bar{e}$ and $S = S^*$ [see (5)], $p = \bar{p}$

and so, $\bar{p} = m - \phi y + \lambda S^*$

hence: $(p - \bar{p}) = \lambda(S - S^*) - \mu(e - \bar{e})$

substituting from (5), $(p - \bar{p}) = \lambda(S - S^*) + \frac{\mu}{\lambda + \psi} (S - S^*)$

$$(6) \quad (p - \bar{p}) = \frac{\lambda(\lambda + \psi) + \mu}{(\lambda + \psi)} (S - S^*)$$

From the goods market, (4): $\dot{p} = \pi \{ \epsilon + \delta(e - p) + (\gamma - 1)y - \sigma S \}$

In equilibrium, when $e = \bar{e}$, $p = \bar{p}$, $S = S^*$, $\dot{p} = 0$

and so: $0 = \pi \{ \epsilon + \delta(\bar{e} - \bar{p}) + (\gamma - 1)y - \sigma S^* \}$

Therefore: $\bar{e} = \bar{p} + \frac{1}{\delta} \{ \sigma S^* + (1 - \gamma)y - \epsilon \}$

Now, from (5): $e = \bar{e} + \frac{1}{\lambda + \psi} (S^* - S)$ and so, substituting for $\bar{e}$:

$$e = \bar{p} + \frac{1}{\delta} \{ \sigma S^* + (1 - \gamma)y - \epsilon \} + \frac{1}{\lambda + \psi} (S^* - S)$$

So the expression for $\dot{p}$ becomes:

$$\begin{aligned} \dot{p} &= \pi \left\{ \begin{aligned} &\epsilon + \delta \bar{p} + \sigma S^* + (1 - \gamma)y - \epsilon + \frac{\delta}{\lambda + \psi} (S^* - S) \\ &- \delta p + (\gamma - 1)y - \sigma S \end{aligned} \right\} \\ &= \pi \left\{ \delta(\bar{p} - p) + \sigma(S^* - S) + \frac{\delta}{\lambda + \psi} (S^* - S) \right\} \end{aligned}$$

But we can substitute from (6) for $(S^* - S)$

$$\dot{p} = \pi \left\{ \delta + \frac{\sigma(\lambda + \psi)}{\lambda(\lambda + \psi) + \mu} + \frac{\delta}{\lambda(\lambda + \psi) + \mu} \right\} (\bar{p} - p)$$

$$\text{Define } \omega = \pi \left\{ \delta + \frac{\sigma(\lambda + \psi)}{\lambda(\lambda + \psi) + \mu} + \frac{\delta}{\lambda(\lambda + \psi) + \mu} \right\}$$

$$\text{Then } \dot{p} = \omega(\bar{p} - p) = -\omega(p - \bar{p})$$

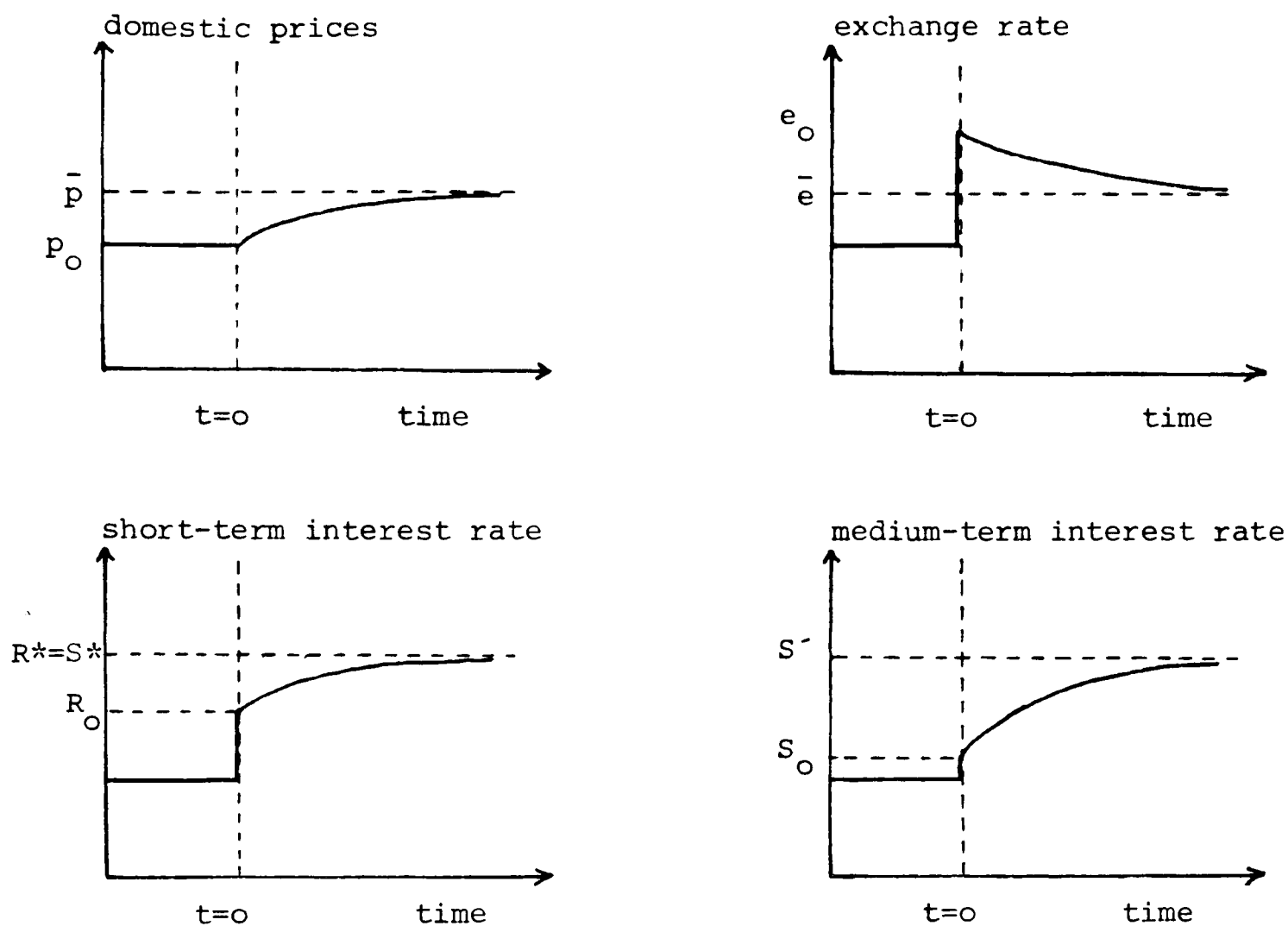
Which has a solution: $p(t) = \bar{p} + (p_0 - \bar{p}) e^{-\omega t}$
(taking $p = p_0$ when $t = 0$)

$$\text{And from (6): } S(t) = S^* + (S_0 - S^*) e^{-\omega t}$$

$$\text{And from (5): } e(t) = \bar{e} + (e_0 - \bar{e}) e^{-\omega t}$$

$$\text{And from (1): } R(t) = R - \psi(e_0 - \bar{e}) e^{-\omega t}$$

Graphically, reaction to foreign real interest rate rise



(The diagrams are drawn for the case where $\mu > 0$, i.e. a depreciated exchange rate increases the demand for nominal money. This has a damping effect on the disturbances, e.g. it allows the step change in the medium term interest rate at $t = 0$ towards its equilibrium level.)

(vii)

Case Two : A Monetary Disturbance Abroad

We consider a sudden, once and for all decrease in the foreign money supply. This leads to an immediate increase in the foreign interest rates to R'_0 and S'_0 . Suppose foreign prices decline over time according to:

$$p' = p^* + (p'_0 - p^*) e^{-\nu t}$$

Then, from the foreign money-market equations one would expect the interest rate to decline to its original level according to:

$$S' = S^* + (S'_0 - S^*) e^{-\nu t}$$

Assume the term structure of foreign interest rates is unchanged so that

$$R' = S'$$

The model becomes:

$$(1) \text{ Short-term market: } \psi(\bar{e} - e) + S' = R$$

$$\text{Arbitrage etc: } \frac{(1 + S)}{(1 + S')} - \xi(\bar{e} - e) = \frac{(1 + R)}{(1 + S')}$$

If one takes $\xi(1 + S') \doteq \xi(1 + S^*) = \chi$ this becomes

$$(2) \quad (S - R) = \chi(\bar{e} - e)$$

$$(3) \text{ Money Market: } m - p = \phi y - \lambda S + \mu(e - \bar{e})$$

$$\text{Goods Market: } \dot{p} = \pi\{\epsilon + \delta(e + p^* + (p_0' - p^*)e^{-\nu t} - p) + (\gamma - 1)y - \sigma S\}$$

as before, take $p^* = 0$

$$(4) \quad \therefore \dot{p} = \pi\{\epsilon + \delta(e + p_0' e^{-\nu t} - p) + (\gamma - 1)y - \sigma S\}$$

Combining (1) and (2):

$$(5) \quad (S - S') = (\chi + \psi)(\bar{e} - e)$$

From the money market:

$$p = m - \phi y + \lambda S - \mu(e - \bar{e})$$

In equilibrium, when $e = \bar{e}$ and $S = S^*$, $p = \bar{p}$,

$$\text{so, } \bar{p} = m - \phi y + \lambda S^*$$

$$(6) \text{ therefore } (p - \bar{p}) = \lambda(S - S^*) - \mu(e - \bar{e})$$

Combining (5) and (6), eliminating S:

$$(7) \quad (e - \bar{e}) = \frac{\lambda}{\lambda(\chi + \psi) + \mu} \left\{ \frac{1}{\lambda} (p - \bar{p}) + (S' - S^*) \right\}$$

From the Goods Market, (4):

$$\dot{p} = \pi\{\epsilon + \delta(e + p_0' e^{-\nu t} - p) + (\gamma - 1)y - \sigma S\}$$

In equilibrium, when $e = \bar{e}$, $p = \bar{p}$, $e^{-\nu t} \rightarrow 0$, $S = S^*$, $\dot{p} = 0$

$$\therefore 0 = \pi\{\epsilon + \delta(\bar{e} - \bar{p}) + (\gamma - 1)y - \sigma S^*\}$$

$$\therefore \bar{e} = \bar{p} + \frac{1}{\delta} \{\sigma S^* + (1 + \gamma)y - \epsilon\}$$

From (5) $e = \bar{e} + \frac{1}{(\chi + \psi)} (S' - S)$ and, substituting for $\bar{e}$:

$$e = \bar{p} + \frac{1}{\delta} (\sigma S^* + (1 - \gamma)y - \epsilon) + \frac{1}{\chi + \psi} (S' - S)$$

So the expression for $\dot{p}$ becomes:

$$\begin{aligned} \dot{p} &= \pi\{\epsilon + \delta\bar{p} + \sigma S^* + (1 - \gamma)y - \epsilon + \frac{\delta}{\chi + \psi} (S' - S) + \delta p_0 e^{-\nu t} - \delta p + (\gamma - 1)y - \sigma S\} \\ &= \pi\{\delta(\bar{p} + p_0 e^{-\nu t} - p) + \sigma(S^* - S) + \frac{\delta}{\chi + \psi} (S' - S)\} \end{aligned}$$

Substituting from (5) for $(S' - S)$ and from (6) for $S - S^*$:

$$\dot{p} = \pi \left\{ \delta(\bar{p} + p_0 e^{-\nu t} - p) + \frac{\sigma}{\lambda} [\bar{p} - p - \mu(e - \bar{e})] + \delta(e - \bar{e}) \right\}$$

Substituting from (7) for $(e - \bar{e})$:

$$\dot{p} = \pi \left\{ \left(\delta + \frac{\sigma}{\lambda} \right) (\bar{p} - p) + \delta p_0 e^{-\nu t} + \frac{\delta\lambda - \mu\sigma}{\lambda^2(\chi + \psi) + \lambda\mu} (\bar{p} - p) + \frac{\delta\lambda - \mu\sigma}{\lambda(\chi + \psi) + \mu} (S' - S^*) \right\}$$

Which from our assumption about S' becomes:

$$\dot{p} = \pi \left\{ \delta + \frac{\sigma}{\lambda} + \frac{\delta\lambda - \mu\sigma}{\lambda^2(\chi + \psi) + \lambda\mu} \right\} (\bar{p} - p) + \pi \left\{ \delta p_0 + \frac{\delta\lambda - \mu\sigma}{\lambda(\chi + \psi) + \mu} (S'_0 - S^*) \right\} e^{-\nu t}$$

$$\text{Define } \omega = \pi \left\{ \delta + \frac{\sigma(\chi + \psi) + \delta}{\lambda(\chi + \psi) + \mu} \right\} \text{ as before and } \pi \left\{ \delta p_0 + \frac{\delta\lambda - \mu\sigma}{\lambda(\chi + \psi) + \mu} (S'_0 - S^*) \right\} = \Phi$$

We get $\dot{p} = -\omega (p - \bar{p}) + \Phi e^{-\nu t}$

Which has solutions:

$$p(t) = \bar{p} + \left(p_0 - \bar{p} + \frac{\Phi}{\nu - \omega} \right) e^{-\omega t} - \frac{\Phi}{\nu - \omega} e^{-\nu t} \quad \text{for } \omega \neq \nu$$

$$\text{and } p(t) = \bar{p} + (p_0 - \bar{p} + \Phi t) e^{-\nu t} \quad \text{for } \omega = \nu$$

In this case $p_0 = \bar{p}$ so the solution becomes (we write out only the case when $\omega \neq \nu$):

$$p(t) = \bar{p} + \left(\frac{\Phi}{v - \omega} \right) \left(e^{-\omega t} - e^{-vt} \right)$$

Now, by assumption $S' = S + (S'_0 - S^*) e^{-vt}$, so from (7):

$$e(t) = \bar{e} - \frac{1}{\lambda(\chi + \psi) + \mu} \left(\frac{\Phi}{v - \omega} \right) \left(e^{-\omega t} - e^{-vt} \right) + \frac{\lambda}{\lambda(\chi + \psi) + \mu} (S'_0 - S^*) e^{-vt}$$

for $v \neq \omega$

And from (6):

$$s(t) = S + \frac{(\chi + \psi)}{\lambda(\chi + \psi) + \mu} \left(\frac{\Phi}{v - \omega} \right) \left(e^{-\omega t} - e^{-vt} \right) + \frac{\mu}{\lambda(\chi + \psi) + \mu} (S'_0 - S^*) e^{-vt}$$

for $v \neq \omega$

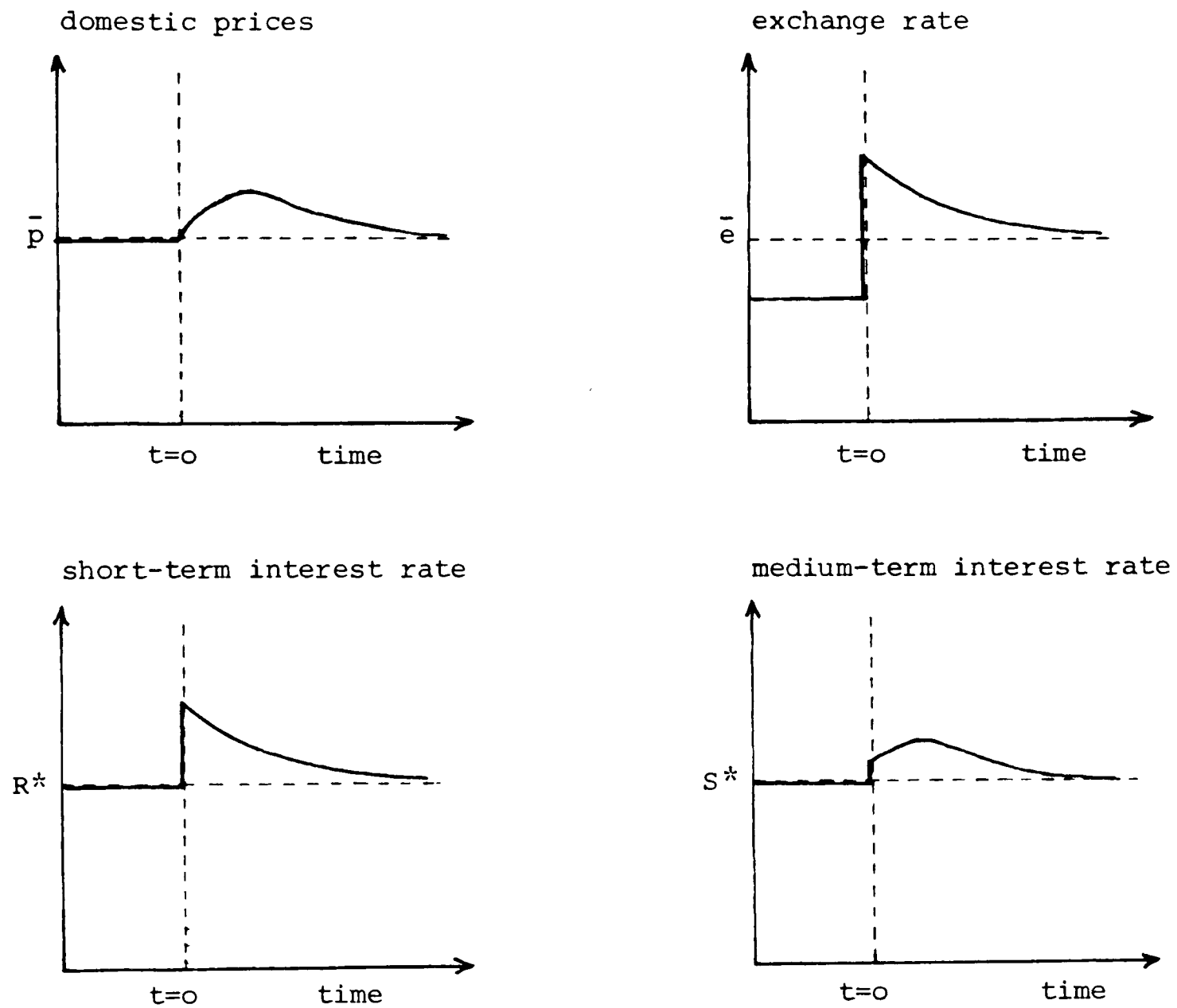
And from (1):

$$R(t) = S^* + (S'_0 - S^*) e^{-vt} - \psi(e - \bar{e})$$

$$= S^* + \frac{\psi}{\lambda(\chi + \psi) + \mu} \left(\frac{\Phi}{v - \omega} \right) \left(e^{-\omega t} - e^{-vt} \right) + \frac{\lambda\chi + \mu}{\lambda(\chi + \psi) + \mu} (S'_0 - S^*) e^{-vt}$$

for $v \neq \omega$

Reaction to a once-for-all decrease in foreign money supply



Thus, with freely floating exchange rates there are transitory changes in interest rates and domestic prices in reaction to even a purely monetary foreign disturbance, and the exchange rate overshoots its equilibrium level. In this case having $\mu > 0$ (depreciation increasing the nominal demand for money) increases the fluctuations of the interest rates.

CHAPTER THREE
SHORT-TERM INTERNATIONAL CAPITAL FLOWS
IN AN IMPERFECT WORLD

(i)

In the previous chapter we were concerned with the short-run dynamics of the exchange rate in the absence of all government intervention. In those circumstances, with trade payments slow to change, there would be no net short-term capital flows (apart from those necessary to finance a possible, temporary trade imbalance). Accordingly, we assumed that the exchange rate and interest rates would adjust so that the existing stock of foreign assets was willingly held. In other words, the conditions necessary for there to be no net capital flows would always be brought into effect: the forward exchange rate would be equal to the expected future spot exchange rate, and the covered interest-rate parity condition would hold exactly.

However, in order to consider possible government intervention in the foreign-exchange market, it becomes necessary to investigate what determines the volume of short-term capital flows when the conditions for zero net capital flows do not obtain. At one extreme it is possible to imagine the case where potential speculators are sufficiently confident and sufficiently well-endowed with funds to ensure that the forward rate is always equal to the expected future spot rate; and to assume that there is a sufficiently large reservoir of internationally mobile capital to ensure that the covered interest-rate parity condition always holds exactly. With international capital thus highly mobile, the government can, at best, determine either the domestic nominal interest rate or the exchange rate, but not both; and the volume of

short-term capital flows will be whatever is necessary to offset government intervention.

But, in the general case, capital will not be so perfectly mobile internationally, and the range of policy options open to the authorities will be somewhat wider. In this chapter, the first sections set out a model of the foreign-exchange markets in a way which has by now become conventional: in this model exchange-rates and capital flows are jointly determined in the presence of imperfectly mobile international capital. But there are other imperfections to be considered as well, particularly government restrictions and the uncertainty of return of some financial assets and of commercial operations, as well as the price uncertainty of consumption goods. These are dealt with by the construction of a portfolio model in which an individual can operate in the foreign-exchange market simultaneously as speculator, interest arbitrageur and commercial trader. The final part of the chapter assesses the implications of such imperfect foreign-exchange markets for the volatility of capital flows and exchange rates and sets the scene for the discussion of exchange-rate policies in Chapter Four.

(ii)

One popular method of analysing the spot and forward exchange-markets has been developed by S.C. Tsiang,¹ drawing on the work of J.M. Keynes, Paul Einzig and others.² At the heart of this approach is the assumption that the forward and spot exchange rates are jointly determined by the behaviour of three groups of participants, namely commercial hedgers, interest arbitrageurs, and forward speculators, apart from any government intervention which might occur. The possibility is not excluded that an individual may act in more than one of these roles, and indeed certain types of transaction are fitted into the three groups listed above by regarding them as combinations of two activities. Thus, the basic assumption is that traders cover forward any foreign currency obligations or receivables. In so far as they leave them uncovered, they can be regarded as implicitly covering all commercial transactions in the forward market, while speculating in the forward market to the extent that their commercial commitments are not matched by their open foreign-exchange positions. Similarly, a trader who covers a future foreign-exchange commitment by a spot purchase or sale of foreign exchange, can be regarded as covering in the forward market, and engaging in interest arbitrage to the amount of his spot transaction.

The case of spot speculation can be decomposed in a similar fashion into forward speculation combined with interest arbitrage in the

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1. S.C. Tsiang, "The Theory of Forward Exchange and Effects of Government Intervention on the Forward Exchange Market", I.M.F. Staff Papers, Vol.7, No.1, April 1959, pp.75-106. Examples, among many others, of works which have adopted or modified this approach, are H. Grubel, "Forward Exchange, Speculation and the International Flow of Capital", 1966, E.E. Leamer and R.M. Stern, "Quantitative International Economics", 1970, Frank McCormick, "A Multiperiod Theory of Forward Exchange", Journal of International Economics, Vol.7, August 1977, pp.269-282.
 2. J.M. Keynes, "A Tract on Monetary Reform", London, 1923; P. Einzig, "The Theory of Forward Exchange", London, 1937.

appropriate direction. Thus, a speculator might sell pounds in order to obtain dollars to hold in expectation of a rise in the value of the dollar: this is equivalent to buying dollars forward (forward speculation) combined with the arbitrage transaction of buying dollars spot and selling them forward. This decomposition is always logically correct, but, as has been pointed out through the combined efforts of H.H. Stokes and S.C. Tsiang,¹ it does show that there are circumstances when spot speculation would be irrational. Thus, in the case above, when forward speculation in favour of the dollar and against the pound is assumed to be profitable ($E[e_{s,t+1}] > e_{f,t}$), the second, arbitrage part of the decomposition will be profitable only when it is profitable to arbitrage towards the U.S., i.e. when:

$$\frac{e_{f,t}}{e_{s,t}} (1 + r_{a,t}) > (1 + r_{h,t}),$$

where $e_{s,t}$ is the spot exchange rate (£ per \$) in period t , $e_{f,t}$ is the forward exchange rate in that period, $E[e_{s,t+1}]$ is the spot exchange rate which is expected in the current period to prevail in period $t+1$, $r_{a,t}$ is the current interest rate abroad (in the U.S.) and $r_{h,t}$ is the interest rate at home (in the U.K.). Now, in general the second condition will hold, because if speculators are buying dollars forward, then someone must be selling a matching amount of dollars forward, and this is most likely to be done by arbitrageurs. But it is possible that the second condition will not hold, and that someone else is providing the forward dollars to the speculators (and perhaps also to operators arbitraging in

1. Houston H. Stokes, "Spot Speculation, Forward Speculation, and Arbitrage: Comment", *American Economic Review*, Vol.63, Dec. 1973, pp.995-998; S.C. Tsiang, "Spot Speculation, Forward Speculation, and Arbitrage: A Clarification and Reply", *American Economic Review*, Vol.63, Dec. 1973, pp.999-1002.

the opposite direction, towards the U.K.). It could be that the authorities are intervening in the forward-exchange market to support the pound. It is also possible, though rather unlikely if there is speculation against the pound, that there is an excess supply of forward dollars on the part of commercial traders, because, let us say, of an unusually high prospective U.K. trade surplus. But whatever the reason, if the second condition does not hold, spot speculation will be irrational for anyone who is able to engage in forward speculation, since it will involve the same risk for a lower return.

For completeness, one should mention that this theory puts long-term foreign investment in a separate category, on the grounds that it will not affect the forward-exchange market, although such investment might be influenced to some extent by the current value of the spot exchange rate.

(iii)

The particular advantage of the foregoing approach is that it reduces all foreign-exchange transactions to the three basic types, so that once the factors determining each are specified, it is a relatively simple matter to find the equilibrium spot and forward exchange rates which result, provided that the behavioural functions for the three types of transaction are independent of one another. (In the same way, specifying supply and demand functions provides a simple way of analysing many markets, provided that the supply and demand functions are independent of each other.)

The behavioural functions are specified in terms of flows rather than stocks: which is appropriate when one is considering trade, or arbitrage capital flows which one can consider as being unwound and re-allocated in each decision period. Certainly, a stock approach would

become quite attractive if medium and long-term capital flows were at the centre of the analysis and changes in total asset supplies played an important role in current account imbalances, as they do notably in the recent models of Pentti Kouri,¹ but the focus there is less on the short-run movements of the exchange rate than on the long-run adjustment to real and monetary disturbances.

Turning first to the forward-exchange market, we suppose for simplicity that all the contracts are for a standard time-period which coincides with the decision period. In the case of speculators, their demand for forward dollars is a function of the difference between the average expected future spot rate and the forward rate:

$$D_{fS} = f \left(E[e_{s,t+1}] - e_{f,t} \right).$$

The supply of forward dollars by arbitrageurs is a function of the difference between the forward exchange rate and the covered-interest-parity exchange rate:

$$S_{fA} = g \left\{ e_{f,t} - e_{s,t} \frac{(1 + r_{h,t})}{(1 + r_{a,t})} \right\}$$

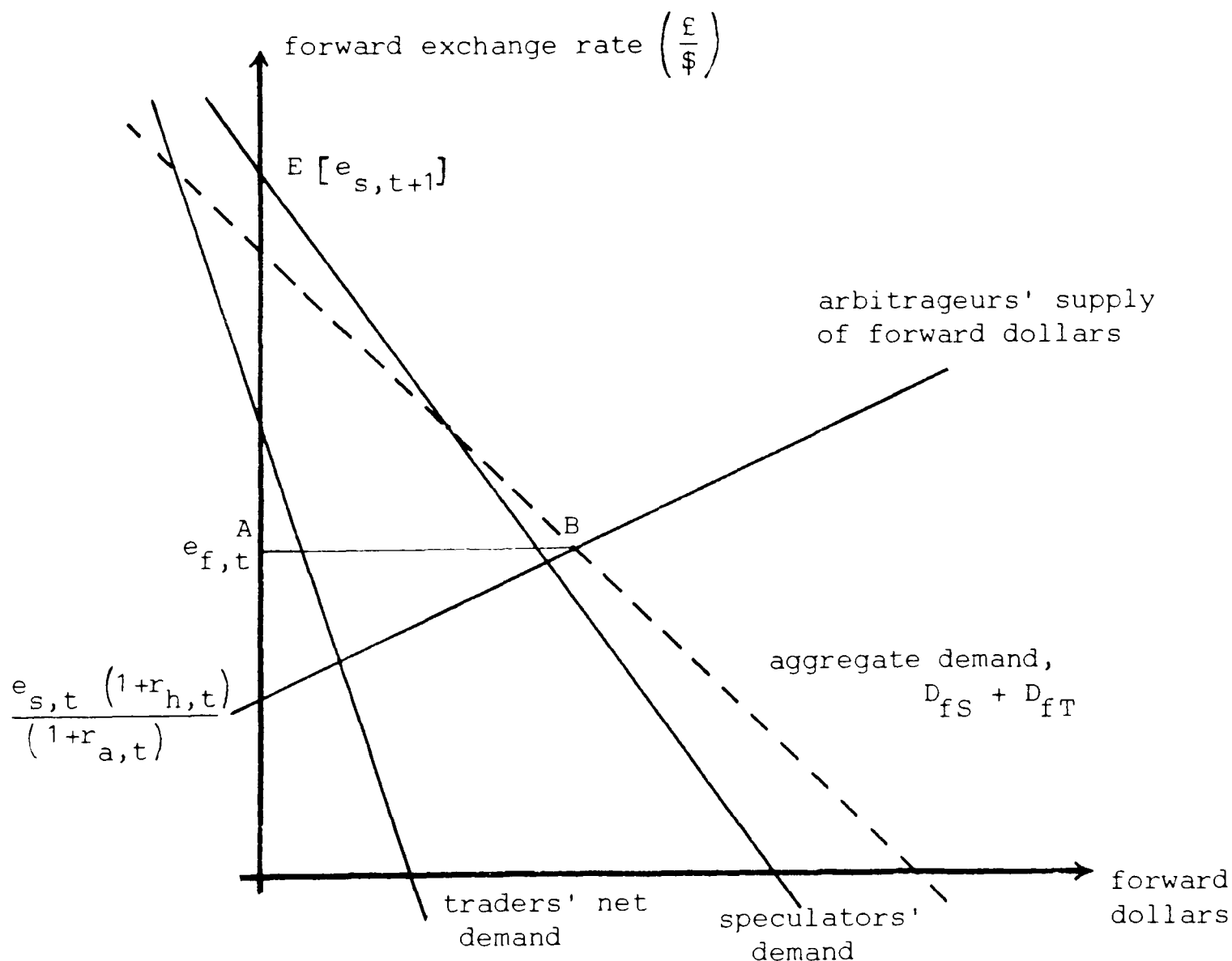
In the case of commercial traders, if we assume that all foreign currency obligations or receivables are covered, and if commercial practices, such as the length of trade credit granted, are invariant, we can express the net demand for forward dollars by traders as a function of the forward exchange rate:

$$D_{fT} = -h(e_{f,t}).$$

1. Pentti J.K. Kouri and Jorge Braga de Macedo, "Exchange Rates and the International Adjustment Process", Cowles Foundation Discussion Paper No.488, March 15th 1978; Pentti J.K. Kouri, "Capital Flows and the Dynamics of the Exchange Rate", Institute for International Economic Studies, University of Stockholm, Seminar Paper No.67, December 1976.

Since traders always cover forward, the forward rate is the exchange rate relevant for their commercial decisions. A trade deficit will increase the net demand for forward dollars, and we assume that a higher e_f , that is, a lower forward value for the pound, will decrease the trade deficit: hence the negative relationship between D_{fT} and $e_{f,t}$.

These three functions can be combined into a diagram of the forward-exchange market.¹



If we look now at the spot-exchange market, there are two types of transaction to be considered. The first arises as the result of contractual obligations entered into in the past, particularly in the implementation

1. Adapted from that of S.C. Tsiang, "The Theory of Forward Exchange and Effects of Government Intervention on the Forward Exchange Market", I.M.F. Staff Papers, Vol.7, No.1, April 1959, p.96.

of forward contracts made in the previous period. The second type of transaction is decided on this period. In the first category we have the net demand for spot exchange by traders,

$$D_{ST} = -h \{e_{f,t-1}\},$$

and the unwinding by arbitrageurs of positions entered into in the previous period. Their supply of spot dollars is given by:

$$S_{SP} = g \left\{ e_{f,t-1} - e_{s,t-1} \frac{(1 + r_{h,t-1})}{(1 + r_{a,t-1})} \right\}$$

Speculators will also have to settle their forward contracts entered into in the previous period, but since they do not possess any foreign exchange this would mean both buying and selling the necessary foreign currency spot. The more usual practice is simply to pay over the profit or loss involved, i.e. the difference between the spot rate and the rate set in the forward contract: whether this involves a net purchase or sale of spot foreign exchange depends on the nationality of those speculators who have gained and the currency in which they wish to take their profits. In any case, the resulting net transactions in spot exchange are likely to be fairly small.

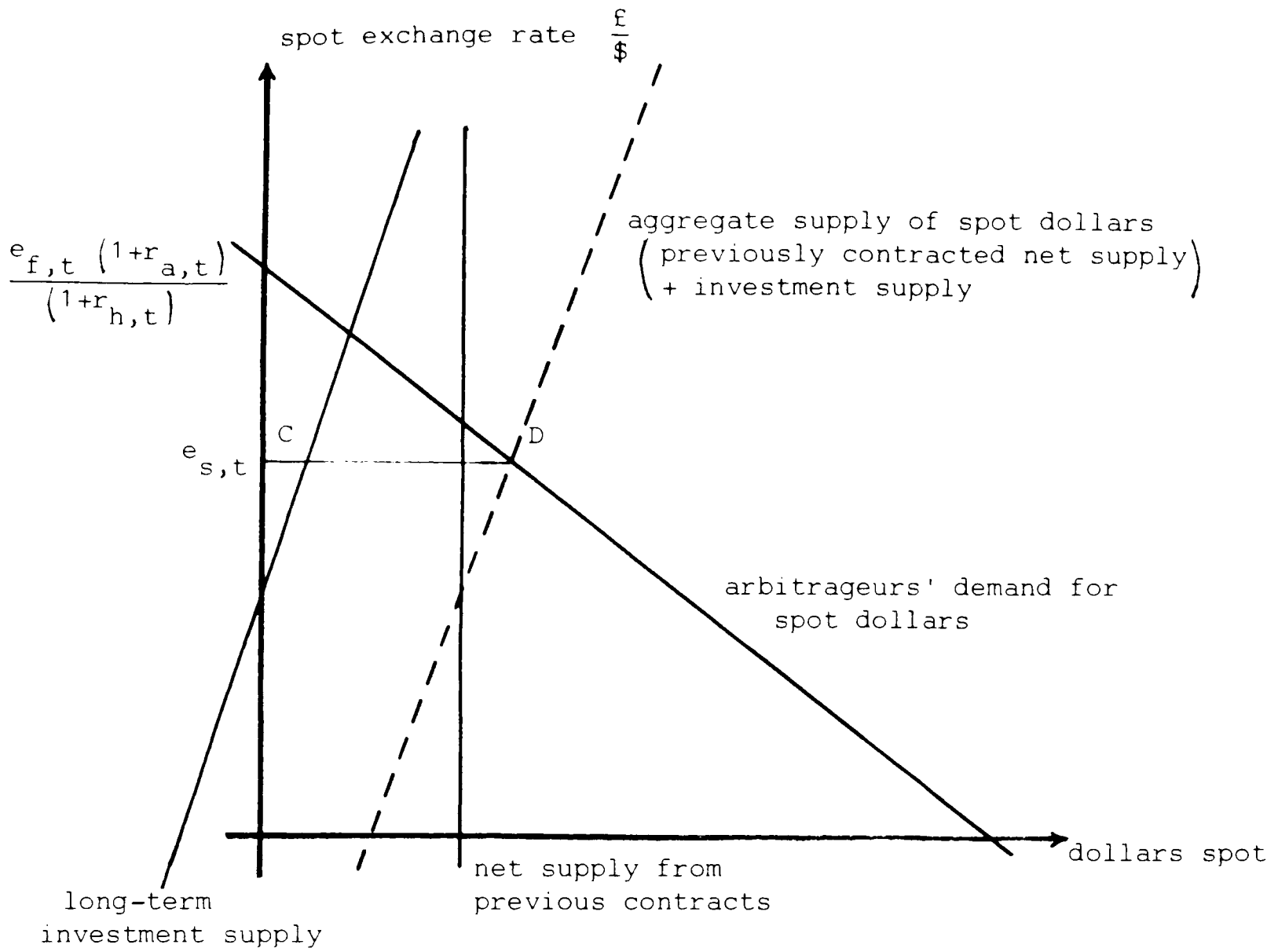
In the second category of transaction are long-term net capital flows, the net supply of spot dollars being given by:

$$S_{SL} = k \{e_s\}.$$

And of course there is the arbitrageurs' demand for spot dollars which is the exact counterpart to their supply of forward dollars:

$$D_{SA} = g \left\{ e_{f,t} - e_{s,t} \frac{(1 + r_{h,t})}{(1 + r_{a,t})} \right\}$$

A diagrammatic representation of these functions is as follows:



It can be seen from this and the preceding diagram of the forward-exchange market that in general there will be a unique determination of the spot and forward rates. Since arbitrageurs buy an equal number of spot dollars to those they sell forward, equilibrium in the two markets requires that $AB = CD$. Since the arbitrageurs' schedules alone are functions of both $e_{f,t}$ and $e_{s,t}$, these schedules and their covered-interest-parity intercepts on the exchange-rate axes can be moved up and down together in the two diagrams (though not by the same amount unless $r_{a,t} = r_{h,t}$) until this condition is achieved. For example, if $AB > CD$, arbitrageurs would be represented as selling more dollars forward than they are buying spot: $e_{f,t}$ is too low for equilibrium, and $e_{s,t}$ also. The arbitrageurs' schedule should be higher in both diagrams, leading AB to be smaller and CD larger, until equality between them is achieved.

(iv)

The model outlined above has been put forward in its most elementary form so as to show the usefulness of the three-fold classification of transactors, and its ability to deal with arbitrage and speculation when their magnitude depends on current and expected exchange rates. The model can be, and has been expanded in various ways, particularly to show the effects of government intervention in the spot or forward foreign-exchange markets. However, this framework is useful only so long as the three types of transaction are, at least substantially, independent of one another. The purpose of this and the following sections is to establish to what extent this independence holds, or what more drastic changes must be made to the analysis, once one allows for various types of imperfection, government restrictions or uncertainty.

In this section we develop a portfolio model in which an individual can operate simultaneously as a trader, an arbitrageur and a speculator, and apply it first of all to the case in which we retain the assumptions of the previous section as to free access to the exchange-markets and the absence of uncertainty other than exchange-rate uncertainty.¹

Let us consider an individual with given wealth and trading commitments at the beginning of the period in question,² who desires to maximise the expected utility of his wealth at the end of the period.

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1. The treatment of arbitrage and speculation is developed from Chapter One of my University of Oxford B.Phil. thesis, 1973. The treatment of hedging is adapted from the Note to Chapter Four of R.I. McKinnon, "Money in International Exchange", New York, O.U.P., 1979, which is based on James Hodder, "Hedging of Exposure to Exchange-Rate Movements", unpublished Ph.D. dissertation, Stanford University, 1978.
 2. We assume throughout that decisions on how much of his wealth he will consume this period and on which commercial undertakings he will enter into are made prior to and independently of his hedging, arbitrage or speculation decisions.

Assume a two-parameter utility function in expected wealth and the variance of expected wealth.

Let his initial wealth, measured in domestic currency be fW . A proportion, a , is invested in domestic assets with a one-period maturity; and a proportion $(1 - a)$ in foreign assets with the proceeds sold forward, i.e. employed in covered-interest arbitrage.

Let the trade receipts he is to receive in foreign currency at the end of the period be $\$X$ and his expenses in domestic currency to be incurred at the end of the period be fY . (X and Y will be positive for an exporter and negative for an importer.) Assume that all foreign currency obligations or receivables are covered forward.

Let the volume of speculative forward contracts he enters into (number of dollars bought forward) be $\$V$.

This covers all possible types of behaviour, since, as we have already established, incomplete forward covering of trade payments, or spot speculation are simply equivalent to altering V , the volume of forward contracts, or $(1 - a)$ the proportion of wealth devoted to arbitrage.

The expected value of wealth at the end of the period will be:

$$\begin{aligned} & W a (1 + r_{h,t}) + W (1 - a) (1 + r_{a,t}) \frac{e_{f,t}}{e_{s,t}} \\ & + X e_{f,t} - Y \\ & + V (E [e_{s,t+1}] - e_{f,t}) \end{aligned}$$

Since the returns to trade, and to arbitrage or domestic investment, are subject to no uncertainty, the variance of expected wealth will be equal to the variance of the expected returns to speculation. Assume $e_{s,t+1}$ is distributed randomly about $E e_{s,t+1}$ with known variance σ^2 . Then since $e_{f,t}$ is certain, the variance of expected wealth will be:

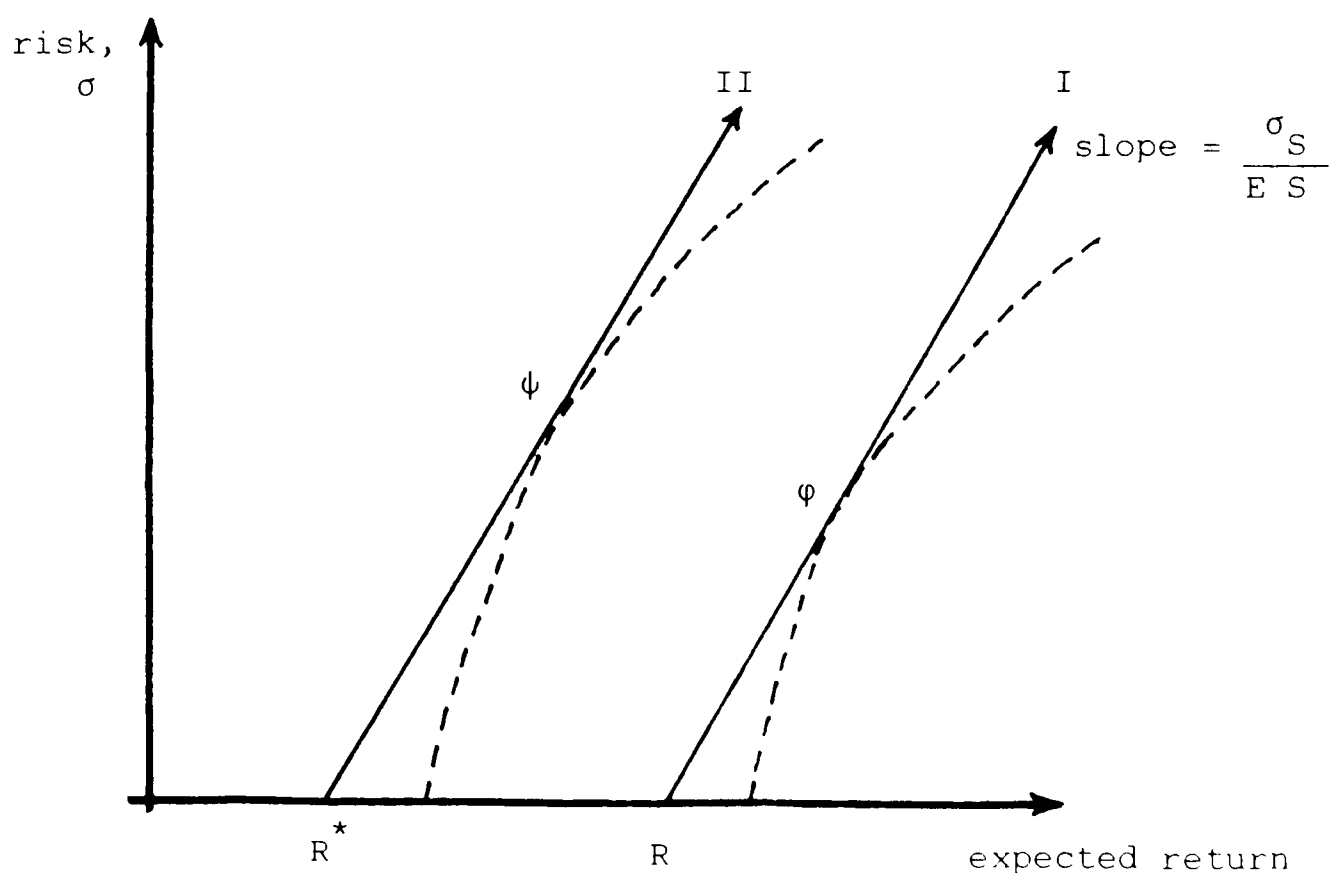
$$V^2 \sigma^2.$$

There are only two decision variables, namely a and V . Since the choice of a does not affect the variance of expected wealth, it will be set so as to maximise expected wealth, i.e. a will be set to zero or unity according as $(1 + r_{a,t}) \frac{e_{f,t}}{e_{s,t}}$ is greater or less than $(1 + r_{h,t})$.

The choice of the volume of arbitrage is therefore independent of any decision about speculation.

The choice of V will affect both expected wealth and its variance. Expected wealth will also be affected by the expected returns from trade and arbitrage, and so the choice of V will be influenced by the trade and arbitrage decisions. For example, if we assume a risk-averse individual who is prepared to trade off lower expected wealth for a lower variance of expected wealth, then high prospective profits from trade and arbitrage would probably reduce the amount of speculation he would engage in; whereas if low returns were expected from trade and arbitrage he would probably engage in more speculation to increase his expected wealth even though that would increase its variance.

Let us look at this example using the standard, diagrammatic risk-



return analysis based on the work of Tobin, Markowitz and Hicks.¹

Let R be the riskless expected return from trade hedged against exchange risk and from covered interest arbitrage. Let $E[S]$ be the expected return from a speculative forward contract for one unit of foreign currency and σ_s the corresponding standard deviation of return. Then the individual's final position can be anywhere on the line I. He will choose a point of tangency with the furthest risk-return indifference curve such as at ϕ . (The curves are drawn to represent a risk-averter's preferences.) If the return to arbitrage and trade decreases to R^* , then he will choose a position such as ψ on line II. Unless certainty is an inferior good relative to expected return,² one would expect $R^* \psi > R\phi$, that is an increased volume of speculation is undertaken to make up to some extent for the lost return, although at the cost of increased overall risk.

Under the assumption of only exchange-rate uncertainty and free access to the exchange-markets there is, therefore, an asymmetry: arbitrage capital flows and hedging will not be functions of forward speculation, but on the other hand expected gains from arbitrage or trading will influence the volume of forward speculation. However, since in practice the determinants of forward speculation are often only vaguely specified, this latter influence alone would probably not require major changes to the traditional analysis.

1. J. Tobin, "Liquidity Preference as Behaviour Towards Risk", Review of Economic Studies, Vol.25, Feb. 1958, pp.65-86; H. Markowitz, "Portfolio Selection", Journal of Finance, Vol.7, March 1952, pp.77-91; John Hicks, "Liquidity", Economic Journal, Vol.72, Dec. 1962, pp.787-802 and "The Pure Theory of Portfolio Selection", Ch.6 in Critical Essays in Monetary Theory, London, O.U.P., 1967, pp.103-125.

2. Which it may be: the richer he is the more he can "afford" to speculate. c.f. J. Tobin, "The Theory of Portfolio Selection", in F.H. Hahn and F.P.R. Brechling (eds.), The Theory of Interest Rates, London, Macmillan, 1965, p.51.

(v)

One situation in which it has long been recognised that the motives for foreign-exchange transactions may be mixed, occurs when there are government restrictions on access to the foreign-exchange markets. These can take many different forms, but as an example of the modifications which have to be made to the analysis of the foreign-exchange markets, let us consider the case where no forward-exchange dealings are allowed except in connection with an underlying commercial transaction. Such restrictions are quite common where the authorities are afraid of the effects of speculation.¹ In practice, restrictions on forward dealing are frequently coupled with other exchange-market restrictions designed to achieve the same objective of limiting speculative capital flows, but although it is possible for a determined exchange-control authority to block almost all financial avenues for speculating on exchange-rate movements, this is likely to be at a prohibitive cost in terms of disruption to normal economic activity.² The type of reaction to restrictions on forward dealing described below would not be excluded by most developed countries' exchange-control regimes.

In the case where access to the exchange-markets was unrestricted it was unnecessary to specify exactly what proportion of trade payments were covered forward, since all eventualities were catered for by assuming that all trade was covered forward and that any deviations from this rule merely

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1. For example, in the U.K. before 1979. As at the end of 1979 this type of restriction on forward exchange dealing, of greater or lesser severity and sometimes applying only to residents, existed in the following developed countries: Australia, Denmark, Finland, France, Greece, Japan, Norway, Portugal, South Africa, Spain, Sweden. c.f. I.M.F. Annual Report on Exchange Arrangements and Exchange Restrictions 1980, Washington D.C.
 2. On the real effects of severe exchange-control see R.I. McKinnon, "Money in International Exchange", O.U.P., New York, 1979, pp.170-175.

gave rise to additional implicit arbitrage or forward speculation.¹ But with ordinary arbitrage flows and speculation restricted, the ability to engage in implicit arbitrage or speculation by altering commercial financial arrangements becomes important.

Let us assume, as in the previous section, that exchange rates and interest rates are such that forward speculation against the pound is expected to be profitable, i.e. $E[e_{s,t+1}] > e_{f,t}$ and that it will pay to undertake covered arbitrage towards the U.S., i.e. $(1 + r_{a,t}) \frac{e_{f,t}}{e_{s,t}} > (1 + r_{h,t})$. As before, the trading profit of an exporter who sells all his foreign currency receipts forward will be: $Xe_{f,t} - Y$. In addition, if he leaves a proportion, b , of his receipts uncovered, his expected return from implicit forward speculation will be:

$$bX (E[e_{s,t+1}] - e_{f,t}).$$

In this situation, an exporter cannot use his underlying commercial transaction as a basis for covered interest arbitrage towards the U.S. without the co-operation of the foreign importer, but consider the case of an importer with dollar payments of M due to be made at the end of the period, and receipts of Z pounds at the end of the period. His trading profits, covered for exchange risk, will be:

$$Z - Me_{f,t}.$$

He, in his turn, cannot engage in speculation without his foreign exporter's co-operation, but suppose he covers a proportion, c , of his dollar payments

1. In point of fact, with only exchange-rate uncertainty and no price uncertainty, only 100% forward covering would eliminate all variance in trading profits, and unless the forward rate were a biased predictor of future spot rates, such a rule would also not lower average profits. The fact that a much smaller proportion of any country's trade is covered forward can be ascribed to other, off-setting, risks which we are for the moment neglecting, to some traders being risk-neutral, to the invoicing of some trade in domestic currency, to transactions costs, and to exchange-controls.

spot rather than forward, borrowing pounds domestically in order to buy dollars spot, which are invested abroad till payment falls due (or else are used for early payment and a saving in foreign trade finance). The returns from this covered interest arbitrage are:

$$cM \left\{ (1 + r_{a,t}) e_{f,t} - (1 + r_{h,t}) e_{s,t} \right\}$$

Finally, the individual may be able to use a proportion $(1-a)$, of his wealth for spot speculation, involving in this case a spot purchase of dollars. It is true that when forward speculation is prohibited, spot movements of capital will often, though not always, be restricted also, but the same effect can often be achieved by altering not just the financing but the timing of trade payments: thus, exporters might encourage their foreign customers to defer payments (and if these are invoiced in foreign currency they might be happy to oblige) and importers could lead their payments. In either of these cases the volume of leads and lags is limited by the wealth or ability to borrow of the domestic resident. As we have shown, such spot speculation can be decomposed into forward speculation and arbitrage, so the end of period expected wealth of the domestic resident, including also the returns from domestic assets, will be:

$$\begin{aligned} & Wa (1 + r_{h,t}) + W (1 - a) (1 + r_{a,t}) \frac{e_{f,t}}{e_{s,t}} \\ & + \frac{W (1 - a)}{e_{s,t}} \left\{ E [e_{s,t+1}] - e_{f,t} \right\}. \end{aligned}$$

Thus, for an individual who acts as importer, exporter and spot speculator, the returns can still be broken down into those to arbitrage, trade and forward speculation as follows:

$$\begin{aligned} \text{arbitrage: } & (Wa - cMe_{s,t}) (1 + r_{h,t}) \\ & + \left\{ \frac{W(1-a)}{e_{s,t}} + cM \right\} (1 + r_{a,t}) e_{f,t} \end{aligned}$$

trade: $Xe_{f,t} - Y + Z - Me_{f,t}$

forward speculation: $\left\{ \frac{W(1-a)}{e_{s,t}} + bX \right\} \left\{ E[e_{s,t+1}] - e_{f,t} \right\}$

and the variance of expected wealth will again result from the forward speculative component alone:

$$\left\{ \frac{W(1-a)}{e_{s,t}} + bX \right\}^2 \sigma^2 .$$

But now a , b and c are all variables whose value will affect expected wealth, and the choice of a and b will affect its variance. Therefore the choice of c (set to either unity or zero) can be made independently, solely on the basis of whether or not covered arbitrage towards the U.S. is profitable; but for an individual who is not risk-neutral, the choices of a and b are interdependent and dependent also on cM . Thus the volume of covered arbitrage is dependent on the volume of trade and on the expected profits from forward speculation.

For example, if the returns to the covered interest arbitrage associated with spot covering of import payments are exceptionally high, there will be a tendency for a risk-averse individual to lower $(1 - a)$ and b , i.e. to engage in less spot speculation and speculation in connexion with uncovered export receipts, because these increase the variance of expected wealth even though they might also increase its expected level. Or if the returns from implicit speculation are expected to be exceptionally high (for a given level of risk), both b and $(1 - a)$ would be raised, implying a higher level of arbitrage capital flows associated with these spot speculative capital movements.

(vi)

But it is not only in the presence of restrictions on the foreign-exchange markets that the usefulness of the triple distinction between arbitrage, hedging and spot speculation breaks down. Even with perfectly free exchange markets there will be interdependence between the three motives, if arbitrage takes place in assets of uncertain return, or if trading profits are subject to any uncertainty besides exchange risk, provided individuals are risk-averse.

Certainly, in the case of trade, it is very likely that there will be risks involved besides exchange risk, so that it is important to take account of them. On the other hand, it is not usual to consider arbitrage in assets of uncertain return: but even here, if one takes into account the risk of insolvency or of political interference, even fixed-interest assets do not yield certain returns, as the freezing of Iranian assets in America has recently re-emphasised. In addition, particularly in relatively narrow financial markets where short-term fixed interest stocks may be unattractive, arbitrage can often take place in assets, such as company shares, with not even a nominally fixed return.¹

It is quite easy to see the nature of the interdependence which uncertainty introduces. Let us look first of all at the hedging decision. One major risk that has to be taken into account is domestic price uncertainty. The importer will be uncertain of the price at which he will be able to sell the goods he orders now; the exporter who signs an export contract cannot be sure of the domestic price of all the imports that he will need. Frequently movements in these domestic prices will

1. For example, De Beers shares are said to be the most popular vehicle for arbitrage between Johannesburg and the financial centres of the U.S. and Britain, although admittedly the most important factor in such arbitrage is probably the varying discount between the financial and the commercial rand.

be correlated with movements in the exchange rate, so that minimising the variance of overall trading profit will usually involve hedging less than 100% of the exchange risk, since the remaining risk will be offset by a component of the variance of domestic prices. But, of course, even such "optimum" hedging takes into account the mean and variance only of trading profits, and not the possible gains to be made by exchange speculation. It might be argued that trading companies are not in the business of foreign-exchange speculation, but their shareholders frequently are, and would presumably wish the trading company which they own to adjust its operations to conform with their own opportunities for speculative profits.

Let us set this out in greater detail. Consider a British importer who is importing M goods which will cost him \$1 each, to be paid next period. The value of the exchange rate next period is denoted by $e_{s,t+1}$ and the domestic price at which he can sell his goods then is P_{t+1} pounds each. The current forward exchange rate is $e_{f,t}$. Then, if he covers forward a proportion f of his dollar debt, his profit will be:

$$- M(1-f) e_{s,t+1} - Mf e_{f,t} + M P_{t+1} .$$

Suppose that purchasing-power parity holds in the long run, so that the expected value of the domestic price is related to the expected value of the exchange rate:

$$E [P_{t+1}] = (1 + g) E [e_{s,t+1}]$$

where g is the proportion of "normal" profit. Then expected trading profit in domestic currency is:

$$M \left\{ (f + g) E [e_{s,t+1}] - f e_{f,t} \right\} .$$

If $e_{f,t} = E [e_{s,t+1}]$, this reduces to:

$$M g E [e_{s,t+1}] .$$

But suppose $E[e_{s,t+1}] > e_{f,t}$ so that there are expected gains to be made from forward speculation. Suppose the trader, reacting to this opportunity for profit, enters into contracts to purchase $\$V$ forward. His expected profits on these contracts will be:

$$V \left(E[e_{s,t+1}] - e_{f,t} \right),$$

and his expected total profit on both trading and forward speculation will be:

$$\{M(f+g) + V\} E[e_{s,t+1}] - \{Mf + V\} e_{f,t}.$$

But there is also the riskiness of the operations to be considered.

The variance of total profit will be:

$$\begin{aligned} & E \left[\left(-M(1-f)e_{s,t+1} - Mfe_{f,t} + MP_{t+1} + Ve_{s,t+1} - Ve_{f,t} \right. \right. \\ & \quad \left. \left. - \{M(f+g) + V\} E[e_{s,t+1}] + \{Ma + V\} e_{f,t} \right)^2 \right] \\ &= E \left[\left(-\{M(1-f) + V\} e_{s,t+1} + MP_{t+1} - \{M(f+g) + V\} E[e_{s,t+1}] \right)^2 \right] \end{aligned}$$

If σ_e^2 is the known (or estimated) variance of $e_{s,t+1}$,

σ_P^2 is the known (or estimated) variance of P_{t+1} ,

ρ is the
$$\frac{\text{covariance}(e_{s,t+1}, P_{t+1})}{\sigma_e \cdot \sigma_P}$$

then, recalling that $E[P_{t+1}] = (1+g) E[e_{s,t+1}]$,

the variance of total profits can be written as:

$$\{V - M(1-f)\}^2 \sigma_e^2 + 2M\{V - M(1-f)\} \text{cov.}(e_{s,t+1}, P_{t+1}) + M^2 \sigma_P^2.$$

Assuming that M is, at least in the short run, fixed, the individual can vary f , the proportion of trade covered forward, and V , the volume of his non-trade related forward contracts so as to reach his preferred

combination of expected profits and variance of expected profits.

Essentially, increasing f or V has similar effects on both expected profits and the variance of expected profits.¹

(vii)

The second area where it is important to consider the effects of uncertainty is that where the returns to arbitrage are uncertain. As in section (iv), consider an individual who engages in both arbitrage and speculation. His expected end of period wealth will be:

$$W a (1+r_{h,t}) + W(1-a) (1+r_{a,t}) \frac{e_{f,s}}{e_{s,t}} + V (E[e_{s,t+1}] - e_{f,t})$$

But now the variance of expected wealth is a function of the variability of the domestic and foreign rates of return, as well as the variability of the exchange rate.

If σ_h^2 is the variance of r_h ,

σ_a^2 is the variance of r_a ,

and σ_e^2 is the variance of $e_{s,t+1}$,

the variance of total wealth is:

$$\begin{aligned} & W^2 a^2 \sigma_h^2 + W^2 (1-a)^2 \left(\frac{e_{f,t}}{e_{s,t}} \right)^2 \sigma_a^2 + V^2 \sigma_e^2 + 2 W^2 a (1-a) \left(\frac{e_{f,t}}{e_{s,t}} \right) \text{cov.} (r_h, r_a) \\ & + 2 W a V \text{cov.} (r_h, e_{s,t+1}) + 2 W (1-a) \left(\frac{e_{f,t}}{e_{s,t}} \right) \text{cov.} (r_a, e_{s,t+1}). \end{aligned}$$

1. To take an extreme case, if his desire is to minimise the variance of expected profits regardless of the effect on total profits, the first-order minimization condition is obtained by partially differentiating the expression for the variance of total profits with respect to V (or f):

$$2 \{V - M(1-f)\} \sigma_e^2 + 2M \text{cov.} (e_{s,t+1}, P_{t+1}) = 0$$

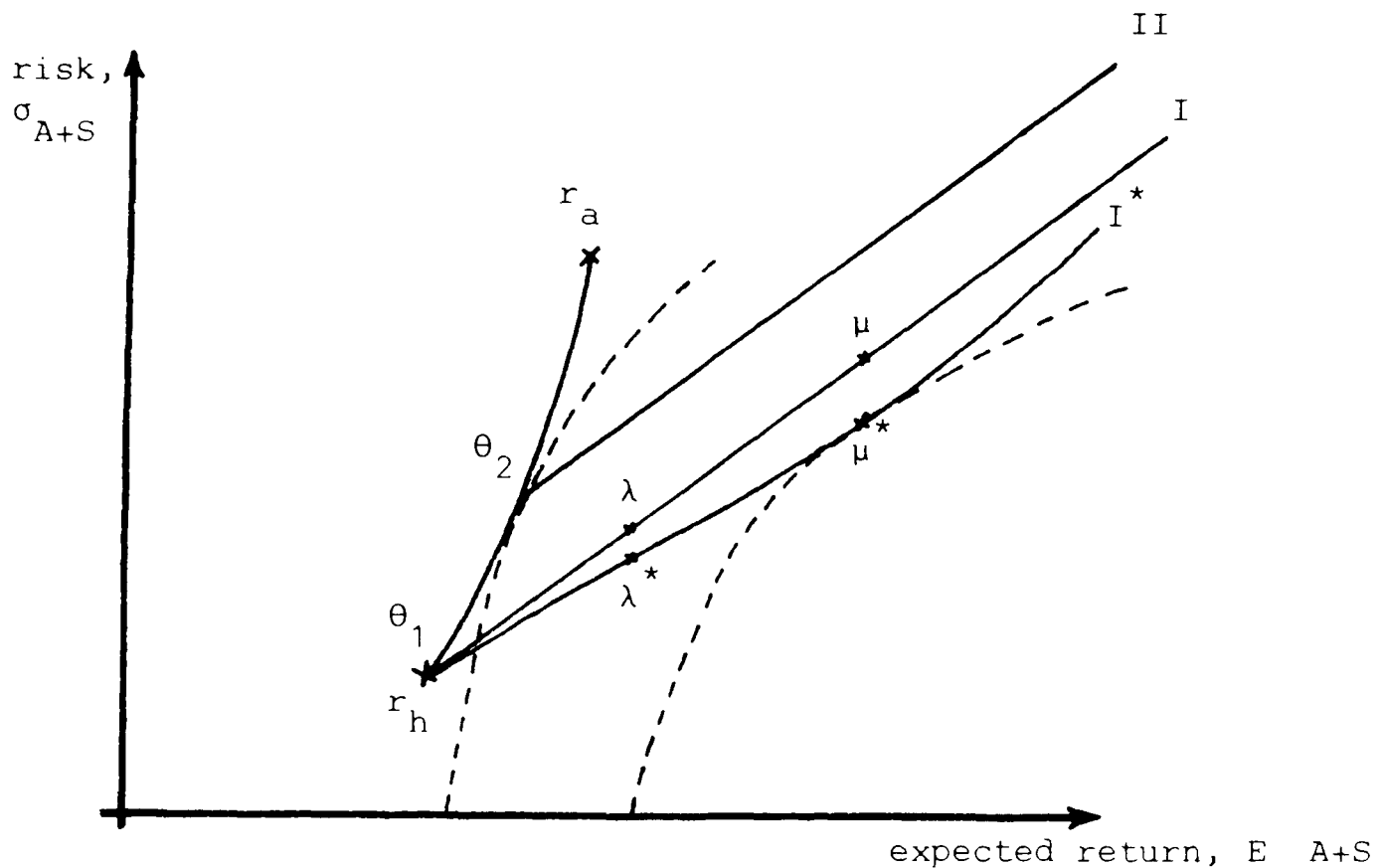
which simplifies to:

$$f + \frac{V}{M} = 1 - \rho \frac{\sigma_P}{\sigma_e}$$

And the individual would choose a and V so as to attain his preferred position within the possible wealth - variance of wealth combinations. If the covariance of either r_h and $e_{s,t+1}$ or r_a and $e_{s,t+1}$ is not zero, the interdependence between the speculative and arbitrage decisions is obvious, since the variance of the overall return can be altered by changing the mix of foreign and domestic assets (i.e. by altering a). But even if both $\text{cov.}(r_h, e_{s,t+1})$ and $\text{cov.}(r_a, e_{s,t+1}) = 0$, the arbitrage decision will be affected by the possibility of speculative profits, because the risk-return outcomes for arbitrage and speculation will not be identical except by chance.

In the figure below, r_h and r_a are uncertain and r_h, r_a and $e_{s,t+1}$ are all uncorrelated. The curve $r_h r_a$ is the risk-return frontier for combinations of domestic and foreign assets (i.e. different values of a).¹ Let the overall return to arbitrage and domestic investment be denoted by A and the overall return to forward speculation by S . The dotted lines are risk return indifference curves.

1. We have used the standard deviation of expected return as the measure of risk, rather than the variance, because it is the more commonly used measure and so that I and II in the diagram will be straight lines - i.e. an increasing volume of speculation adds to both return and risk in proportion. Using the variance rather than the standard deviation as the measure of risk would alter the shapes of the curves: $r_a r_h$ would be more markedly convex from below, I and I* would coincide, but I and II would now be convex from below.



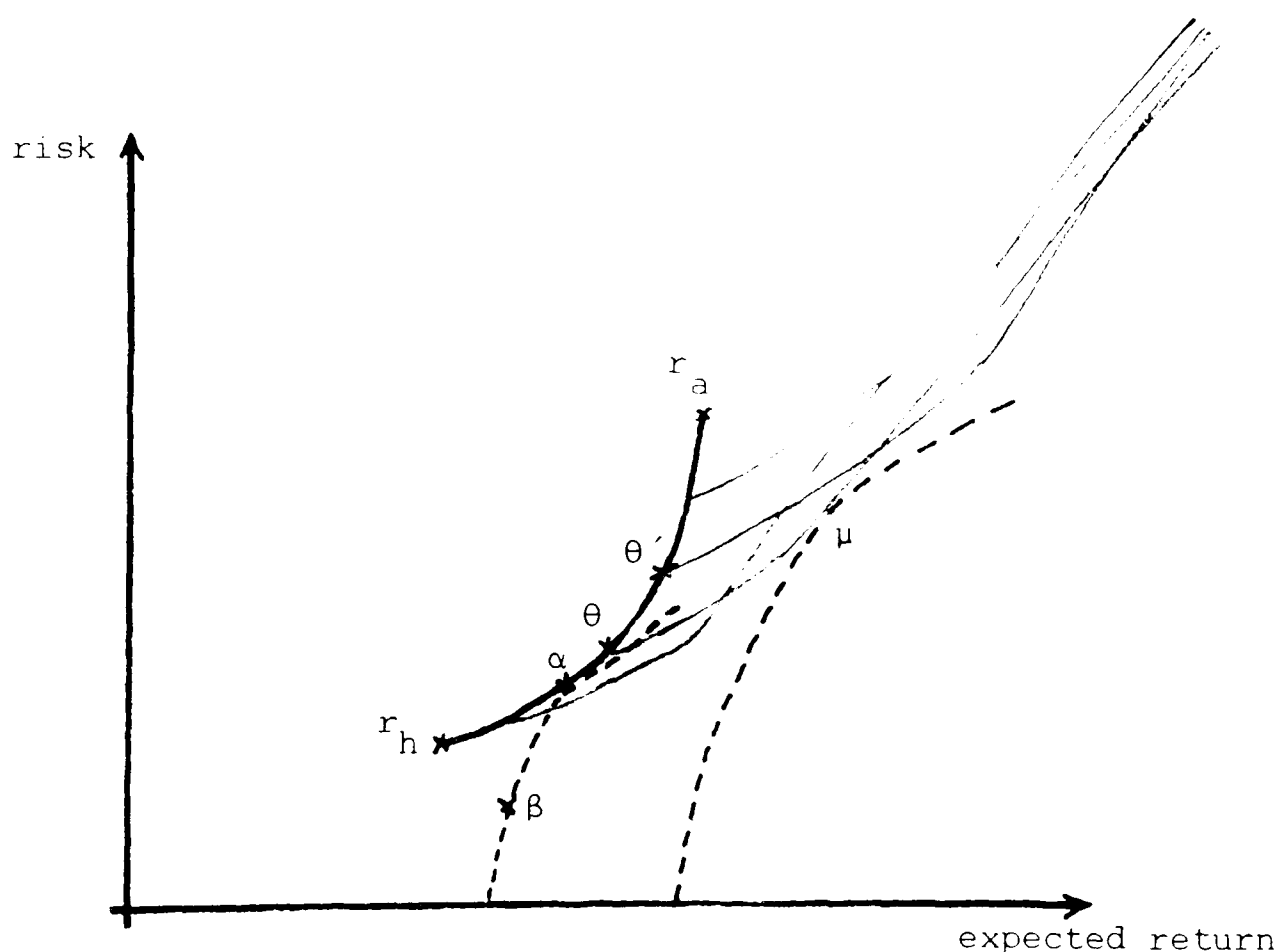
Point θ_2 would be the optimum point if there were no speculative possibilities.

But assume that the individual investor is able to speculate. Considering each possible arbitrage-investment point $\theta_1, \theta_2, \dots$ on the $r_h r_a$ locus as an origin in $\sigma_S, E[S]$ space, possible speculative positions lie anywhere on the straight lines I, II, ... respectively. For each speculative position such as λ, μ , the corresponding overall risk-return position will be given by a point such as λ^*, μ^* on I^* . ($E[A+S] = E[A] + E[S]$, i.e. the overall return is the sum of the returns to arbitrage and speculation; because of our assumption of no covariance of returns, $\sigma_{A+S}^2 = \sigma_A^2 + \sigma_S^2$, but since risk is measured by the standard deviation, $\sigma_{A+S} = \sqrt{\sigma_A^2 + \sigma_S^2}$ which is necessarily $< \sigma_A + \sigma_S$, i.e. the sum of the individual risk measures.) As the volume of speculation increases, I^* becomes asymptotic to I.

As drawn, the optimum position with speculation is μ^* , implying that the whole arbitrage portfolio is invested in domestic assets.

Depending on the shape of the $r_h r_a$ locus, it is not necessary for I^* to dominate all other possible arbitrage-speculation schedules,

although if the individual is uniformly risk-averse his arbitrage portfolio, if affected at all, will almost always be shifted towards a greater concentration on the low risk-low return asset. This occurs because the opportunity to speculate offers an unlimited possibility to add return (and risk) to his portfolio at a fixed rate, so that if he decides to speculate at all it must be because by doing so he adds return for a smaller increase in risk than he would by shifting his portfolio at the margin from the low-return to the high-return asset. On the other hand, he might well decide to add certainty, now that he is better off, by shifting from the high-return to the low-return asset, unless certainty is a markedly inferior good. To see this diagrammatically, construct the envelope of all the speculation-arbitrage curves such as I^* .



If his optimal position with speculation is μ , the slope of the envelope at μ must be no steeper than that of $r_h r_a$ at θ (otherwise a small shift of the portfolio to θ would take μ outside the envelope). Consequently the no-speculation position could only have been at a point like c to the

left of θ if the indifference curve at α is flatter than that at μ . (This is just possible with non-intersecting indifference curves, but it implies that certainty must be an inferior good relative to return, since at a point like β with the same shape as at μ , a lower indifference curve has greater certainty). In the normal case the no-speculation position will have been to the right of θ , implying that the opportunity to speculate shifts the portfolio towards the low-risk asset.

(viii)

So far, in the demonstration that different types of uncertainty will lead to interdependence between the volume of trade, arbitrage and forward speculation undertaken by an individual, we have relied on the risk-aversion of the individual, who wishes, other things being equal, to reduce the variance of return on all his activities taken together. But even for an entirely risk-neutral person there may still be interdependence, if we consider that he derives utility not from wealth as such but from the goods on which he spent it. If the returns to his trade or arbitrage are correlated either with domestic or foreign prices or with the expected exchange rate, the expected purchasing power of his wealth will be maximised by taking account of such correlation in his trading and arbitrage decisions.

Consider, for example, as before, an arbitrageur who can invest in domestic or foreign assets. The expected value of his wealth (measured in pounds) in period $(t+1)$ is:

$$Wa(1 + E[r_{h,t}]) + W(1-a)(1 + E[r_{a,t}]) \frac{e_{f,t}}{e_{s,t}}.$$

Since he is risk-neutral, his portfolio decision involves setting $a = 0$ or $a = 1$.

Suppose covered interest rate parity holds so that:

$$1 + E[r_{h,t}] = \left(1 + E[r_{a,t}] \right) \frac{e_{f,t}}{e_{s,t}}$$

Then if he is interested in maximising the value of nominal wealth he will be indifferent between domestic and foreign assets.

But suppose there are two goods, one domestic with price in period (t+1) of P_h pounds, and one foreign, with price in period (t+1) of P_d dollars. Suppose furthermore a utility function log-linear in the quantities of the two goods, so that

$$\text{Utility} = H \cdot D,$$

where H is the quantity of the home good and D the quantity of the foreign good. Such a utility function implies that an equal amount will be spent on each good: if W_{t+1} is the wealth in period (t+1), $P_h H = P_d e_{s,t+1} D = \frac{1}{2} W_{t+1}$.¹ This is the case even if P_h and P_d are currently uncertain, because although the investment decision must be made now so as to maximise the expected utility yielded by W_{t+1} , the consumption decision can be made once W_{t+1} , P_h , P_d and $e_{s,t+1}$ are known.

Therefore the expected utility will be:

$$E \left[\frac{W_{t+1}}{2 P_h} \cdot \frac{W_{t+1}}{2 P_d e_{s,t+1}} \right]$$

$$= E \left[\frac{\left\{ W a (1 + r_{h,t}) + W (1-a) (1 + r_{a,t}) \frac{e_{f,t}}{e_{s,t}} \right\}^2}{4 P_h P_d e_{s,t+1}} \right]$$

1. Formally, maximising $U = HD$ subject to $HP_h + DP_d e_{s,t+1} = W_{t+1}$:
The Lagrangian is $HD - \lambda (W_{t+1} - HP_h - DP_d e_{s,t+1})$, giving as first order maximisation conditions:

$$\begin{aligned} H + \lambda P_d e_{s,t+1} &= 0 \\ D + \lambda P_h &= 0 \\ W_{t+1} - HP_h - DP_d e_{s,t+1} &= 0 \end{aligned}$$

which yield the results given in the text.

To simplify matters, suppose P_h, P_d and $r_{a,t}$ are all certain. Expected utility is then

$$= \frac{W^2}{4P_h P_d} E \left[\frac{\left\{ a (1+r_{h,t}) + (1-a) (1+r_{a,t}) \frac{e_{f,t}}{e_{s,t}} \right\}^2}{e_{s,t+1}} \right]$$

Again, the portfolio decision for the risk-neutral investor reduces to choosing $a = 0$ or $a = 1$.

With $a = 0$:

$$E[U] = \frac{W^2}{4P_h P_d} (1+r_{a,t})^2 \frac{e_{f,t}^2}{e_{s,t}^2} E \left[\frac{1}{e_{s,t+1}} \right]$$

With $a = 1$:

$$E[U] = \frac{W^2}{4P_h P_d} \left\{ E \left[(1+r_{h,t})^2 \right] \cdot E \left[\frac{1}{e_{s,t+1}} \right] + \text{cov} \left((1+r_{h,t})^2, \frac{1}{e_{s,t+1}} \right) \right\}$$

Since we assume covered-interest-rate parity,

$$E \left[(1+r_{h,t})^2 \right] = (1+r_{a,t})^2 \frac{e_{f,t}^2}{e_{s,t}^2} = R^2, \text{ say}$$

$$\text{Thus with } a = 0, E[U] = \frac{W^2 R^2}{4P_h P_d} \left\{ E \left[\frac{1}{e_{s,t+1}} \right] \right\}$$

$$\text{with } a = 1, E[U] = \frac{W^2 R^2}{4P_h P_d} \left\{ E \left[\frac{1}{e_{s,t+1}} \right] + \text{cov} \left((1+r_{h,t})^2, \frac{1}{e_{s,t+1}} \right) \right\}$$

so that the investor is no longer indifferent as between domestic and foreign assets, but will set $a = 0$ (arbitrage towards the U.S.) or

$a = 1$ (invest in domestic assets), according as $\text{cov} \left((1+r_{h,t})^2, \frac{1}{e_{s,t+1}} \right)$

is negative or positive. In this way this arbitrage decision is dependent on expectations about $e_{s,t+1}$, and so will be related to his decision on

the volume of forward speculation which also depends on $e_{s,t+1}^1$

(ix)

We have shown that a theory of the foreign-exchange markets developed on the assumption of certainty (other than of exchange rates) has to be modified when the usual portfolio-balance considerations of uncertainty are added to it or when the possibility of government intervention is introduced, and in particular that the various motives for foreign-exchange transactions can no longer be clearly separated and their effects simply added together. But what are the implications of these additions to the theory for the nature of capital flows and exchange-rate policy? In general one must answer that it all depends: the more general the theory, the more empty of predictive capacity unless particular circumstances are specified. But one can indicate some likely, and intuitively appealing modifications to the more clear-cut results generated by the narrower theory.

First of all the effects of uncertainty. As far as arbitrage capital flows are concerned, there is theoretical reinforcement for the view that covered interest-rate parity is unlikely to hold exactly. Arbitrageurs' portfolio considerations have already been recognised as a principal reason why there might not be unlimited funds willing to respond to any covered interest-rate differential;² but it becomes

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1. In our simple model there is no wealth constraint on the amount speculated, so that an entirely risk-neutral individual would speculate an infinite amount or nothing, so one must suppose there is some external constraint on V , perhaps in the form of increasing margin requirements with increasing V .
 2. c.f. P.M. Oppenheimer, "Forward Exchange: Theory and Policy", Surrey Papers in Economics, No.4, August 1971.

clear that this applies not only in the sense that investors have a large part of their portfolio locked up in investments too illiquid to respond immediately to new opportunities for covered-interest arbitrage, but also in the sense that even among the class of short-term investments, investors will want to spread their portfolio and not put it entirely in the highest yielding asset even if purely exchange-rate risks are covered. As a result, the stock elasticity of the international allocation of capital in response to changes in the covered-interest rate is likely to be less than would otherwise be indicated.

Moreover, the desire to diversify short-term investments has implications for the composition of individual portfolios. If we consider that arbitrageurs are also able to engage in forward speculation, there is likely to be a bias towards investment in the low-risk asset, even if that yields the lower return. And since estimates of the riskiness of an asset may vary with the residence of the investor, with home assets being less risky to the domestic resident than to the foreigner, this would tend to lower the volume of arbitrage capital flows for a given covered interest rate differential.

In the case of trade and forward-exchange hedging, it has already been recognised that to some extent the decision on whether or not to hedge exposed foreign-currency positions is substitutable with the decision on forward-exchange speculation. Consequently, in a world of perfect capital markets firms could neglect exchange exposure and leave it to their individual shareholders to engage in just so much off-setting forward-exchange speculation as suited their degree of risk aversion and their consumption mix between foreign and domestic goods.¹

1. Ian H. Giddy, "Exchange Risk: Whose View", *Financial Management*, Summer 1977, pp.23-33; Dennis E. Logue and George S. Oldfield, "Managing Foreign Assets When Foreign Exchange Markets are Efficient."

But of course, quite apart from exchange-control and tax considerations, information and transactions costs might make it desirable for firms to act on their shareholders' behalf. What one can say is that if shareholders do have free access to a wide forward market in foreign exchange, it becomes less important for a trading firm to take a view on the future fluctuations of the exchange rate and easier for it to adopt a consistent rule on what proportion and what type of exchange exposure it should hedge.

(x)

When one comes to look at the effects of restrictions on the foreign-exchange markets it becomes even more the case that the nature of the restrictions and the private reaction must be specified in more detail before the general theory can yield any results. Let us therefore confine ourselves to the case, already set out in section (v), where restrictions take the form of limiting access to the forward market to transactions associated with commercial operations and where individuals are still able to alter in some measure the timing of their commercial payments and the extent to which they take out forward cover.

The net result of the repercussions studied in section (v) will be that some of the pressures that would have operated in the forward market will be transferred to the spot market.¹ Whether this is desirable or

1. The most spectacular example is the rather unusual case noted earlier, where in an unrestricted market there would be forward speculation against the pound but where covered interest rate differentials are such as to favour arbitrage towards the U.K., involving spot purchases of pounds, so that spot speculation against the pound would be irrational for anyone who could speculate in the forward market. But restrictions on such forward speculation might make spot speculation attractive, converting a spot capital inflow to a capital outflow.

not depends on the purpose for which the restrictions were introduced and on whether the forward speculation would have been stabilizing. But if, as is likely, restrictions on forward dealing were introduced because it was feared that forward speculation would be destabilizing, then one must presume that the spot market becomes more volatile as the result of having some of the speculative pressure transferred to it (or else there would have to be increased government intervention in the spot market). Of course, the total volume of speculative capital flows, forward and spot combined, will usually be reduced, so that such restrictions may still make sense for a chronically mis-aligned exchange rate, if not for one merely subject to large, temporary swings.

But consider further the case where such restrictions on forward dealing are applied to a market which already operates a dual exchange-rate system with a financial and a commercial rate. There is now a transfer of speculative pressure not only from the forward to the spot market but also, very likely, from the financial to the commercial market.¹ And again, if the original purpose of creating a dual exchange market was to separate the more volatile financial flows from the presumably more stable commercial transactions,² such a transfer of speculative pressure is likely to destabilize the commercial market.

Now, it is possible that the dual exchange-rate system was set up originally not for reasons of stability, but simply to limit net capital

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1. When the financial and commercial rates differ, there will already be an incentive to try to switch some transactions from the financial to the commercial market. If in addition it is possible to engage in foreign-exchange speculation in the commercial but not the financial market, the incentive to switch transactions from one market to the other will be increased.
 2. See Brendan D. Brown, "Exchange Restrictions: Their Implications for Portfolio Management", *Economic Journal*, Vol.87, Sept. 1977, pp.548 and 549.

flows (probably to limit net capital outflows), while supporting the commercial rate. But even so, that is no justification for adding restrictions on forward dealing. The dual exchange market itself prevents a net capital outflow - once it exists it is counterproductive to limit forward positions taken in the financial market: not only may this destabilize the commercial market, it also may provide the incentive needed to transfer transactions, by one means or another, to the commercial market and so encourage the very capital outflow which the dual exchange market was set up to prevent.

CHAPTER FOUR

ECONOMIC INSTABILITY AND THE ORIGIN OF DISTURBANCES :

AN ILLUSTRATION IN THE CASE OF LESS DEVELOPED COUNTRIES

(i)

Levich and Wihlborg have recently made the point that in view of the close interrelationships involved, it becomes extremely difficult to forecast exchange rates, inflation rates and interest rates separately, and that it may therefore be easier to forecast the development of deviations from equilibrium relationships such as purchasing-power parity or covered interest rate parity. And thus, for businessmen, "sources of disturbances and the speed of the market process would be the primary variables to forecast."¹

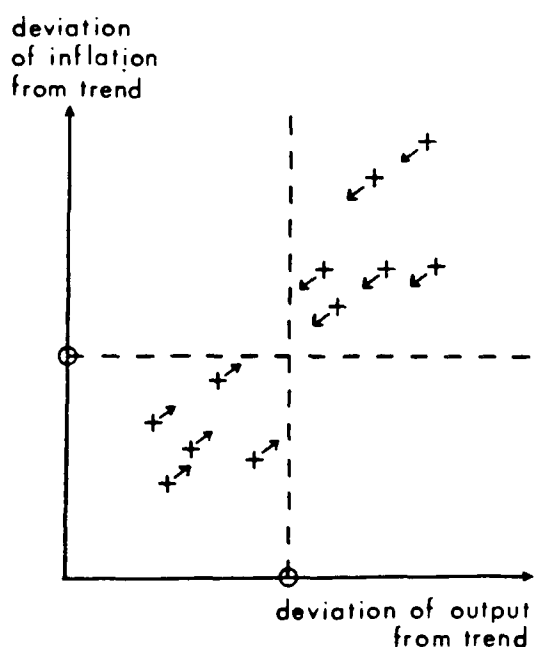
For policy makers, too, it is important to be able to determine the predominant sources of disturbances. Because of the types of disturbance involved and the lack of strong counter-cyclical macro-economic policy, it turns out that this task is likely to be rather easier in the case of less developed countries than for industrialised ones, and, if anything, even more important. In the first part of this chapter we identify the predominant sources of disturbance for a sample of eighteen sub-Saharan African countries, by considering the different effects (noted in section viii of Chapter One) of supply and demand disturbances on output and inflation. Following on from this we make some remarks likely to be applicable not only to less developed countries but to small, open economies at any stage of development, on the degree of insulation from disturbances that can be provided by various additional policies.

1. R.M. Levich and C.G. Wihlborg (eds.), "Exchange Risk and Exposure", Lexington, D.C. Heath, 1980, Introduction, p.8.

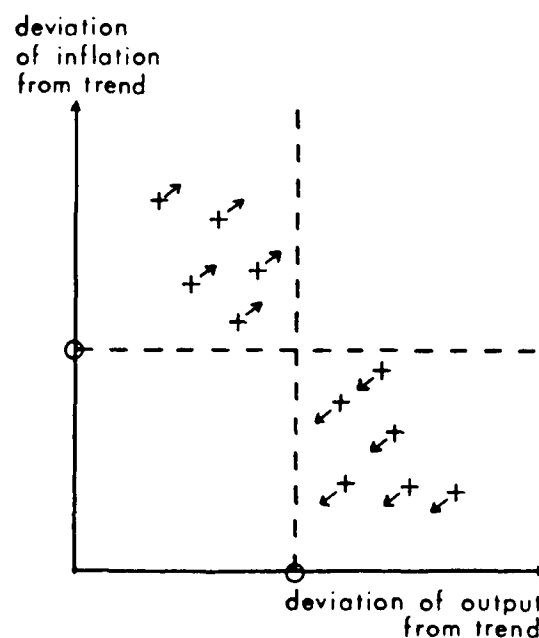
(ii)

The starting assumption is that over the period in question (generally 1965-1977) there was in each of the eighteen countries studied a trend in the level of output and a trend in the rate of inflation.¹ Our analysis concentrates on the stability of output and of the rate of inflation about these trends.² The degree of such stability or instability is of some interest in itself and will be returned to later. However, the central focus will be on the correlation for each country between the deviations of inflation from trend and the deviations of output from trend. For any particular country this correlation may be positive or negative.

Positive correlation between deviations of output and inflation from trend. Demand disturbances predominate.



Negative correlation between deviations of output and inflation from trend. Supply disturbances predominate.



(Each cross represents averages for one year).

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1. We assume a linear trend in each. An alternative procedure sometimes used is to eliminate trend by using first differences. One might expect this to give rather different results since the changes are then measured with reference only to the previous year rather than the trend of the whole period.
 2. c.f. Robert E. Lucas, "Some International Evidence on Output-Inflation Tradeoffs", *American Economic Review*, Vol.63, No. 3, April 1973, pp.326-334.

The observed correlation can be explained in a number of ways, but at the most general level one can assert that demand disturbances will tend to give rise to a positive correlation and supply disturbances to a negative correlation. In the case of demand disturbances the reasoning is familiar from the Phillips curve literature: any increase in demand will tend to increase both prices and real output, at least in the short term, whereas a drop in demand will decrease both prices (from their trend level) and output. The proportion in which the change in demand is manifested in prices and output will depend on the features of the economy concerned and perhaps also on the magnitude of the disturbance. In the case of supply disturbances one would expect a negative correlation, given an unchanged monetary policy, since an autonomous decrease in supply resulting, for example, from a crop failure or industrial unrest, would both reduce output and lead to a rise in price for the reduced output.

But that is only the beginning of the story. It has been pointed out, particularly for the advanced countries, that the observed correlation will depend very importantly on the macroeconomic policies pursued. Let us suppose, as an example, that the government has been pursuing a countercyclical demand policy aimed at reducing fluctuations in real output and that it has been pursuing this policy successfully. Then the observed deviations in each year might be shifted according to the arrows in the diagram above. In the case where autonomous demand disturbances predominate, countercyclical demand policies aimed at stabilising output will also tend to stabilise prices, so that an active countercyclical demand policy will reduce any observed positive correlation. (The observed deviations are pushed towards a central cluster, weakening the significance of the positive diagonal. Conversely, continued attempts to take advantage of a short-term Phillips curve

trade off - more output for more inflation - would move the observed deviations further out along the positive diagonal and so make the correlation more marked.) In the case where autonomous supply disturbances predominate, activist demand policies which stabilize output will tend to destabilize prices.¹ (The arrows tend to push the observations towards a vertical straight line.) Consequently, for advanced countries, whatever correlation, or lack of it, is observed between deviations of output and inflation is likely to be the result as much of the nature of the macroeconomic policies being pursued as of the underlying disturbances to the economy.²

In the case of the less developed countries of Africa, the main distinction to be made is between economic disturbances which originate from outside the country and those which are internal or of non-economic origin. Countercyclical macroeconomic policy will still have some effect but in these countries it is likely to be of a smaller order of magnitude than in the advanced industrial countries. In the first place, both internal and external autonomous disturbances have been exceptionally strong. In the second place, macroeconomic policy is likely to be weak in effect and limited in use. In particular, the severe balance-of-payments constraint facing most African countries means that the only practicable increase in demand will result from an increase in the demand for the country's exports: while decreases in

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1. Of course the government could pursue policies aimed at influencing the supply side of the economy, but these are not usually sufficiently flexible to be useful as stabilizing measures (though some forms of incomes policy might be exceptions to this).
 2. For a study of ten advanced economies where policy variations across countries are assumed to show greater variations than do economic structures, see John B. Taylor, "Output and Price Stability: An International Comparison", *Journal of Economic Dynamics and Control*, Vol.2, 1980, pp.109-132.

the demand for exports will depress output beyond the range of counter-cyclical macroeconomic policy. We therefore postulate for such countries a positive correlation between deviations of inflation and of output from trend, to give a relationship similar to a Phillips curve. To the extent that foreign changes in demand for the country's exports are more marked, the greater will be these deviations and the more marked (one expects) the positive correlation between them. Superimposed on this relationship are internal or non-economic supply-side disturbances, such as crop failures, interruptions to transport arrangements and political upheavals. These typically will reduce output and lead to shortages and an upward pressure on prices: conversely, favourable supply developments provide at least the scope for reducing inflation.¹ Inasmuch as such internal or non-economic disturbances predominate one will observe a negative correlation between the deviations of inflation and output from trend.

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1. Data limitations dictated the use of the consumer price index as the measure of inflation, whereas studies of industrial countries generally use the g.d.p. or g.n.p. deflator. But since we wish to identify the effects of excess aggregate demand or supply and since prices of many exports (which enter the g.d.p. deflator more than the consumer price index) tend to be fixed in world markets, the consumer price index is probably the more appropriate measure of inflation. Using the consumer price index to deflate nominal output does mean that we are measuring real g.d.p. in terms of constant purchasing power rather than in volume terms, but that, too, is the more appropriate assumption. The calculations were repeated using the g.d.p. (in the case of Zimbabwe the g.n.p.) deflator for the seven countries for which estimates were available, namely Ghana, Liberia, South Africa, Tanzania, Zambia, Zaire and Zimbabwe. Only in the case of South Africa and Zambia were there marked changes in the results, the correlation between deviations in output and inflation changing from being significantly of one sign to being insignificantly of the opposite sign. If the consumer price index and the g.d.p. deflator move in the same direction, then, if the c.p.i. is less volatile than the g.d.p. deflator, using the c.p.i. instead of the g.d.p. deflator will tend to bias the results towards a more positive correlation, because then the calculated real output will be higher (will be deflated less) when prices increase. Conversely, the c.p.i. measure will give a more negative correlation if the c.p.i. is more volatile than the g.d.p. deflator.

Of course not all disturbances impinging on these countries will fit exactly into either of these patterns. The period included the first major oil price increase of 1973-74: although its most important impact was probably its negative effect on the trend of output of African countries, via its contribution to world recession, it did provide a short term increase in inflationary pressure without any concomitant tendency to increase output. In addition, in some cases internal autonomous changes in demand could have had some effect. Nevertheless, an examination of the correlation between output and inflation deviations from trend should provide an indication of the predominant source of disturbance.

(iii)

The countries selected were all eighteen sub-Saharan African countries for which data were available for the period in question (generally 1965-1977, plus 1964 and 1978 to calculate the rate of inflation). Data were taken from the International Monetary Fund's International Financial Statistics, August 1980 and 1979 Yearbook and, in the case of Zimbabwe, from the Zimbabwe Monthly Digest of Statistics of July 1980 and December 1973. Linear trends were calculated for both real output and the rate of inflation¹ and the deviation of the rate of inflation from its trend and the proportionate deviation of output from its trend calculated for each year. The correlation

1. The rate of inflation for year t was calculated as $(P_{t+1} - P_t) \div P_t$ where P_t is the price index for year t . An alternative measure, $(P_t - P_{t-1}) \div P_t$ was also tried: the sign of the correlation coefficient was changed for four countries, namely Tanzania, Kenya, The Gambia, Sudan - in the case of Kenya from significantly positive to significantly negative. The first measure was regarded as being more appropriate since changes in output are postulated to lead changes in the consumer price index.

between these deviations is reported below for each country in column 3 of the Table.

Country	Years covered	Correlation of deviation of inflation and proportionate deviation of output from trend	Standard deviation of deviations of inflation from trend (%)	Standard deviation of proportionate deviations of output from trend (%)
South Africa	65-77	+0.782*	1.79	3.44
Ghana	64-75	+0.604*	13.23	7.89
Zimbabwe	65-77	+0.566*	1.03	6.08
Gabon	64-77	+0.483*	5.58	46.72
Tanzania	66-77	+0.473*	6.49	8.97
Kenya	65-77	+0.408*	3.88	3.09
Ivory Coast	65-77	+0.396*	5.51	7.48
Nigeria	65-77	+0.385*	7.34	20.38
The Gambia	65-77	+0.373	5.34	18.45
Sudan	65-76	+0.327	8.90	6.55
Sierra Leone	65-77	+0.279	4.83	4.43
Madagascar	65-77	+0.266	4.92	4.29
Mauritius	65-77	+0.141	6.64	16.28
Cameroon	65-77	-0.044	3.60	7.33
Liberia	66-77	-0.101	6.23	8.14
Togo	64-76	-0.271	3.55	10.06
Zaire	65-77	-0.451**	18.18	19.64
Zambia	65-77	-0.593**	4.34	11.90

*significantly positive at the 10% level of significance (1-tailed test)

**significantly negative at the 10% level of significance (1-tailed test)

Given the fairly short data series used, the results for any individual country must be treated with a certain amount of caution. Nevertheless, the method seems to sort the countries fairly well in accordance with a priori notions of the predominant source of disturbances for the period involved. Zaire and Zambia clearly did suffer from severe internal disturbances.¹ South Africa (gold and minerals), Ghana (cocoa), Tanzania, Kenya and the Ivory Coast (coffee), Zimbabwe (minerals) experienced swings in commodity demand and price which eclipsed any internal sources of disturbance for the period as a whole.²

(iv)

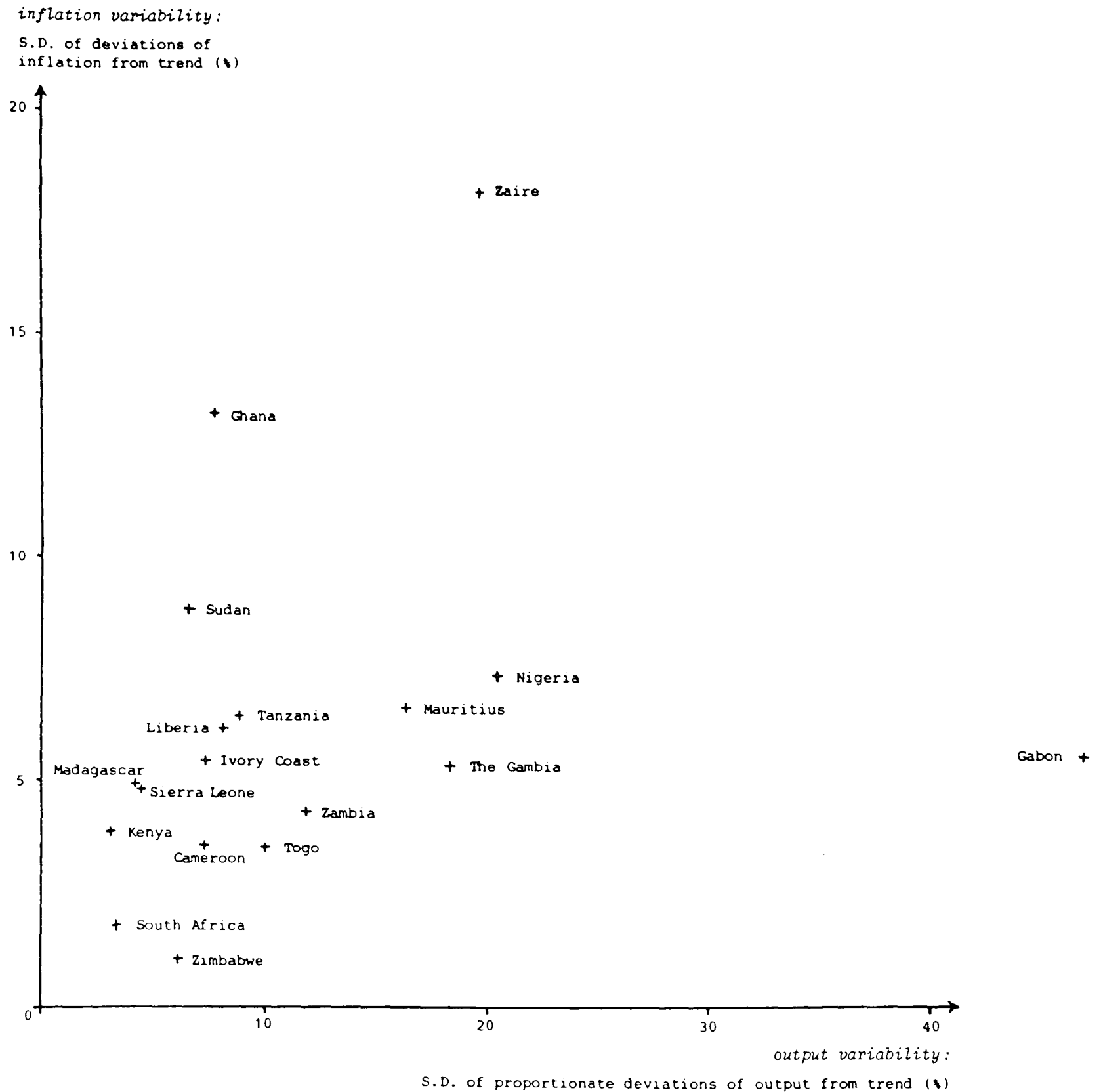
A further test, though a rather indirect one, of our basic hypothesis that external demand changes led to output and inflation movements in the same direction may lie in a study of the variability of output and inflation across countries. If such a relationship exists for each country (modified in some cases by internal or non-economic disturbances) and if the relationship is not too dissimilar across countries, then in general one would expect countries with a high variability of output to have a high variability of inflation as well.

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1. Some other African countries suffered equal or even more severe internal or non-economic disturbances, but these also disturbed the collection of economic statistics and so the countries are not included here.
 2. Mauritius is one country which might appear to be misplaced, since no significant effects of the wide fluctuations in sugar prices are picked up. Even though the Commonwealth Sugar Agreement and the Lomé Convention reduced the swings in the price received by Mauritius for its sugar exports there were still considerable fluctuations in the later years of the period. However, to quite a large extent the fluctuations in price were offset by fluctuations in Mauritian production: thus the unit value of sugar exports peaked in 1975, while export volume in 1975 was the lowest for the period. It is also worth noting that the war in Zimbabwe began to cause economic difficulties only after 1976.

On the other hand, if each country has no short-term Phillips curve relationship between output and inflation, then variations in output would bear no relationship to variations in inflation.

Robert E. Lucas in the paper already mentioned attempted to find such a relationship for a sample of twelve developed and five Central and South American countries, and, finding none, concluded that no such relationship exists, or that to the extent it does exist it disappears with use, and that high variance-of-inflation countries have no concomitant variability of output. Of course, as has already been pointed out, even if there were a similar relationship among the countries in question, if they pursued effective macroeconomic policies the relationships involved would be obscured, so that Lucas's result is not decisive for the industrial countries.

In the case of African countries, countercyclical macroeconomic policy is less likely to obscure any underlying output-inflation trade-off. It is therefore of some interest to examine the variability of inflation against the variability of output. Accordingly, columns 4 and 5 of the Table report respectively the standard deviation of the deviations of inflation from trend and the standard deviation of the deviations of output from trend (expressed as a proportion of the actual level of output in that year). And the figure below then plots these two standard deviations against one another.



For all eighteen countries taken together there is in fact no significant correlation between the variability of output and of inflation (correlation coefficient 0.228, significantly different from zero at the 36% level). But the result is heavily influenced by one or two extreme values. The Spearman rank correlation coefficient for all eighteen countries between the rank of output and inflation variability is 0.511, significant at better than the 5% level. More importantly,

if one drops the two oil exporters, Nigeria and Gabon, on the grounds that the other countries could hardly have been subjected to similar disturbances, the correlation between output and inflation variability becomes 0.519, significant at the 4% level. It is not, perhaps, conclusive proof of a short-term output-inflation tradeoff, but nevertheless some evidence in its favour.¹

Part Two

Dual Exchange-Rate and Interest-Rate Systems and the Origin of Disturbances

(i)

We have developed a measure which indicates ex post whether the predominant sources of economic instability in some African countries were changes in demand, assumed to originate externally, or else internal or non-economic. Although a rather crude measure, it is likely to give a better indication of the origin of disturbances than can be gleaned from indirect measures such as the commodity concentration of exports or the ratio of trade to domestic product.

Knowing the main source of disturbances can also give a useful indication of the appropriate macroeconomic policies. The two cases emphasised above might seem to provide particularly clear-cut cases for exchange-rate policy. In the case of an external demand disturbance, some degree of exchange-rate flexibility should be stabilizing for both output and inflation, since the exchange rate would tend to appreciate during periods of buoyant demand for exports and this

1. But recall our earlier point that balance-of-payments constraints may make it impossible for many countries to use such a tradeoff to increase output even in the short run.

appreciation would damp down the incipient increase in both output and inflation; but this would only be the case provided its effects did not act with too long a time lag, and provided that the required degree of exchange-rate flexibility was feasible for the country concerned, since for many small countries the usefulness of their currency as a store of value would be excessively reduced by large fluctuations of the exchange rate. On the other hand, the case of an internal supply disturbance would seem to be a clear example of the advantages of maintaining a fixed exchange rate, since, for example, the current account deficit consequent on a failure of domestic supply would meet the excess domestic demand without any pressure being put on the domestic price level; but this assumes that the cost of financing the deficit is not excessive, and that the supply disturbance is, and is seen to be, temporary, so that confidence in the government's ability to maintain a fixed parity is not undermined. And the case of a domestic demand disturbance might also be met by a fixed exchange rate for the sake of the favourable effect on price stability, though here the main burden of adjustment must eventually fall on demand policy rather than exchange-rate policy.

What this amounts to, is that although in some circumstances a flexible exchange rate can provide a useful degree of insulation from foreign disturbances, one also needs to know "the speed of the market process" and how this is affected by various macroeconomic policies. It is not our purpose here to add to the discussion concerning the balance to be struck between the likely source of disturbances and the efficiency of adjustment under various exchange-rate regimes;¹ or to

1. For a survey of the issues involved see E. Tower and T.D. Willett, "The Theory of Optimum Currency Areas and Exchange-Rate Flexibility", Princeton Special Paper in International Economics, No. 11, May 1976.

consider the efficiency of monetary and fiscal policy under different exchange-rate systems;¹ or to judge the merits of forward and spot exchange-market intervention,² though all these are of very great importance for the correct choice of exchange-rate policy. Rather, we wish to review the question of whether there are types of disturbances for which it might be advantageous to add a different type of insulation between the domestic and foreign economies by means of a dual exchange rate, or, what is often very similar in effect, a dual interest-rate policy.

(ii)

Most countries, particularly the non-industrial countries, operate with some form of interference with international capital movements, but it cannot be said that the main aim is usually economic stabilization. Instead, the primary purpose might be to restrict permanently the size of any capital outflow, or to maintain a low domestic real rate of interest, or to subsidise certain sectors of the economy by providing them with cheap credit, or even to prevent tax evasion. Nevertheless, such interferences do have implications for economic stability.

Dual currency systems have been extensively analysed, but one way of showing their resemblance to a dual interest-rate system is to analyse them as being equivalent to a tax on foreign investments by

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1. A framework for such a consideration is provided by V. Argy and J. Salop, "Price and Output Effects of Monetary and Fiscal Policy under Flexible Exchange Rates", I.M.F. Staff Papers, Vol.26, June 1979, pp.224-256, and by V. Argy and M.G. Porter, "The Forward Exchange Market and the Effects of Domestic and External Disturbances under Alternative Exchange Rate Systems", I.M.F. Staff Papers, Vol.19, 1972, pp.503-522.
 2. Some aspects of this question are discussed in Chapter Two, "Policies Towards Capital Mobility", of my University of Oxford B.Phil. thesis, 1973.

residents and a subsidy on domestic investments by non-residents, the amount of the tax or subsidy being variable (according to the discount between the financial and the commercial exchange rates), with the tax revenue from new foreign investment going to existing holders of foreign securities and the subsidy on inward domestic investment being paid by existing holders of domestic investments.¹

One of the distinctive features of a dual exchange-rate system is that (provided there are no leakages) it enables the government to control the volume of net capital movements, and, specifically, if it refrains from intervention in the financial exchange-market, to set net capital movements equal to zero. Along with this determinate effect on capital movement goes a less determinate effect in separating the domestic and foreign interest rates. In the case where there are no other restrictions on either the commercial or financial markets, the domestic real interest rate will indeed be related in a stable manner to the foreign real interest rate, provided that the discount between the financial and commercial exchange rates is, and is expected to be, constant.² But in circumstances where there are added incentives for outward investment (a *ceteris paribus* decline in domestic interest rates for example) the discount on the financial exchange rate is likely to widen, so that real interest-rate differentials between home and abroad can alter, in contrast to the case with a unitary exchange rate.

1. This is the approach taken by B.D. Brown, "Exchange Restrictions: Their Implications for Portfolio Management", *Economic Journal*, vol.87, September 1977, pp.543-553.

2. If interest payments are also made through the financial market the real interest rates will be equal in such circumstances, if through the commercial market the domestic real interest rate will be below the foreign rate if the financial exchange rate stands at a discount from the commercial exchange rate.

A dual interest-rate system operates in the reverse manner, with an indirect effect on capital movements through having a determinate effect on interest differentials. In its mildest form such a system might operate simply by modifying existing liquidity preferences - for example the U.S. "Operation Twist" in the early 1960's which aimed to raise U.S. short-term interest rates (by sales of bills) and to depress U.S. long-term rates (by restricting the issue of bonds), but even for a country with as dominant a capital market as the U.S., this proved unsuccessful. Direct regulations are more common. They may affect only a segment of the domestic market, where domestic institutions are required to invest in low-yield debt issued by a favoured institution, for example; or direct regulations may lower the interest-rate structure of the whole domestic monetary system (with credit rationing if necessary), while exchange control prevents lending abroad - and at the same time a few domestic residents, such as importers and exporters, may also be able to participate in the international credit market, by means of trade credits, for example.

But the most clear-cut example of a dual interest-rate system is provided by the interest-equalization tax. If the purpose is simply to insulate the domestic interest rate from external influences, rather than to maintain a permanently lower real interest rate, it should probably be a two-way tax, whereby residents are taxed on the difference between foreign interest received and domestic interest rates when foreign rates are higher, and foreigners have a tax withheld on the difference between domestic and foreign interest rates when foreign interest rates are lower. (The government might also want to subsidise foreign holders of domestic securities when foreign rates are high, and subsidise domestic holders of foreign securities when foreign rates are low, but this should not be necessary to maintain the target domestic

interest rate, provided the domestic capital market is not excessively small.) Of course, especially in a world of floating exchange rates and high inflation (unlike when the U.S. applied such a tax in the 1960's), identifying real interest rates is difficult, particularly if one wants to take account of different risk classes as well. Still, the difficulties of inflation-accounting have not prevented governments from taxing nominal profits earned by foreign subsidiaries, so that even in present circumstances an interest-equalization tax remains quite feasible.¹

Applying an interest-equalization tax to all investments provides a degree of insulation between domestic and foreign rates: a dual interest-rate system is established if it is applied only to one class of investments, say (as in the U.S. from 1963) to investments with a maturity of one year or more. This then creates two classes of financial investments open to residents, one, say short-term, subject to the full influence of foreign development, particularly the tendency towards covered interest-rate parity; the second, say medium-term, insulated to some extent from foreign developments, but perhaps of greater importance for domestic investment and in influencing the demand for money. This was the situation analysed in Chapter Two, although there the difference between the interest rates on the two maturities was not exaggerated by a tax but was sustained simply by a degree of liquidity preference and by the short-term interest rate not entering directly into the demand for money or aggregate demand for goods equations.

1. As with a dual exchange-rate system there will be significant administrative costs, and potentially significant economic costs as well if the long-run trend of domestic real interest rates is made to diverge from that of the rest of the world.

(iii)

Since both dual exchange-rate and dual interest-rate systems operate by driving a wedge between the capital market and factors such as the commercial exchange rate and the domestic rate of interest which have a major influence on production, one would expect that if one is primarily interested in stabilizing variables such as output and inflation, these types of dual system would be worth considering in situations in which initial disturbances originate in the capital or money markets. And in fact the analysis of Chapter Two indicates that in the case of an external monetary or real capital disturbance, exactly those cases in which overshooting is likely to be a problem under freely floating rates,¹ some separation of short and medium term interest rates will lead to a damping of the fluctuations in the medium-term interest rate.

For external capital or monetary disturbances a dual exchange rate and a dual interest rate work very similarly, since in the one case the financial exchange rate, in the other the "financial" or short-term interest rate is free to respond rapidly to restore covered interest-rate parity, while other domestic variables respond more slowly and only if the foreign disturbance is more than temporary. The choice between the two systems is therefore likely to be a matter of administrative convenience and of the degree of leakage that might occur in

1. The overshooting case was established for a small country where there was a high degree of capital mobility. But even for less developed countries where risk factors might diminish capital mobility, the effect of capital flows on the exchange rate can be a problem, particularly if liberalization of capital flows precedes trade liberalization. See the Comment by R.I. McKinnon, pp.141-146, on C.F. Diaz-Alejandro, "Southern Cone Stabilization Plans", Chapter Four, pp.119-141, in W.R. Cline and S. Weintraub (eds.), "Economic Stabilization in Developing Countries", Washington D.C., the Brookings Institution, 1981.

each case between the financial and commercial markets which are supposed to be being kept separate.

In the case of internal capital or monetary disturbances there may be slightly more significant differences in the operation of a dual exchange-rate and a dual interest-rate system, depending on whereabouts in the domestic economy the disturbance first manifests itself. Consider first a purely monetary disturbance, say a once and for all increase in the domestic money supply. Under free floating this is liable to give rise to overshooting, with the domestic interest rate initially decreasing to rise again slowly, while the exchange rate depreciates past the eventual purchasing-power parity level and slowly appreciates towards that level. With a dual exchange-rate policy, the domestic interest still declines, and the financial exchange rate is likely to overshoot its eventual purchasing-power parity level, but the commercial exchange rate can adjust much more slowly. With a dual interest rate there will still be the initial decline in the domestic (medium-term) rate and the single exchange rate might depreciate sharply towards its purchasing-power parity level, but the divorce from the financial market should limit any overshooting. In this case the "financial" or short-term interest rate need change very little.

With an external disturbance in the capital market - say an incipient capital flight caused by a political upheaval - the initial impact would tend to be felt in the exchange market. With a dual exchange-rate system the financial exchange rate would depreciate very sharply, and the interest rate might rise somewhat, too, with the commercial exchange rate depreciating more slowly in response to price developments. With a dual interest rate, the financial (short-term) interest rate would rise very sharply and the single exchange rate

depreciate somewhat, with the domestic (medium-term) interest rate reacting more slowly.

With a flexible exchange rate, therefore, some sort of dual system has potential advantages in ensuring a smoother response to foreign capital or monetary disturbances. In the case of temporary internal capital or monetary disturbances there is also likely to be an improvement in some of the domestic variables depending on the system implemented, though even a modified floating exchange-rate system may not work very well in such a case.

With a fixed (commercial) exchange rate, the dual systems retain their advantage in ensuring a smoother response to external capital or monetary disturbances. In the case of internal capital or monetary disturbances the balance of advantage is less clear: by limiting the opportunities or incentives for a capital inflow or outflow the dual systems reduce the need for exchange-market intervention, but a credibly fixed exchange rate in itself provides an efficient means of stabilizing such temporary disturbances and the dual systems limit the ability to finance temporary balance of payments deficits by attracting a capital inflow. Thus one is liable to get larger fluctuations of the domestic interest rate under either dual system, whereas in the unified fixed rate case, covered interest-rate parity will constrain it within much narrower limits.

A rather similar situation arises in the remaining cases, of real demand or supply disturbances. The point has frequently been made that a dual system is likely to be inefficient in such cases, since it throws the burden of adjustment onto the trade account alone.¹ This is all

1. e.g. J.R. Sheen, "A Monetary Analysis of Dual Exchange Rates and Capital Accumulation", University of Essex, Dept. of Economics D.P. No.131, August 1979.

the more the case where the "wrong" exchange-rate system is used - a fixed rate for an external demand, a flexible rate for an internal demand or supply disturbance - since the unfavourable effects on output and inflation are exaggerated. But in the case where the right exchange rate response operates there is something of an asymmetry, since dual systems will make little difference to the operation of a flexible rate with an external demand disturbance, whereas a fixed rate response to real internal disturbances relies on financing via the capital account, which is rendered more difficult by a dual system.

(iv)

The transition from a fixed to a floating exchange-rate, by removing the balance of payments constraint which was the main reason for imposing capital controls, has sometimes made complete liberalization of capital flows under a unified exchange rate seem more attractive. But from the point of view of economic stability, if the predominant sources of disturbance are such that a more flexible exchange rate is the correct choice, then the case for considering some form of dual exchange-rate or interest-rate system is increased. Of course, there are other important factors besides the origin and type of disturbances which should determine the choice of exchange-rate policy, and one has also to weigh up the administrative costs of such a system and the potential economic losses if departures from a uniform world interest rate are prolonged. But it should not be surprising if some form of insulation of the capital market turns out to be at least a second-best solution, since the problems of overshooting and excessive fluctuations of exchange rates arise precisely because the uncontrolled capital market can often react more quickly than the goods or domestic money markets.

CHAPTER FIVE

PART ONE

EXCHANGE-RATE MODELS OF A SMALL OPEN ECONOMY

(i)

The starting point for the models of this Part is the model which was outlined in Chapter Two to illustrate the transmission of disturbances under a freely floating exchange rate. This is amplified by a treatment of capital flows, the forward market and exchange-rate policy, drawing on some of the results of Chapters Three and Four. On this basis we can construct a model which allows us to study the effects of exchange-rate policy, whether specified according to the degree of intervention in the foreign-exchange markets or as an exchange-rate target. We can also allow for the accompanying monetary policy, specified either in terms of interest rates or in terms of the money supply. Since we shall not be considering changes in the term-structure of interest rates, we revert to a single domestic interest rate: in this amplified model, step changes in the single domestic interest rate can still be allowed for - both by means of changes in the demand for money caused by changes in the terms of trade, as in Chapter Two, and by means of automatic or deliberate changes in the money supply.

We still need to specify the determinants of output a little more closely. Since our interest is not in the average level of output but in its stability, we follow Dornbusch¹ in taking output as being demand-determined. Variations in the rate of inflation (of the prices of domestically produced goods) about its long-term trend are then supposed

1. R. Dornbusch, "Expectations and Exchange-Rate Dynamics", Journal of Political Economy, Vol.84, Dec. 1976, pp.1161-1176.

to depend on the difference between actual and trend (a proxy for full-employment) output.

The real and monetary sectors of the model can be summarized by the equations given below, where, for the moment, lags in the operation of variables are neglected, and the notation used is as follows (starred variables are exogenous):

C	real private consumption,
D*	domestic component of the real money base,
E	exchange rate (domestic currency per unit of foreign currency),
E_f	forward exchange rate,
G	real government expenditure,
I	real private investment,
M	real expenditure on imports,
M_d	real demand for money,
M_s	real supply of money,
P	price index of domestically produced goods,
P_a^*	foreign price index (in foreign currency),
R	domestic interest rate,
T	net government sales of domestic currency in the spot foreign-exchange market,
X	real exports (measured in domestic currency),
X^*	autonomous real exports,
Y	real national income,
$\bar{Y}$	trend level of real national income,

a subscript -i indicates a lag of i periods.

(i) The goods sector:

$$Y \equiv C + I + G^* + X - M$$

$$C = f(Y)$$

$$I = f(R, Y)$$

(ii) The trade sector:

$$X = f\left(X^*, \frac{E_f P_a}{P}\right)$$

$$M = f\left(Y, \frac{E_f P_a}{P}\right)$$

(iii) The monetary sector:

$$M_d = f\left(Y, R, P, \frac{E P_a}{P}\right)$$

$$M_s = f\left(D^*, \sum_{i=0}^{\infty} T_{-i}\right),$$

that is, the money supply depends on the domestic component of the money base and on the level of foreign-exchange reserves.

(iv) The rate of inflation of domestic prices:

$$\frac{dP}{dt} / P = a + f(Y - \bar{Y})$$

Adding the following notation, one can summarise the equilibrium conditions in the foreign-exchange markets:

$\tilde{E}$ expected spot exchange rate - expected now to prevail next period,

R_a^* foreign interest rate,

T_f net government sales of domestic currency in the forward exchange market.

(v) In the spot market for foreign exchange:

One can distinguish four components giving rise to a net supply of domestic currency in the spot foreign-exchange market,

- (a) government intervention (buying foreign currency spot),
- (b) net trade payments, based on contracts entered into last period on the basis of last period's forward exchange rate, but recorded as this period's trade,
- (c) current arbitrage, based on the covered interest differential in favour of the foreign centre, namely

$$\left\{ \frac{(1 + R_a) E_f}{E} - (1 + R) \right\} ,$$

- (d) the unwinding of last period's arbitrage, the current supply of domestic currency depending on last period's interest differential in favour of the domestic centre, namely

$$\left\{ (1 + R_{-1}) - \frac{(1 + R_{a-1}) E_{f-1}}{E_{-1}} \right\} .$$

There is also some net settling up of past forward speculative contracts, but since the net profits are likely to be small and will give rise to an uncertain net spot demand for or supply of foreign exchange, we neglect them. This element may become important only when there has been substantial previous intervention in the forward exchange market. Since we are for the moment assuming unrestricted foreign-exchange markets, there is no spot speculation to be considered separately.

(vi) The net supply of domestic currency in the forward market consists of:

- (a) forward intervention (buying foreign currency forward),
- (b) net trade contracts, entered into this period, on the basis of this period's forward exchange rates (but recorded as

next period's trade),

- (c) current arbitrage demand for forward foreign exchange, based on the covered interest rate differential in favour of the domestic centre, namely

$$\left\{ (1 + R) - \frac{(1 + R_a) E_f}{E} \right\} ,$$

- (d) current forward speculation based on the difference between the expected future spot rate and the forward rate, namely

$$\left(\tilde{E} - E_f \right) .$$

Let us now consider a linear specification of the above model (log-linear in prices and exchange rates) with lags of up to only one period.

$$\log P - \log P_{-1} = a + b (Y - \bar{Y})$$

$$Y \equiv C + I + G^* + X - M$$

$$C = C^* + vY$$

$$I = I^* + xY - zR$$

$$X = X^* + d \left(\log E_{f-1} + \log P_{a-1}^* - \log P_{-1} \right)$$

$$M = M^* + gY_{-1} - h \left(\log E_{f-1} + \log P_{a-1}^* - \log P_{-1} \right)$$

$$M_d = M_d^* + kY - mR - n \left(\log E + \log P_a^* - \log P \right) + p \log P$$

$$M_s = qD^* + r \sum_{i=0}^{\infty} T_{-i} + rT$$

$$M_d = M_s$$

$$O = T - (X - M) + s \{ \log E_f - \log E + R_a - R \} \\ - t \{ \log E_{f-1} - \log E_{-1} + R_{a-1} - R_{-1} \}$$

$$O = T_f - (X_{+1} - M_{+1}) + u (\log \tilde{E} - \log E_f) \\ - s \{ \log E_f - \log E + R_a - R \}$$

All the parameters, $a, b, d, g, h, k, m, p, q, r, s, t, u$ are expected to be positive (or zero). n could be either positive or negative.

q and r , the money multipliers applicable respectively to domestic and foreign reserves may be different from each other, allowing for partial sterilization of foreign-exchange intervention. s and t are likely to be similar in magnitude unless there is substantial portfolio growth.

This system gives us 13 equations in 15 unknowns, $P, Y, C, I, X, M, T, R, E, E_f, M_d, M_s, T_f, X_{+1}, M_{+1}$ (assuming that $\tilde{E}$ is exogenous and taking X_{+1}, M_{+1} to be functions of current variables, just as X, M are functions of lagged variables). This allows the government, in general, to determine two of T, T_f, E, E_f, R , although to the extent that q and r , the money multipliers, or D^* , the domestic component of the monetary base, can be varied, the government has an additional policy instrument.

We can reduce the system to the equilibrium conditions for four markets plus a reduced-form Phillip's curve. (The bond market must then also be in equilibrium, from Walras' Law).

Goods:

$$(1 - v - x)Y = C^* + I^* + G^* + X^* - M^* - gY_{-1} - zR \\ + (d + h) (\log E_{f-1} + \log P_{a-1}^* - \log P_{-1})$$

Money:

$$qD^* + r \sum_{i=0}^{\infty} T_{-i} + rT = M_d^* + kY - mR + p \log P \\ - n (\log E + \log P_a^* - \log P)$$

Spot Foreign Exchange:

$$T - X^* + M^* - (d + h) (\log E_{f-1} + \log P_{a-1}^* - \log P_{-1}) + gY_{-1} \\ + s (\log E_f - \log E + R_a^* - R) - t (\log E_{f-1} - \log E_{-1} + R_{a-1}^* - R_{-1}) = 0$$

Forward Foreign Exchange:

$$T_f - X_{+1}^* + M_{+1}^* - (d + h) (\log E_f + \log P_a^* - \log P) + gY \\ - s (\log E_f - \log E + R_a^* - R) + u (\log \tilde{E} - \log E_f) = 0$$

Reduced-Form Phillip's Curve:

$$\log P - \log P_{-1} = a + b (Y - \bar{Y})$$

As before, with the five equations in the seven unknowns, Y, R, P, E, E_f, T, T_f , the government is able to predetermine two of T, T_f, E, E_f, R , with the possibility of further flexibility through variations in r or q or D^* .

(ii)

In order to examine the short-run response of the system to policy changes, differentiate the five equations totally, setting all exogenous changes equal to zero, to obtain:

$$(1 - v - x) \cdot dY + z \cdot dR = 0$$

$$k \cdot dY + (p + n) \cdot d \log P - m \cdot dR - n \cdot d \log E - r \cdot dT = 0$$

$$-s \cdot dR - s \cdot d \log E + s \cdot d \log E_f + dT = 0$$

$$g \cdot dY + (d + h) \cdot d \log P + s \cdot dR + s \cdot d \log E$$

$$- (d + h + s + u) \cdot d \log E_f + dT_f = 0$$

$$b \cdot dY - d \log P = 0$$

Consider first of all the case where T and T_f are the chosen policy targets. The system can be written:

$$\begin{bmatrix} (1 - v - x) & 0 & z & 0 & 0 \\ k & (p + n) & -m & -n & 0 \\ 0 & 0 & -s & -s & s \\ g & (d + h) & s & s & -(d + h + s + u) \\ b & -1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} dY \\ d \log P \\ dR \\ d \log E \\ d \log E_f \end{bmatrix} = \begin{bmatrix} 0 \\ r \cdot dT \\ -dT \\ -dT_f \\ 0 \end{bmatrix}$$

The determinant, A , of the matrix of coefficients is given by:

$$A = s(d + h + u) \{ (1 - v - x)(n - m) - zbp - kz \} + zns (g - bu)$$

Since $(1 - v - x) > 0$, A is almost certainly negative, unless n is very large and positive and $g > bu$. The latter condition simply requires that the effect of income on imports be large relative to its effect on inflation and relative to the propensity to engage in forward speculation; but for n to be large and positive would require that a worsening of the terms of trade lead to a marked decrease in the real demand for money, and, specifically, that this effect should greatly outweigh any interest-rate effect on the demand for money.

Let us first of all look at the impact effect on the endogenous variables of an increase in T (i.e. net government sales of domestic currency in the spot market).

$$\frac{\partial \log E}{\partial T} = \frac{1}{A} \left\{ \begin{array}{l} -rs(1 - v - x)(d+h+u) - rzs[g + b(d+h)] \\ + (d+h+s+u) \{-m(1 - v - x) - z[k + b(p+n)]\} \end{array} \right\}$$

The numerator on the right hand side is certainly negative, so that with the reservations noted above concerning the negative sign of A , $\frac{\partial \log E}{\partial T}$ is positive, indicating, not surprisingly, that government sales of domestic currency will depreciate the spot exchange rate. We also have:

$$\frac{\partial \log E_f}{\partial T} = \frac{1}{A} \left\{ \begin{array}{l} -rsz[g + b(d+h)] - s(1 - v - x)(m - n) \\ -bz[s(p+n) + n(d+h)] - z(ks + ng) \end{array} \right\},$$

so that the forward rate will also be depreciated (which one would expect unless there were a very marked decrease in domestic interest rates, since exchange-rate expectations are assumed given).

$$\frac{\partial R}{\partial T} = \frac{1}{A} \left\{ (1 - v - x) [sr(d+h+u) + n(d+h+s+u)] \right\},$$

so that, with given exchange-rate expectations, government selling of domestic currency will decrease the domestic interest rate (unless n is

very large and negative, i.e. unless a depreciation of the exchange rate leads to a very great increase in the demand for money).

$$\frac{\partial Y}{\partial T} = \frac{1}{A} \left\{ -z [rs (d + h + u) + n (d + h + s + u)] \right\}$$

It follows that, unless n is extraordinarily large and negative (leading to an increase in R), the effect on Y will be positive.

$$\frac{\partial \log P}{\partial T} = \frac{1}{A} \left\{ -bz [rs (d + h + u) + n (d + h + s + u)] \right\},$$

so, under similar conditions, the price level of domestic goods will increase.

Consider the effects of a change in T_f , i.e. government sales of domestic currency forward.

$$\frac{\partial \log E_f}{\partial T_f} = \frac{1}{A} \left\{ -s (1 - v - x) (m - n) - zs [k + b (p + n)] \right\}$$

$$\frac{\partial \log E}{\partial T_f} = \frac{1}{A} \left\{ -ms (1 - v - x) - zs [k + b (p + n)] \right\}$$

$$\frac{\partial R}{\partial T_f} = \frac{1}{A} \left\{ ns (1 - v - x) \right\}$$

$$\frac{\partial Y}{\partial T_f} = \frac{-nsz}{A}$$

$$\frac{\partial \log P}{\partial T_f} = \frac{-bnsz}{A}$$

In the case of such intervention in the forward market, the forward exchange rate and spot exchange rate will be depreciated, but the impact effect on the interest rate, income and the price level depends on n , the terms of trade effect in the demand for money, and so is likely to be rather small.

The second case to be considered is that in which the government sets targets for E and E_f , adjusting T and T_f to whatever values are

necessary to ensure that the targets are met. We have:

$$\begin{bmatrix} (1-v-x) & 0 & z & 0 & 0 \\ k & (p+n) & -m & -r & 0 \\ 0 & 0 & -s & 1 & 0 \\ g & (d+h) & s & 0 & 1 \\ b & -1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} dY \\ d \log P \\ dR \\ dT \\ dT_f \end{bmatrix} = \begin{bmatrix} 0 \\ n \log E \\ s \log E - s \log E_f \\ -s \log E + (d+h+s+u) \log E_f \\ 0 \end{bmatrix}$$

The determinant, B, of the matrix of coefficients is:

$$B = - (m + rs) (1 - v - x) - z [k + b (p + n)]$$

and is certainly negative.

Let us look at the effects of a depreciation of the spot exchange rate, that is, an increase in $\log E$ alone.

$$\frac{\partial T}{\partial \log E} = \frac{1}{B} \left\{ - (m - n) s (1 - v - x) - zs [k + b (p + n)] \right\}$$

$$\frac{\partial T_f}{\partial \log E} = \frac{1}{B} \left\{ (m - n) s (1 - v - x) + zs [k + b (p + n)] \right. \\ \left. + z (rs + n) [g + b (d + h)] \right\}$$

$$\frac{\partial R}{\partial \log E} = \frac{1}{B} \left\{ (n + rs) (1 - v - x) \right\}$$

$$\frac{\partial Y}{\partial \log E} = \frac{-z (n + rs)}{B}$$

$$\frac{\partial \log P}{\partial \log E} = \frac{-bz (n + rs)}{B}$$

A depreciation of the spot exchange rate alone therefore requires sales of domestic currency spot and purchases forward giving rise to a fall in the domestic interest rate (unless n is very large and negative, so that $n + rs < 0$), and a rise in output and in the price level.

The impact effects of a depreciation of the forward exchange rate alone can be summarised:

$$\frac{\partial T_f}{\partial \log E_f} = (d + h + s + u) + \frac{1}{B} \left\{ -bzrs (d + h) + rs^2 (1 - v - x) \right\}$$

$$\frac{\partial T}{\partial \log E_f} = \frac{1}{B} \left\{ ms (1 - v - x) + zs [k + b (p + n)] \right\}$$

$$\frac{\partial R}{\partial \log E_f} = \frac{1}{B} \left\{ -rs (1 - v - x) \right\}$$

$$\frac{\partial Y}{\partial \log E_f} = \frac{zrs}{B}$$

$$\frac{\partial \log P}{\partial \log E_f} = \frac{bzrs}{B}$$

What are required, therefore, are sales of domestic currency forward and purchases spot, leading to a rise in the domestic interest rate and to falls in income and the price level.

Of more interest is the case where both $\log E$ and $\log E_f$ are changed by the same amount, say increased by $\partial \log E'$.

$$\frac{\partial T}{\partial \log E'} = \frac{ns (1 - v - x)}{B}$$

$$\frac{\partial T_f}{\partial \log E'} = (d + h + u) - \frac{1}{B} \left\{ ns (1 - v - x) + zn [g + b (d + h)] \right\}$$

$$\frac{\partial R}{\partial \log E'} = \frac{n (1 - v - x)}{B}$$

$$\frac{\partial Y}{\partial \log E'} = \frac{-nz}{B}$$

$$\frac{\partial \log P}{\partial \log E'} = \frac{-bnz}{B}$$

Here there will be sales of domestic currency forward. Other changes are a function of n , the terms of trade effect in the demand for money, and so are likely to be rather small, their direction depending on the sign of n . If, for example, n is positive (a depreciation decreases the demand for money), there will have to be purchases of domestic currency spot and there will be a fall in interest rates and a rise in income and domestic prices. The main requirement, however, will be the forward sales of domestic currency, emphasizing the powerful short run effects of forward market intervention on the spot exchange rate, at least when exchange rate expectations are static.

(iii)

Although a full study of the stability of the system would require a more explicit specification of a probably quite long lag structure, there is some interest in looking at the system with lags of only one period.

We first write the system in terms of deviations from the equilibrium values. Using a bar over variables to denote equilibrium values, we first assume that $a = 0$, T_{-i} , $T_{f-i} = 0$ for all i , $R_a^* = R_{a-1}^* = \bar{R}$, $\bar{E} = \bar{E}_f = \bar{E}$, $P_a^* = P_{a-1}^*$. Then in the goods market, we have in equilibrium:

$$\bar{Y} (1 - v - x) = C^* + I^* + G^* + X^* - M^* - g\bar{Y} - z\bar{R}$$

$$+ (d + h) (\log \bar{E} + \log P_{a-1}^* - \log \bar{P})$$

And, since

$$Y (1 - v - x) = C^* + I^* + G^* + X^* - M^* - g\bar{Y}_{-1} - zR$$

$$+ (d + h) (\log E_{f-1} + \log P_{a-1}^* - \log P_{-1}),$$

writing $\hat{Y} = Y - \bar{Y}$, $\hat{Y}_{-1} = Y_{-1} - \bar{Y}$ etc., we can express the goods market in terms of deviations from equilibrium values as:

$$\hat{Y}(1 - v - x) = -g\hat{Y}_{-1} + (d + h) (\log \hat{E}_{f-1} - \log \hat{P}_{-1}) - z\hat{R}$$

Similarly for the other reduced-form equations:

Money market:

$$0 = k\hat{Y} - m\hat{R} + p \log \hat{P} - n (\log \hat{E} - \log \hat{P})$$

Spot foreign exchange:

$$- (d + h) (\log \hat{E}_{f-1} - \log \hat{P}_{-1}) + g\hat{Y}_{-1} + s (\log \hat{E}_f - \log \hat{E} - \hat{R})$$

$$- t (\log \hat{E}_{f-1} - \log \hat{E}_{-1} - \hat{R}_{-1}) = 0$$

Forward foreign exchange:

$$- (d + h) (\log \hat{E}_f - \log \hat{P}) + g\hat{Y} - s (\log \hat{E}_f - \log \hat{E} - \hat{R}) - u \log \hat{E}_f = 0$$

Reduced-form Phillip's curve:

$$\log \hat{P} - \log \hat{P}_{-1} = b\hat{Y}$$

The system can be written:

$$\begin{bmatrix} (1-v-x) & 0 & z & 0 & 0 \\ k & (p+n) & -m & -n & 0 \\ 0 & 0 & s & s & -s \\ g & (d+h) & s & s & -(d+h+s+u) \\ b & -1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \hat{Y} \\ \log \hat{P} \\ \hat{R} \\ \log \hat{E} \\ \log \hat{E}_f \end{bmatrix} = \begin{bmatrix} -g & -(d+h) & 0 & 0 & (d+h) \\ 0 & 0 & 0 & 0 & 0 \\ g & (d+h) & t & t & -(d+h+t) \\ 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \hat{Y}_{-1} \\ \log \hat{P}_{-1} \\ \hat{R}_{-1} \\ \log \hat{E}_{-1} \\ \log \hat{E}_{f-1} \end{bmatrix}$$

which can be written in standard form as:

$$\begin{bmatrix} \hat{Y} \\ \log \hat{P} \\ \hat{R} \\ \log \hat{E} \\ \log \hat{E}_f \end{bmatrix} = \frac{1}{A} \begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} & C_{15} \\ C_{21} & C_{22} & C_{23} & C_{24} & C_{25} \\ C_{31} & C_{32} & C_{33} & C_{34} & C_{35} \\ C_{41} & C_{42} & C_{43} & C_{44} & C_{45} \\ C_{51} & C_{52} & C_{53} & C_{54} & C_{55} \end{bmatrix} \begin{bmatrix} \hat{Y}_{-1} \\ \log \hat{P}_{-1} \\ \hat{R}_{-1} \\ \log \hat{E}_{-1} \\ \log \hat{E}_{f-1} \end{bmatrix}$$

where $A = s (d + h + u) [(1 - v - x) (n - m) - zbp - zk] + zns (g - bu)$

and

$$C_{11} = -g(m-n)s(d+h+u) + gzn(d+h+s+u)$$

$$C_{12} = -(d+h+u)s[(m-n)(d+h) + z(p+n)] + zn(d+h)[d+h+2s+u]$$

$$C_{13} = tzn(d+h+s+u)$$

$$C_{14} = tzn(d+h+s+u)$$

$$C_{15} = (d+h)(m-n)s(d+h+u) - (d+h+t)zn(d+h+s+u)$$

$$C_{21} = -gb(m-n)s(d+h+u) + gbzn(d+h+s+u)$$

$$C_{22} = (m-n)s(d+h+u)[(1-v-x) - b(d+h)] + bznu(d+h) - zns g + z(d+h+u)[sh+bn(d+h)]$$

$$C_{23} = tbzn(d+h+s+u)$$

$$C_{24} = tbzn(d+h+s+u)$$

$$C_{25} = (d+h)b(m-n)s(d+h+u) - (d+h+t)bzn(d+h+s+u)$$

$$C_{31} = -gs(d+h+u)[k+b(p+n)] - gn(1-v-x)(d+h+u+s) + gns[g+b(d+h)]$$

$$C_{32} = -(d+h)s(d+h+u)[k+b(p+n)] + (d+h)ns[g+b(d+h)] + (1-v-x)(p+n)s(d+h+u) - n(1-v-x)(d+h)(d+h+2s+u)$$

$$C_{33} = -tn(1-v-x)(d+h+s+u)$$

$$C_{34} = -tn(1-v-x)(d+h+s+u)$$

$$C_{35} = (d+h)s(d+h+u)[k+b(p+n)] - (d+h)ns[g+b(d+h)] + (d+h+t)(1-v-x)n(d+h+s+u)$$

$$\begin{aligned}
C_{41} &= g [k+b(p+n)] [(d+h+u)(s+z) + sz] - gsm [g+b(d+h)] \\
&\quad + gm(d+h+s+u)(1-v-x) \\
C_{42} &= (d+h+u)(d+h)(s+z) [k+b(p+n)] + (d+h+u)(1-v-x) [m(d+h) - s(p+n)] \\
&\quad + s [g+b(d+h)] [z(p+n) - m(d+h)] + 2s(d+h) [m(1-v-x) + kz] \\
C_{43} &= t(d+h+s+u) \{m(1-v-x) + z [k+b(p+n)]\} \\
C_{44} &= t(d+h+s+u) \{m(1-v-x) + z [k+b(p+n)]\} \\
C_{45} &= - (d+h)s [k+b(p+n)] (d+h+u) + ms(d+h) [g+b(d+h)] \\
&\quad - (d+h+t)(d+h+s+u)m(1-v-x) - (d+h+t)(d+h+s+u)z [k+b(p+n)] \\
C_{51} &= g [g+b(d+h)] [zn-s(m-n)] + gs(m-n)(1-v-x) + gzs [k+b(p+n)] \\
C_{52} &= (d+h) [g+b(d+h)] [zn-s(m-n)] + 2zks(d+h) \\
&\quad + 2(1-v-x)(d+h)(m-n) + zs(p+n) [-g+b(d+h)] \\
C_{53} &= ts(m-n)(1-v-x) + tzs [k+b(p+n)] + tzn [g+b(d+h)] \\
C_{54} &= ts(m-n)(1-v-x) + tzs [k+b(p+n)] + tzn [g+b(d+h)] \\
C_{55} &= [g+b(d+h)] [s(d+h)(m-n) - zn(d+h+t)] \\
&\quad - (d+h+t)s(m-n)(1-v-x) - (d+h+t)zs [k+b(p+n)]
\end{aligned}$$

The matrix of coefficients $\{C_{ij}\}$ is rather too cumbersome for the establishment of any stability conditions in general. Making the special assumption that the price effects on the real demand for money are negligibly small, that is $p = n = 0$, we obtain:

$$A = s(d+h+u) [-m(1-v-x) - zk]$$

and

$$\begin{aligned}
C_{11} &= -gms(d+h+u) \\
C_{12} &= -ms(d+h)(d+h+u) \\
C_{13} &= 0 \\
C_{14} &= 0 \\
C_{15} &= ms(d+h)(d+h+u) \\
C_{21} &= -gmbs(d+h+u) \\
C_{22} &= s(d+h+u) [m(1-v-x) + zk] - mbs(d+h)(d+h+u) \\
C_{23} &= 0 \\
C_{24} &= 0 \\
C_{25} &= mbs(d+h)(d+h+u) \\
C_{31} &= -gsk(d+h+u) \\
C_{32} &= -sk(d+h)(d+h+u) \\
C_{33} &= 0 \\
C_{34} &= 0
\end{aligned}$$

$$\begin{aligned}
C_{35} &= sk (d+h) (d+h+u) \\
C_{41} &= gk (d+h+u) (s+z) + gszk - gsm [g+b (d+h)] + gm (d+h+s+u) (1-v-x) \\
C_{42} &= (d+h+u) (d+h) k (s+z) + m (d+h+u) (1-v-x) (d+h) \\
&\quad - sm (d+h) [g+b(d+h)] + 2s (d+h) [m (1-v-x) + zk] \\
C_{43} &= t(d+h+s+u) [m (1-v-x) + zk] \\
C_{44} &= t(d+h+s+u) [m (1-v-x) + zk] \\
C_{45} &= -ks (d+h) (d+h+u) + ms (d+h) [g+b (d+h)] \\
&\quad - (d+h+t) (d+h+s+u) [m (1-v-x) + zk] \\
C_{51} &= -gms [g+b(d+h)] + gs [m (1-v-x) + zk] \\
C_{52} &= -ms (d+h) [g+b(d+h)] + 2m (d+h) (1-v-x) + 2zks (d+h) \\
C_{53} &= ts [m (1-v-x) + zk] \\
C_{54} &= ts [m (1-v-x) + zk] \\
C_{55} &= ms (d+h) [g+b(d+h)] - s (d+h+t) [m (1-v-x) + zk]
\end{aligned}$$

One set of stability conditions¹ can be expressed in terms of the row sums of the absolute values of the coefficients $|S_i| = \sum_{j=1}^{j=5} \left| \frac{C_{ij}}{A} \right|$.

A set of sufficient stability conditions is that all $|S_i|$ are smaller than 1.

We have:

$$|S_1| = \frac{2m (d+h) + gm}{m (1-v-x) + zk}$$

$$|S_2|^2 = \frac{m (1-v-x) + zk + gmb}{m (1-v-x) + zk}$$

$$|S_3| = \frac{gk + 2k (d+h)}{m (1-v-x) + zk}$$

$$|S_4| = \frac{1}{A} \left\{ \begin{aligned} &[m (1-v-x) + zk] [(d+h+s+u) (d+h+3t) + 2s (d+h)] \\ &- ms [g+b(d+h)] [g+2(d+h)] + gskz \\ &+ m (1-v-x) [g (d+h+s+u) + (d+h) (d+h+u)] \\ &+ k (d+h+u) [(d+h) (2s+z) + g (s+z)] \end{aligned} \right\}$$

1. G. Gandolfo, "Mathematical Methods and Models in Economic Dynamics", North Holland, 1971, p.133.

2. assuming $m (1-v-x) + zk > mb (d+h)$.

$$|S_5| = \frac{3(d+h+t) + g}{d+h+u} - \frac{m [g+2(d+h)] [g+b(d+h)]}{(d+h+u) [m(1-v-x) + zk]}$$

This set of sufficient conditions for stability will certainly not be met (c.f. the expression for $|S_2|$), but one can say that in general it would be more nearly met:

the larger are s , u and (almost certainly) z ,

the smaller are t , d , h , g , v , x .

Whether k , m , b should be large or small for greater stability is uncertain.

This implies that stability is likely to be improved with a larger propensity to engage in covered interest arbitrage this period, with a larger propensity to speculate (given $\tilde{E} = \bar{E}$) and, almost certainly, with a larger interest rate effect on investment. These conditions all seem plausible.

On the other hand, one wants last period's propensity to arbitrage to have been low (since it is unwound this period), and one wants a small marginal propensity to consume and invest and to import out of income, as well as a small relative price effect on imports and exports. A small marginal propensity to consume and invest are plausible as reducing the income multiplier; but a small marginal propensity to import and a small relative price effect on trade are not intuitively appealing conditions for stability, since a large propensity to import reduces the multiplier, and the Marshall-Lerner condition for exchange-market stability emphasises high elasticities of demand for imports and exports. But in this case we are looking at sufficient conditions for stability, and all these parameters, g , d and h operate only with a lag, so that if other (mainly monetary) influences can dampen disturbances immediately, a strong, delayed reaction by the trade account could certainly cause oscillations or overshooting.

One could conduct a similar exercise in terms of columns, but we limit ourselves to looking at the sum of the absolute values of the coefficients in column three, which is: $\frac{t (d+h+2s+u)}{s (d+h+u)}$

This emphasises that $t < s$, that is, some growth in arbitrage portfolios, would improve stability.

(iv)

The model of the previous section can easily be modified to represent a situation in which access to the forward market is restricted. Let us consider the case where no access to the forward market is permitted for non-commercial transactions, and where the forward rate for commercial transactions is set at a fixed premium or discount to the spot rate¹ - for convenience assume it is equal to the spot rate. Following the analysis of Chapter Three, short-term capital outflows can be specified as a function of implicit interest arbitrage and spot speculation:

$$K = C (R_a^* - R) - f (R_{a-1}^* - R_{-1}) + i (\log \tilde{E} - \log E + R_a^* - R) \\ - j (\log \tilde{E}_{-1} - \log E_{-1} + R_{a-1}^* - R_{-1}),$$

where spot speculation, as well as interest arbitrage, is limited by portfolio considerations or the volume of commercial transactions with which such implicit arbitrage or spot speculation can be associated.

One may as well write this function as:

$$K = S (R_a^* - R) - t (R_{a-1}^* - R_{-1}) + u (\log \tilde{E} - \log E) - w (\log \tilde{E}_{-1} - \log E_{-1}).$$

1. We shall argue in Part Two of this chapter that this is a realistic characterization of the South African situation, at least prior to 1980. See G. de Kock, Governor's Report to the Sixty-First Ordinary General Meeting of the South African Reserve Bank, Pretoria, August 1981, p.5.

The other equations of the model are substantially unaltered, so, neglecting long-term capital flows (assumed autonomous), it may be written:

$$\log P - \log P_{-1} = a + b (Y - \bar{Y})$$

$$Y \equiv C + I + G^* + X - M$$

$$C = C^* + vY$$

$$I = I^* + xY - zR$$

$$X = X^* + d (\log E_{-1} + \log P_{a-1}^* - \log P_{-1})$$

$$M = M^* + gY_{-1} - h (\log E_{-1} + \log P_{a-1}^* - \log P_{-1})$$

$$M_d = M_d^* + kY - mR - n (\log E + \log P_a^* - \log P) + p \log P$$

$$M_s = qD^* + r \sum_{i=0}^{\infty} T_{-i} + rT$$

$$M_d = M_s$$

$$0 = T - (X - M) + s (R_a^* - R) - t (R_{a-1}^* - R_{-1}) \\ + u (\log \tilde{E} - \log E) - w (\log \tilde{E}_{-1} - \log E_{-1})$$

As before, all the parameters, except possibly n , are expected to be positive or zero. We now have 10 equations in the 11 unknowns, $P, Y, C, I, X, M, T, R, E, M_d, M_s$ allowing the government in general to predetermine one of T, E, R , with the possibility of an additional target if D^* or r or q can be altered.

The system can be reduced to four equations, representing equilibrium in three markets plus a reduced-form Phillips curve:

Goods:

$$(1 - v - x) Y = C^* + I^* + G^* + X^* - M^* - gY_{-1} - zR \\ + (d+h) (\log E_{-1} + \log P_{a-1}^* - \log P_{-1})$$

Money:

$$qD^* + r \sum_{i=0}^{\infty} T_{-i} + rT = M_d^* + kY - mR + p \log P \\ - n (\log E + \log P_a^* - \log P)$$

Foreign Exchange:

$$T - X^* + M^* + gY_{-1} - (d+h) (\log E_{-1} + \log P_{a-1}^* - \log P_{-1}) \\ + s (R_a^* - R) - t (R_{a-1}^* - R_{-1}) + u (\log \tilde{E} - \log E) - w (\log \tilde{E}_{-1} - \log E_{-1}) = 0$$

Reduced-form Phillip's Curve:

$$\log P - \log P_{-1} = a + b (Y - \bar{Y})$$

(v)

The impact effects of policy changes can be studied by differentiating the four equations above totally, setting all exogenous changes equal to zero, which gives:

$$(1 - v - x) \cdot dY + z \cdot dR = 0$$

$$k \cdot dY + (p+n) \cdot d \log P - m \cdot dR - n \cdot d \log E - r \cdot dT = 0$$

$$- s \cdot dR - u \cdot d \log E + dT = 0$$

$$b \cdot dY - d \log P = 0$$

Considering first the case where T is the chosen policy target, we can write:

$$\begin{bmatrix} (1 - v - x) & 0 & z & 0 \\ k & (p + n) & -m & -n \\ 0 & 0 & s & u \\ b & -1 & 0 & 0 \end{bmatrix} \begin{bmatrix} dY \\ d \log P \\ dR \\ d \log E \end{bmatrix} = \begin{bmatrix} 0 \\ r \cdot dT \\ dT \\ 0 \end{bmatrix}$$

The determinant, F, of the matrix of coefficients is given by:

$$F = (mu - ns) (1 - v - x) + zu [k + b (p + n)],$$

which is almost certainly positive. The impact effects of an increase in T, i.e. net government sales of domestic currency in the spot market, are given by:

$$\frac{\partial Y}{\partial T} = \frac{z (ru + n)}{F}$$

$$\frac{\partial \log P}{\partial T} = \frac{bz (ru + n)}{F}$$

$$\frac{\partial R}{\partial T} = \frac{-(1 - v - x)(ru + n)}{F}$$

$$\frac{\partial \log E}{\partial T} = \frac{1}{F} \left\{ (m + sr)(1 - v - x) + z[k + b(p + n)] \right\}$$

The short run effect of government sales of domestic currency will therefore be to depreciate the exchange rate, lower the domestic interest rate, and raise income and the price level.

If E is to be the policy target, we obtain:

$$\begin{bmatrix} (1 - v - x) & 0 & z & 0 \\ k & (p + n) & -m & -r \\ 0 & 0 & -s & 1 \\ b & -1 & 0 & 0 \end{bmatrix} \begin{bmatrix} dY \\ d \log P \\ dR \\ dT \end{bmatrix} = \begin{bmatrix} 0 \\ n \cdot d \log E \\ u \cdot d \log E \\ 0 \end{bmatrix}$$

The determinant of the matrix of coefficients is given by:

$$H = (1 - v - x)(m + rs) + z[k + b(p + n)],$$

and the impact effects by:

$$\frac{\partial Y}{\partial \log E} = \frac{z(ru + n)}{H}$$

$$\frac{\partial \log P}{\partial \log E} = \frac{bz(ru + n)}{H}$$

$$\frac{\partial R}{\partial \log E} = \frac{-(1 - v - x)(ru + n)}{H}$$

$$\frac{\partial T}{\partial \log E} = \frac{1}{H} \left\{ (1 - v - x)(mu - ns) + zu[k + b(p + n)] \right\}$$

So, in this case, in contrast to the case where there was free access to an uncontrolled forward market, a depreciation of both spot and forward rates together will produce a marked impact effect on Y, P and R.

(vi)

In order to study the stability of the system, we can re-write it in terms of deviations from equilibrium values (assuming $a = 0$,

$T_{-i} = 0$ for all i , $\tilde{E} = \tilde{E}_{-1} = \bar{E}$):

$$(1 - v - x) \hat{Y} = z\hat{R} - g\hat{Y}_{-1} + (d + h) (\log \hat{E}_{-1} - \log \hat{P}_{-1})$$

$$0 = k\hat{Y} - m\hat{R} + p \log \hat{P} - n (\log \hat{E} - \log \hat{P})$$

$$g\hat{Y}_{-1} - (d + h) (\log \hat{E}_{-1} - \log \hat{P}_{-1}) - s\hat{R} + t\hat{R}_{-1} - u \log \hat{E} + w \log \hat{E}_{-1} = 0$$

$$\log \hat{P} - \log P_{-1} = b\hat{Y}$$

This can be written:

$$\begin{bmatrix} (1-v-x) & 0 & z & 0 \\ k & (p+n) & -m & -n \\ 0 & 0 & s & u \\ b & -1 & 0 & 0 \end{bmatrix} \begin{bmatrix} \hat{Y} \\ \log \hat{P} \\ \hat{R} \\ \log \hat{E} \end{bmatrix} = \begin{bmatrix} -g & -(d+h) & 0 & (d+h) \\ 0 & 0 & 0 & 0 \\ g & (d+h) & t & w-(d+h) \\ 0 & -1 & 0 & 0 \end{bmatrix} \begin{bmatrix} \hat{Y}_{-1} \\ \log \hat{P}_{-1} \\ \hat{R}_{-1} \\ \log \hat{E}_{-1} \end{bmatrix}$$

which can be written in standard form as:

$$\begin{bmatrix} \hat{Y} \\ \log \hat{P} \\ \hat{R} \\ \log \hat{E} \end{bmatrix} = \frac{1}{F} \begin{bmatrix} e_{11} & e_{12} & e_{13} & e_{14} \\ e_{21} & e_{22} & e_{23} & e_{24} \\ e_{31} & e_{32} & e_{33} & e_{34} \\ e_{41} & e_{42} & e_{43} & e_{44} \end{bmatrix} \begin{bmatrix} \hat{Y}_{-1} \\ \log \hat{P}_{-1} \\ \hat{R}_{-1} \\ \log \hat{E}_{-1} \end{bmatrix}$$

where $F = (\mu - ns) (1 - v - x) + zu [k + b (p + n)]$

and

$$e_{11} = -g (\mu - ns) + gzn$$

$$e_{12} = -(d+h) (\mu - ns) + (d+h)zn - zu (p+n)$$

$$e_{13} = tzn$$

$$e_{14} = (d+h) (\mu - ns) + (w-d-h)zn$$

$$e_{21} = -gb (\mu - ns) + gbzn$$

$$e_{22} = -b (d+h) (\mu - ns) + (d+h)bzn + (\mu - ns) (1-v-x) + zku$$

$$e_{23} = btzn$$

$$e_{24} = b(d+h) (\mu - ns) + (w-d-h)bzn$$

$$\begin{aligned}
e_{31} &= -gu [k+b(p+n)] - gn (1-v-x) \\
e_{32} &= -(d+h)u [k+b(p+n)] - (d+h)n (1-v-x) + u (p+n) (1-v-x) \\
e_{33} &= -tn (1-v-x) \\
e_{34} &= u(d+h) [k+b(p+n)] - n(w-d-h) (1-v-x) \\
e_{41} &= g(s+z) [k+b(p+n)] + gm(1-v-x) \\
e_{42} &= (d+h) (s+z) k+b(p+n) + (d+h)m (1-v-x) - s(p+n) (1-v-x) \\
e_{43} &= tm(1-v-x) + tz [k+b(p+n)] \\
e_{44} &= [-s(d+h) + z(w-d-h)] [k+b(p+n)] + m(w-d-h) (1-x-v)
\end{aligned}$$

Anticipating the empirical results of Part Two, put $m = 0$, that is, no interest rate effect on the demand for money. Further, assume that there is no portfolio growth or change in the propensity to engage in interest arbitrage or spot speculation, so that $t = s$ and $w = u$.

Then:

$$F = -ns (1-v-x) + zu [k+b(p+n)]$$

and

$$\begin{aligned}
e_{11} &= gn (s+z) \\
e_{12} &= n(d+h) (s+z) - zu(p+n) \\
e_{13} &= szn \\
e_{14} &= -n(d+h) (s+z) + uz m \\
e_{21} &= bg n (s+z) \\
e_{22} &= bn(d+h) (s+z) - ns (1-v-x) + zku \\
e_{23} &= bszn \\
e_{24} &= -bn(d+h) (s+z) + buz n \\
e_{31} &= -gu [k+b(p+n)] - gn (1-v-x) \\
e_{32} &= -(d+h)u [k+b(p+n)] - (d+h)n (1-v-x) + u(p+n) (1-v-x) \\
e_{33} &= -sn (1-v-x) \\
e_{34} &= u(d+h) [k+b(p+n)] - n(u-d-h) (1-v-x) \\
e_{41} &= g(s+z) [k+b(p+n)] \\
e_{42} &= (d+h) (s+z) [k+b(p+n)] - s(p+n) (1-v-x) \\
e_{43} &= sz [k+b(p+n)] \\
e_{44} &= -(s+z) (d+h) [k+b(p+n)] + uz [k+b(p+n)]
\end{aligned}$$

this stability condition, too, if the other parameters are appropriate. This would require, for example, that u , the propensity to speculate (with the expected spot rate equal to the equilibrium rate) be small, so that this does seem the more perverse case and, as was indicated in section (ii), a large and positive n , i.e. a depreciation markedly decreasing the demand for money, might cause difficulties.

In the intermediate cases, with only one of conditions (i) or (ii) fulfilled, the required sizes of n and p are less clearcut, depending on the sizes of the other parameters.

PART TWO

A SIMULATION OF EXCHANGE-RATE POLICIES

IN THE CASE OF SOUTH AFRICA

(1)

In order to bring out the implications of the model developed in the first Part of this chapter, it is a useful exercise to estimate it using the data of a particular country and then study the results of applying different exchange-rate policies. Of course, there are limitations to the conclusions that can be inferred from such simulations. At their best they are an exercise in economic history, showing what the outcome would have been in the past with different policies. In applying those conclusions to the present, one has to remember that conditions and behaviour could have changed since then, so that the lessons of history cannot be applied blindly. In addition, as the advocates of rational expectations have insisted, economic behaviour can change not only over time, but in response to a different policy environment. So, simulations of one set of policies carried out with a model estimated over a period when another set of policies was in force may not be a true test of those policies, unless - an almost impossible task - all the ways in which economic behaviour might change are explained within the model. In this particular case, this is not likely to be an overwhelming objection. Over the period in question South Africa had a number of different types of managed float: the policies being simulated are of managed floating under consistent rules fairly close to some of those actually used. The simulations of free floating are indeed a more radical departure from actual policy, but in a limited field and in an economy whose structure and dual exchange-rate system make it rather unlikely that significant, unpredictable changes in

economic behaviour would result.

More generally, there are a number of reasons why South Africa is an appropriate choice for such a simulation exercise. Firstly, it is small enough to satisfy the small country assumption, but not dominated economically by a large neighbour. Secondly, it has over the years tried a large variety of exchange-rate rules, so there is no obviously superior exchange-rate policy.¹ Thus, since 1971, South Africa has had successively: a fixed gold parity with sterling as the intervention currency; a peg to the floating dollar (August-December 1971); a peg to sterling; a fixed but adjustable peg to the dollar; a crawling peg vis-à-vis the dollar, designed to maintain a roughly constant weighted value of the rand; a peg to the dollar with alterations "only in the event of basic changes in international economic circumstances"; and, since January 1979, a heavily managed independent float. The transitions between these policies were usually also marked by effective devaluations or revaluations of the rand.

Finally, although it is by most measures a developed country, with reasonably developed economic statistics, South Africa shares with the majority of countries outside the industrial West a pronounced vulnerability to outside disturbances in the form of changes in the prices of its export goods - in this case pre-eminently gold.

1. H.R. Heller, "Choosing an Exchange Rate System", Finance and Development, June 1977, pp.23-27, finds that on the criteria he uses South Africa falls among the "borderline cases" between those countries which general practice indicates should peg and those which should float. P. Holden et al., "The Determinants of Exchange Rate Flexibility: An Empirical Investigation", Review of Economics and Statistics, Vol.61, August 1979, pp.327-333, although they rate South Africa's actual policies as "too flexible", calculate a predicted flexibility index (indicating the degree of exchange-rate flexibility, its economic characteristics would have warranted if it had followed average world practice) which puts it among other borderline countries such as Finland, Greece, Iceland, Israel, Portugal and Yugoslavia.

(ii)

Since no suitable model of the South African economy could be adapted for our purposes,¹ it was necessary to estimate a completely new, though very small model, which is presented in this section. I have, of course, drawn on existing empirical work for South Africa in choosing the specification of various equations and, in particular, in specifying lag structures, which are likely to be particularly important in a study of economic stability.

The model of this section is, with one or two adaptations, the empirical counterpart of the model developed in the first Part of this chapter for the case when forward exchange dealings are restricted. Needless to say, it does not pretend to be a general-purpose model of the South African economy, since it has been constructed for a specific purpose, namely to trace the influence of different exchange-rate rules. Thus, although the foreign sector is well represented, for example, no allowance is made for changes in fiscal policy, and the domestic monetary sector is included in only the most rudimentary fashion. Moreover, it is an explanatory rather than a predictive model, which makes the task of model-building slightly easier -

1. There is, in fact, no current published model of the complete South African economy. Sections of larger models have been published by E. Shostak, "The Monetary Block of the Standard Bank Econometric Model: An Application of the Portfolio Approach to Monetary Analysis in South Africa", *Studies in Economics and Econometrics*, No.4, March 1979, pp.20-50; by G.L. de Wet and H.A.B. Herbst, "A Flexible Money Multiplier and a Model of the Monetary Sector for South Africa", *Studies in Economics and Econometrics*, No.10, April 1981, pp.3-24, and G.L. de Wet and T. van der Walt, "A Simple Model of the Current Account of the Balance of Payments", *Studies in Economics and Econometrics*, No.11, July 1981, pp.3-10. A smaller, complete model of the South African economy, with heavy emphasis on the monetary sector, was published by E. Contogiannis, "An Econometric Model of South Africa's Monetary Sector", in M.L. Truu (ed.), *Public Policy and the South African Economy*, O.U.P., 1976, pp.131-142.

specifically, the financial rand exchange-rate and the gold price can be taken as exogenous rather than having to be predicted, and when the deviation of real income from trend is included as an explanatory variable, the trend can be calculated over the whole sample period rather than extrapolated from the past.

The model was estimated on a quarterly basis over the period 1974 I to 1981 II inclusive, with data from 1972 I to 1981 II inclusive. Details of the South African and foreign data series used and some comments on their reliability are included in the appendix to this chapter, where, in the interests of reproducibility, and since they do not all come directly from published series, the raw data series used are also copied out.

First of all, the model is set out in its complete form, followed by the notation used (which is generally consistent with that employed in the first Part). Then the individual equations are discussed and the reasons for particular formulations indicated. All equations were estimated by both two-stage least squares¹ and ordinary least squares. The two-stage least squares estimates, which are used in the simulations, are given here, and the ordinary least squares estimates are listed in the appendix. Except in the money supply, inflation, and capital-flows equations, where simultaneity is more marked, the estimates are very similar, and even in these cases there are no very great differences.

1. Although the number of predetermined variables was less than the number of observations, in order not to reduce the degrees of freedom too far, the reduced-form estimates of the exogenous variables were restricted in each case to the fifteen (out of twenty-three) "best" predetermined variables chosen on the basis of a forward stepwise regression procedure which adds additional independent variables according to their square partial correlation with the dependent variable.

Behavioural Equations

Consumption

$$\begin{aligned}
 \text{II 1} \quad C &= 787.1 - 556.0 S_1 - 136.3 S_2 - 249.1 S_3 \\
 &\quad (8.09) \quad (2.51) \quad (4.79) \\
 &\quad + 0.13562 Y + 0.62350 C_{-1} \\
 &\quad (3.52) \quad (5.29)
 \end{aligned}$$

$R^2 = 0.894$
 $DW = 1.526$

Private Fixed Investment

$$\begin{aligned}
 \text{II 2} \quad I &= 556.7 - 126.8 S_1 - 12.4 S_2 - 1.5 S_3 \\
 &\quad (4.05) \quad (0.40) \quad (0.04) \\
 &\quad + 0.04766 \sum_{i=0}^7 w_i Y_{-i} \\
 &\quad (2.15) \\
 &\quad - 20.29727 \sum_{i=0}^7 w_i \left\{ R_{-i} - 400 (\log P_{-i} - \log P_{-i-1}) \right\} \\
 &\quad (4.48)
 \end{aligned}$$

$R^2 = 0.697$
 $DW = 1.120$

Imports

$$\begin{aligned}
 \text{II 3} \quad M &= 28,575.9 - 117.0 S_1 + 34.6 S_2 + 38.2 S_3 \\
 &\quad (1.79) \quad (0.53) \quad (0.57) \\
 &\quad + 0.51120 \sum_{i=0}^4 x_i Y_{-i} - 4307.5 \sum_{i=0}^8 y_i \log \left(\frac{E.Pa^*}{P} \right)_{-i} \\
 &\quad (11.22) \quad (6.00)
 \end{aligned}$$

$R^2 = 0.858$
 $DW = 1.073$

Exports

$$\begin{aligned}
 \text{II 4} \quad X &= -26,919.1 + 106.2 S_1 + 138.0 S_2 + 232.7 S_3 \\
 &\quad (2.05) \quad (2.66) \quad (4.35) \\
 &\quad + 1.45145 \sum_{i=0}^4 x_i F_{-i}^* + 3870.6 \sum_{i=0}^8 y_i \log \left(\frac{E.Pa^*}{P} \right)_{-i} \\
 &\quad (4.29) \quad (5.89)
 \end{aligned}$$

$R^2 = 0.859$
 $DW = 1.722$

Change in Inventories

$$\begin{aligned}
 \text{II 5} \quad \Delta H = & -1094.8 - 90.5 S_1 + 465.2 S_2 - 46.2 S_3 \\
 & (0.91) \quad (4.51) \quad (0.45) \\
 & +0.18073 Y - 0.08496 H_{-2} + 0.36920 \Delta H_{-1} \\
 & (2.68) \quad (1.60) \quad (2.07)
 \end{aligned}$$

$$R^2 = 0.716$$

$$DW = 2.381$$

Private Short-Term Capital Flows

$$\begin{aligned}
 \text{II 6} \quad K = & -178.4 + 324.8 S_1 + 168.7 S_2 + 155.5 S_3 \\
 & (3.03) \quad (1.65) \quad (1.49) \\
 & +75.10 \left\{ (R_a^* - R) - (R_{a-1}^* - R_{-1}) \right\} + 0.20117 (Y - \bar{Y}) \\
 & (2.93) \quad (1.33) \\
 & +400.22 (\log FR^* - \log E) \\
 & (1.05)
 \end{aligned}$$

$$R^2 = 0.422$$

$$DW = 2.019$$

Money Demand

$$\begin{aligned}
 \text{II 7} \quad M_d = & 997.9 - 15.8 S_1 + 124.4 S_2 - 4.3 S_3 \\
 & (0.21) \quad (1.96) \quad (0.07) \\
 & +0.14907 Y + 1763.5 \log P - 1946.8 \log \left(\frac{P_a^* E}{1000} \right) \\
 & (1.93) \quad (3.37) \quad (3.37) \\
 & +0.80433 M_{d-1} \\
 & (8.45)
 \end{aligned}$$

$$R^2 = 0.918$$

$$DW = 1.885$$

Change in Money Supply

$$\begin{aligned}
 \text{II 8} \quad \Delta M_s = & 270.4 - 271.0 S_1 + 32.1 S_2 - 241.4 S_3 \\
 & (3.60) \quad (0.41) \quad (2.99) \\
 & -0.35849 T \\
 & (2.09)
 \end{aligned}$$

$$R^2 = 0.479$$

$$DW = 1.119$$

Inflation

$$\text{II 9A} \quad \log P - \log P_{-4} = 0.03855 - 0.00359 S_1 - 0.00309 S_2 - 0.00125 S_3$$

(0.49) (0.42) (0.16)

$$+ 0.00001487 (Y - \bar{Y}) + 0.72538 (\log P_{-1} - \log P_{-5})$$

(1.49) (5.67)

$$R^2 = 0.661$$

$$DW = 1.762$$

$$\text{II 9B} \quad \log p - \log P_{-4} = 0.12598 - 0.00358 S_1 - 0.00465 S_2 - 0.00032 S_3$$

(0.39) (0.51) (0.03)

$$+ 0.24444 (\log N_{-4} - \log N_{-8})$$

(2.67)

$$+ 0.00001265 \sum_{i=0}^3 \frac{1}{4} (Y - \bar{Y})_{-i}$$

(0.49)

$$- 0.28639 (\log P_{-4} - \log P_{-8})$$

(1.15)

$$R^2 = 0.496$$

$$DW = 0.710$$

Identities

National Income Identity

$$\text{II 10} \quad Y \equiv C + I + \Delta H + G^* + A + X - M$$

Money Market Equilibrium

$$\text{II 11} \quad M_s = M_d$$

Balance of Payments Identity

$$\text{II 12} \quad -T + K - (X - M) - A + K_1^* + K_g^* \equiv 0$$

Notation

Starred variables are exogenous. A subscript of $-i$ indicates a lag of i quarters. Except where otherwise indicated, data are not seasonally adjusted.

- A real value of gold production (Rm.).
- C real private consumption (Rm.).
- E weighted commercial exchange-rate index, 1975 = 1000,
increase → depreciation.
- F* foreign income index, 1975 = 1000.
- FR* weighted financial exchange-rate index, with commercial
exchange rate index 1975 = 1000.
- G* real government consumption and investment (Rm.).
- H real level of inventories (Rm.), calculated for period t as

$$\sum_{i=t}^{i=0} \Delta H_{-i}, \quad t = 0 \text{ in 1971 IV.}$$
- ΔH change in level of real stocks (Rm.).
- I real private investment (Rm.).
- K real private short-term capital outflows, including errors
and omissions (Rm.).
- K_1^* real private and official long-term capital outflows (Rm.).
- K_g^* real government short-term capital outflows (Rm.).
- M real expenditure on imports (Rm.).
- M_d real demand for money, narrowly defined (Rm.).
- ΔM_s change in the real money stock over the current quarter (Rm.).
- N level of the nominal money stock (Rm.).
- P production price index of goods produced domestically for
domestic use, seasonally adjusted, 1975 = 1000.
- p_a^* foreign price index, 1975 = 1000.
- R three-month bankers' acceptances interest rate, quarterly
average of weekly rates.
- R_a^* weighted average of foreign interest rates.
- S_1, S_2, S_3 seasonal dummies for first, second and third quarters,
respectively.
- T decrease in real net gold and foreign exchange reserves owing
to balance of payments transactions (Rm.).

- X real expenditure on non-gold exports of goods and services (Rm.).
- Y real national income (Rm.).
- $\bar{Y}$ trend level of real national income (obtained by fitting an exponential trend to Y), (Rm.).
- w_i lag structure for income and the real interest rate in the investment equation : $w_0 = 0.074$, $w_1 = 0.132$, $w_2 = 0.170$, $w_3 = 0.183$, $w_4 = 0.171$, $w_5 = 0.138$, $w_6 = 0.091$, $w_7 = 0.041$.
- x_i lag structures for income in the imports and non-gold exports equations : $x_i = 0.2$ for $i = 0, \dots, 4$.
- y_i lag structure for relative prices in the imports and non-gold exports equations : $y_0 = 0.08$, $y_1 = 0.13$, $y_2 = 0.18$, $y_3 = 0.16$, $y_4 = 0.14$, $y_5 = 0.12$, $y_6 = 0.09$, $y_7 = 0.07$, $y_8 = 0.03$.
- R^2 is the multiple correlation coefficient unadjusted for degrees of freedom.
- DW is the Durbin-Watson statistic,¹
- the figures in brackets below the coefficients are the t-ratios.²

Notes on the Equations

Consumption - equation II 1

Since taxes and changes in tax rates are not accounted for in the model, consumption is specified as a function of national income rather than disposable national income.

Private Fixed Investment - equation II 2

The weights used for lagged income and the real interest rate are the normalized values of the weights estimated by Almon for U.S.

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1. For thirty observations and five explanatory variables, the upper and lower limits for the DW statistic at the 5% significance level are 1.07 and 1.83.
 2. The 5% critical value for the t-ratio with 24 degrees of freedom is 2.06. In a few cases explanatory variables are included with coefficients merely greater than their standard errors.

data.¹ The equation was also estimated using the nominal rather than the real interest rate, but although the coefficient for the interest rate had the expected negative sign, it was not as significant as that for the real interest rate, which in any case seems preferable on theoretical grounds.

Imports - equation II 3

The weights for the relative price index are those estimated by Erasmus.² In the case of income Erasmus estimated weights, starting from lag 0, of 0.26, 0.25, 0.25, 0.24 but chose to use income simply lagged one quarter. Estimates by Courtney³ gave a slightly longer average lag, with weights, starting from lag 1, of 0.150, 0.263, 0.306, 0.281. The weights imposed here are a compromise, and starting from lag 0 are 0.2, 0.2, 0.2, 0.2, 0.2. The Durbin-Watson statistic for this equation is low enough to suggest some positive autocorrelation of residuals, but is inconclusive at the 5% level of significance.

Exports - equation II 4

Since less detailed work has been done on South African exports than on imports, we impose the same weights for the income and relative price variables as for imports. They seem to perform quite well. The implied long-run partial exchange-rate elasticity (evaluated at the means) is 2.58 and the elasticity with respect to foreign income is 1.05 (c.f. an exchange-rate elasticity of 1.86 and an income elasticity of 1.53 for imports). The exchange-rate elasticity is, of course,

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1. S. Almon, "The Distributed Lag Between Capital Appropriations and Expenditures", *Econometrica*, Jan. 1965, p.188.
 2. C.M. Erasmus, "Elasticities and Lag Structures in South African Imports", *Studies in Economics and Econometrics*, No.3, Sept. 1978, p.33.
 3. M.M. Courtney, "Exchange Rate Policy and Imported Inflation", in M.L. Truu (ed.), *Public Policy and the South African Economy*, O.U.P., 1976, p.188.

likely to be a good deal lower once subsequent changes in price are allowed for.

Change in Inventories - equation II 5

The formulation adopted here follows a suggestion by Evans for the United States.¹ An alternative formulation brings out the procyclical nature of inventory changes (estimated by 2SLS),

$$\begin{aligned} \Delta H = & 50.77 - 205.4 S_1 + 416.7 S_2 - 12.1 S_3 \\ & (2.48) \quad (4.43) \quad (0.13) \\ & + 0.43033 (Y - \bar{Y}) + 0.27037 \Delta H_{-1} \\ & (3.68) \quad (1.64) \end{aligned} \quad \begin{aligned} R^2 &= 0.762 \\ DW &= 2.042 \end{aligned}$$

but the form including the level of inventories (lagged two quarters) was preferred as being more directly related to the variables influencing firms' stockpiling decisions.

Private Short-Term Capital Flows - equation II 6

Short-term capital flows include the errors and omissions in the balance of payments statistics and, on a quarterly basis especially, there is bound to be a large random component to capital flows, so that the fairly low degree of explanation provided by this equation is not too unsatisfactory.

Both theoretical grounds (neglecting portfolio growth) and preliminary estimates (see equation II 6 (ii) in section (iii) of the Appendix giving the OLS results, and the equation below), suggested equal and opposite coefficients for $(R_a^* - R)$ and $(R_{a-1} - R_{-1}^*)$, a condition imposed on the estimate used in the model.

1. M.K. Evans, *Macroeconomic Activity*, Harper and Row, New York, 1969, pp.217-218.

A preliminary estimate (estimated by 2SLS):

$$K = -168.1 + 326.1 S_1 + 170.7 S_2 + 161.3 S_3$$

(2.99) (1.64) (1.52)

$$+ 79.56 (R_a^* - R) - 72.94 (R_{a-1}^* - R_{-1})$$

(2.89) (2.76)

$$+ 0.12714 (Y - \bar{Y}) + 347.04 (\log FR^* - \log E)$$

(0.59) (0.87)

$$R^2 = 0.428$$

$$DW = 1.991$$

We assume that the dual-exchange-rate system worked as it was supposed to, separating "financial" or portfolio from "commercial" transactions. The high discounts on the financial rand, sometimes up to 40%, suggest that this was indeed the case. The net capital flows considered here went through the commercial market, but the existence of the quite freely floating financial rand rate provides a useful indicator of exchange-market sentiment. The term $(\log FR^* - \log E)$ is meant to pick up the speculative motive for movements of capital, on the assumption that the financial rand exchange rate, being a relatively unregulated rate, reacts sooner to exchange-market pressures than does the commercial rate. Thus a widening of the financial rand discount (and so an increase in $(\log FR^* - \log E)$ would imply an expected depreciation of the commercial rand. This assumption is likely to work better for the latter part of the period when the financial rand market was broader, and is perhaps a rather drastic assumption when applied to a period as long as a quarter, but finding a suitable estimate for the expected value of next period's spot rate is notoriously difficult.¹

1. The financial rand term worked much better than assuming perfect foresight and setting $\tilde{E} = E_{+1}$: a term with $(\log E_{+1} - \log E)$ had the wrong sign.

This term has the right sign and a coefficient larger than its standard error, even though not significantly different from zero at the 95% confidence level. The theoretical discussion of Part One would suggest the inclusion of a term $(\log FR_{-1}^* - \log E_{-1})$ but such a term always had an estimated coefficient close to zero and is omitted. This suggests that exchange-rate sensitive capital flows are not limited by portfolio considerations and the feasible size of leads and lags in the way that interest-sensitive flows are.¹

Money Demand - equation II 7

We use the narrow definition of the money stock - coin, banknotes and demand deposits - as being likely to respond with greater regularity to changes in the money base. The estimation follows conventional formulations, but with the inclusion of the terms of trade, as argued in Chapter 2. (The equation II 7 is equivalent to the following one which is more directly in the form specified in Part One of this chapter - also estimated by 2SLS:

$$\begin{aligned}
 M_d = & 14,446.1 - 15.8 S_1 + 124.4 S_2 - 4.3 S_3 \\
 & (0.21) \quad (1.96) \quad (0.07) \\
 & + 0.14907 Y - 183.4 \log P - 1946.8 \log \frac{Pa E}{P} \\
 & (1.93) \quad (1.12) \quad (3.37) \\
 & + 0.80433 M_{d-1} \\
 & (8.45)
 \end{aligned}$$

$R^2 = 0.918$
 $DW = 1.885$

An increase in home prices does seem to increase the real demand for money, whereas an increase in foreign prices or a depreciation of the exchange-rate lowers it; that is, an improvement in the terms of trade

1. The size of the flows involved is not large. A widening of the financialrand discount by 10% would lead to a capital outflow of about R17 million per quarter.

increases the real demand for money.

In common with other recent estimates of the demand for money in South Africa,¹ we failed to find any significant effect of the interest rate on the demand for money - an interest rate term was of the wrong sign and statistically non-significant.

Change in Money Supply - equation II 8

This equation is not designed to provide a complete explanation for changes in the money supply, but only of the extent to which changes in net foreign exchange reserves affect the money supply once sterilizing changes in the Reserve Bank's net domestic assets and possible changes in the money multiplier (because, for example, of changes in the banking system's excess cash ratio²) have taken place. To the extent that the money multiplier can be taken to be constant, the coefficient for T is a measure of the extent to which sterilization of net reserve changes has taken place, with a value of zero implying complete sterilization. The structure of the model brings out the simultaneity inherent in the fact that net reserve changes may themselves be partly the result - though mainly the delayed result - of changes in the money supply,³ but this causes no problem with an estimation procedure which eliminates simultaneous-equation bias. Using equation II 8, the estimates for the level of the money supply are therefore $M_s =$

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1. c.f. the discussion by G. Stadler, "The Demand for Money in South Africa", South African Journal of Economics, June 1981, pp.145-52.
 2. E. Contogiannis, "The Money Supply Process in South Africa", South African Journal of Economics, Vol. 45, Sept. 1977, p.278.
 3. This is a point made by V. Argy and P. Kouri, "Sterilization Policies and the Volatility of International Reserves", in R.Z. Aliber (ed.), National Monetary Policies and the International Financial System, University of Chicago Press, 1974, pp.209-230.

$M_S^* - 0.35849 (T - T^*)$ where M_S^* and T^* are the actual values and M_S and T the values implied by the particular solutions of the model.¹ Since the coefficient of T is mainly a result of sterilization policy, it will be assumed variable in some of the simulations.

Inflation - equations II 9A and II 9B

Since quarterly rates of inflation are subject to considerable random elements, from changes in administered prices for example, the approach used here is to explain the rate of inflation measured as the percentage change between the price level this quarter and the price level a year before.

Equation II 9A follows directly from the model of Part One and has the corresponding measure of inflation for the previous period and the current deviation of income from trend as the only explanatory variable, implying a geometrically distributed lag for the effects of the deviation of income from trend as the sole determinant of the variations in inflation about a constant value (14.04% per annum in this case, neglecting seasonality).² It is thus an exclusively demand-pull explanation for variations in the inflation rate.

Statistically, the task of identifying other influences on inflation is made more difficult by the fact that during the period under study the South African annual rate of inflation (measured for every quarter relative to a year ago) fluctuated within a fairly narrow range with 8.6% and 16.7% as the extreme values. There is fairly general agreement that autonomous cost-push elements of inflation are less

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1. In some of the simulations we assume the authorities have a target for changes in the money supply rather than its level, which gives a slightly different result. See below, p.171.
 2. The overlap between the dependent variable and the lagged-value of the dependent variable in this equation means that the multiple correlation coefficient is likely to overstate the degree of explanation provided.

important in South Africa than in many Western industrial countries,¹ except, perhaps, for a cost-push element from the price of imports;² but including foreign prices adjusted for exchange-rate changes failed to provide a significant coefficient (and usually of the wrong sign) whether current values, or values lagged as for the trade estimates were used.

There is some evidence that the rate of growth of the nominal money supply has influenced variations in the rate of inflation, though with a long and uncertain lag. Various estimates were made, using the rate of growth of the nominal money supply or the rate of growth of the nominal money supply in excess of the rate of growth of real income, both in the current and in the previous year. Equation II 9B was judged to be the most satisfactory of these. It indicates that given the rate of growth of the nominal money supply, inflation in the previous year has a negative influence on inflation in the current year, which is consistent with an uncertain distribution over time of the effects of monetary growth. Since the other equations of the model are in terms of the real money supply, an expression for the GNE deflator measure of the price level (instead of just for the domestic price level), was needed in simulations involving the nominal money supply, and for this purpose

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1. A good summary of the features of South African inflation is provided by the Nedbank Group Economic Unit, "South Africa: An Appraisal, The Sovereign Risk Criteria", Johannesburg, 1977, pp.257-261. See also M.L. Truu, "Inflation in the South African Economy", South African Journal of Economics, Vol.43, December 1975, pp.446-470.
 2. This element has been stressed, rather controversially, by P.D.F. Strydom. See P.D.F. Strydom and L. Steenkamp, "Inflation in South Africa I", and "Inflation in South Africa II", South African Journal of Economics, Vol.44, June 1976, pp.115-138 and Dec.1976, pp.417-434 and the Comments in the Dec. 1976 and June 1977 issues of the S.A.J.E. A more considered version of this view appears in P.D.F. Strydom and L. Wiehahn, "Cost-Push Inflation and the Balance of Payments", S.A.J.E., Vol.45, Sept. 1977, pp.257-267.

equation A (ii) 2 of the data appendix was used.

On the whole, the inflation equation including the effect of the money supply performed slightly better than equation II 9A in simulations which departed more widely from the actual course of the economy; but, particularly in view of the uncertainty of the time lag involved, all simulations were performed with both forms of the inflation equation.

(iii)

In this section we set out the simulation properties of the model in simulating the actual course of the economy.

The model estimated in the previous section can be reduced to four equations, representing equilibrium in the goods market, money market and foreign-exchange market and a reduced-form Phillip's curve, as follows.

Goods:

$$\begin{aligned}
 \text{(iii) 1} \quad & - 0.7826216 Y - 1.5019979 R - 53.44881 \log P \\
 & + 654.248 \log E + G^* + A^* + 0.62350 C_{-1} \\
 & + 0.04766 \sum_{i=1}^7 w_i Y_{-i} - 0.51120 \sum_{i=1}^4 x_i Y_{-i} \\
 & + 1.45145 \sum_{i=0}^4 x_i F_{-i}^* - 600.79919 \log P_{-1} \\
 & - 20.29727 \sum_{i=1}^7 \left\{ R_{-i} - 400 [\log P_{-i} - \log P_{-i-1}] \right\} \\
 & + 8178.1 \sum_{i=1}^8 y_i (\log E_{-i} + \log P_{a-i}^* - \log P_{-i}) + 654.248 \log P_a^* \\
 & - 0.084964 H_{-2} + 0.36920 \Delta H_{-1} - 55251.4 \\
 & - 550.1 S_1^* + 419.9 S_2^* - 102.2 S_3^* + 193 = 0
 \end{aligned}$$

Foreign Exchange:

$$\begin{aligned}
 \text{(iii) 2} \quad & - T - 75.10 R + 0.30341 Y - (1054.468 + A^*) \log E \\
 & + 654.248 \log P + K_1^* + K_g^* + 75.10 R_a^* - 75.10 (R_{a-1}^* - R_{-1})
 \end{aligned}$$

$$\begin{aligned}
& - 0.20117 \bar{Y}^* + 0.51120 \sum_{i=1}^4 x_i Y_{-i} + 400.22 \log FR^* \\
& - 1.45145 \sum_{i=0}^4 x_i F_{-i}^* - 8178.1 \sum_{i=1}^8 y_i (\log E_{-i} + \log P_{a-i}^* - \log P_{-i}) \\
& - 654.248 \log P_a^* - A^* (1 - \log E^*) + 55316.6 \\
& + 101.6 S_1^* + 65.3 S_2^* - 39.0 S_3^* + 36 = 0
\end{aligned}$$

Money:

$$\begin{aligned}
\text{(iii) 3 } & uT - uT^* + 0.14907 Y + 1763.5 \log P - 1946.8 \log E \\
& - M_S^t + 0.80433 M_{S-1} - 1946.8 \log P_a^* + 14445.9 \\
& - 15.8 S_1^* + 124.4 S_2^* - 4.3 S_3^* = 0
\end{aligned}$$

Inflation:

$$\begin{aligned}
\text{(iii) 4A } & - \log P + \log P^* + \log P_{-4} - \log P_{-4}^* + 0.00001487 Y \\
& - 0.00001487 Y^* + 0.72538 (\log P_{-1} - \log P_{-5} - \log P_{-1}^* + \log P_{-5}^*) \\
& = 0
\end{aligned}$$

$$\begin{aligned}
\text{(iii) 4B } & 0.24444 (\log M_{-4} - \log M_{-8} - \log M_{-4}^* - \log M_{-8}^*) + \log P^* \\
& - 0.0000031625 Y^* - \log P + 0.0000031625 Y \\
& + 0.947016 (\log P_{-4} - \log P_{-4}^*) + 0.0572983 (\log P_{-8} - \log P_{-8}^*) \\
& + 0.0000031625 \sum_{i=1}^3 (Y_{-i} - Y_{-i}^*) = 0
\end{aligned}$$

In the above equations the starred variables assume the actual values and the unstarred ones are determined in the simulation. There are a total of seven variables to be determined. Y, R, P, E, T, u, M_S^t . M_S^t is not the real money supply in the current period but the target money supply, determined by changes in the domestic component of the money base and in the reserve ratio: it differs from M_S , the simulated money supply this period by the factor $u(T-T^*)$, i.e. by unanticipated changes in the foreign exchange reserves. Where the authorities are assumed to have a money supply target, there are two possibilities:

firstly a target in terms of levels, in which case $M_S^t = M_S^*$; secondly, a target in terms of changes in the money supply, in which case $M_S^t = M_S^* - (M_{S-1}^* - M_{S-1})$. u and M_S^t are determined by whatever we assume domestic monetary policy to have been and R or E or T can also be determined by the domestic authorities. The final constant terms +193 in equation (iii) 1, and +36 in equation (iii) 2 are intercept adjustments.

In simulating the actual course of the economy, we can therefore set any three out of R , E , T , u , M_S^t at their actual values (or in the case of M_S^t at what we assume its actual value to have been) and determine the other four variables simultaneously. In a perfectly specified model we would get exactly the same result whatever three were selected as the policy variables. In fact, of course, the results will be slightly different in each case. And since we shall later want to compare these "actual" results with those when alternative policies are used, each of these simulations will be appropriate for comparison to different alternative policies. If, for example, the alternative policy consists of pegging the exchange rate in a certain way and maintaining a money supply target, the comparison should be with a simulation which sets E , u and M_S^t at their actual levels. If the alternative policy consists of a policy towards T , i.e. foreign exchange intervention, and the level of the interest rate, then the comparison should be with a simulation which sets T and R at their actual levels and determines Y , P , E and M_S within the model (the question of determining u does not then arise).

The question of the most appropriate simulation of the actual course of the economy would be easier to resolve if we knew exactly what the government's policy targets had been. But the changes in exchange-rate policy have already been mentioned and the situation with regard to monetary policy has recently been summarised by the Governor

of the South African Reserve Bank:¹

"In the past, monetary policy in South Africa has at times been characterised by the absence of a clearly defined approach to monetary aggregates or interest rates and therefore also to the relationship between them. Until recently, no use was made of either published or unpublished targets for M1, M2, cash base or any other monetary aggregate, except in one instance where this was a pre-condition for a drawing on the International Monetary Fund. Nor were any specific targets set for interest rates. Indeed, for long periods, interest rates did not feature prominently in monetary policy at all."

Accordingly, the model was simulated over the period 1974 I - 1981 II for five specifications of the assumed joint exchange-rate and monetary policy regime. Where appropriate both formulations of the money supply rule were applied: in every case one was clearly superior (and more appropriate theoretically) and only that formulation is reported here. Each simulation was also carried out for both inflation equations, and although the results in this series of simulations are very similar, both are reported in each case.

Regime 1) $R = R^*, u = u^*, M_S^t = M_S^*$.

This regime is not in fact needed for comparison to any alternatives, but is included as being the most severe test of the model's ability to track the external sector. The domestic monetary policy is assumed predetermined as to both the interest rate and the money supply, and the sterilization coefficient is fixed at its estimated value. Both the exchange rate and the level of foreign-exchange intervention are left to be determined by the model.

Regime 2) $T = T^*, M_S^t = M_S^*$ (since $T = T^*$, u does not enter into the model). Here we assume that the domestic authorities have been

1. G. de Kock, "Monetary Policy in South Africa in 1981/82", Address to the Financial Mail Investment Conference, 20 November 1981, p.13.

pursuing a money supply target rigidly together with a fixed pattern of foreign-exchange intervention. The exchange rate and interest rate vary in response.

Regime 3) $T = T^*$, $R = R^*$ (again, since $T = T^*$, u does not enter into the model.) Here, the assumption is that the authorities determine interest rates and set the level of foreign-exchange intervention (perhaps with some joint money supply/exchange-rate outcome in view). The money supply and exchange rate are free to vary.

Regime 4) $E = E^*$, $R = R^*$, $M_S^t = M_S^*$.

Here we assume the government has targets for the exchange rate, the interest rate and the money supply. These are reconciled by altering the level of foreign-exchange intervention and the sterilization coefficient needed from one period to the next.

Regime 5) $E = E^*$, $u = u^*$ (other values of u were also simulated), $M_S^t = M_S^* - (M_{S-1}^* - M_{S-1})$. Here the government has an exchange-rate and a money supply target, and a fixed sterilization coefficient. In this case it has to be assumed that the money supply target is in the form of target changes in the money supply, as trying to maintain a target money supply level with given sterilization coefficient and exchange rate makes changes in foreign-exchange intervention very ineffective as a policy instrument and throws an unreasonable burden on interest-rate variations.¹

The table following presents the summaries for these simulations. For each of the policy regimes we record first the deviations of the most important variables from their actual values after 1, 4, 10, 18

1. As a matter of fact, simulations with $M_S^t = M_S^*$ gave reasonable results only with the sterilization coefficient set to give no or almost no sterilization of foreign-exchange intervention, i.e. allowing the maximum deviation between M_S and M_S^t .

and 30 quarters, and then, as a summary measure of the goodness of fit, the Root Mean Square Errors of Y, P, the rate of inflation, and E (except for those regimes where E is set equal to E^*), expressed as a percentage of the mean of the variable involved. The RMS Error of the variable K is thus measured as:

$$100 \sqrt{\frac{1}{30} \sum_{t=1}^{30} (K_t - K_t^*)^2} / \frac{1}{30} \sum_{t=1}^{30} K_t^*$$

The next set of statistics gives the range of reserves and of some other variables, as a reference against which to measure the feasibility of alternative policies. Finally we list some measures of the stability of the economy for each regime: the coefficients of variation of Y, P, the rate of inflation, and E relative to a trend calculated as a nine quarter moving average; and, since such a way of measuring stability can be sensitive to the method by which the trend is measured, we also list the coefficients of variation of the rate of inflation and of E relative to their mean values.

For a variable, K, the coefficient of variation relative to trend is thus calculated as:

$$100 \sqrt{\frac{1}{26} \sum_{t=1}^{26} \left(K_t - \frac{1}{9} \sum_{j=-4}^4 K_{t+j} \right)^2} / \frac{1}{26} \sum_{t=1}^{26} K_t$$

And the coefficient of variation relative to the mean is:

$$100 \sqrt{\frac{1}{30} \sum_{t=1}^{30} \left(K_t - \frac{1}{30} \sum_{t=1}^{30} K_t \right)^2} / \frac{1}{30} \sum_{t=1}^{30} K_t$$

Except perhaps in the case of Regime 3, where R and T are fixed and the exchange rate has to do all the adjusting to external shocks,

the fit is fairly close for such a long simulation period, as measured by the conformity of Y , E or the level of reserves to actual values. The price level is always (except in some cases in Regime 3) very well simulated, but this is partly a result of the specification of inflation in equations (iii) 4A or (iii) 4B in terms of deviations from actual values, so that if the levels of real income and the money supply are close to their actual values, the price level will be very close to its actual value. In the regimes in which the money supply is predetermined the interest rate is more volatile than the actual figures - this is partly because one is then allowing no trade-off between money-supply and interest-rate targets, and partly because we are not allowing for the government regulations, institutional rigidities and moral suasion which kept interest rates stickier in the real South African situation than the underlying market conditions would have warranted.

Regime 1	A
$R=R^*, u=u^*$	
$M_S^t=M_S^*$	B
Regime 2	A 5
$T=T^*, M_S^t=M_S^*$	B 2
Regime 3	A
$T=T^*, R=R^*$	B
Regime 4	A
$E=E^*, R=R^*$	
$M_S^t=M_S^*$	B
Regime 5	A
$E=E^*, u=u^*$	
$M_S^t=M_S^*-(M_{S-1}^*-M_{S-1})$	B
Regime 5	A
with	
$u = -0.71698$	B

(iv)

The alternative policies considered fall into two distinct groups. In the first group are those policies in which T , the level of foreign-exchange intervention is predetermined. The only policies considered in this category involve setting $T = 0$, i.e. a freely floating exchange rate. This can be combined with either a money supply or an interest rate target, taking in each case the actual values that prevailed as the supposed government target in the monetary sphere. Since monetary policy was presumably co-ordinated with the actual exchange-rate policies, the results are likely to understate somewhat the benefits of alternative exchange-rate policies.

The results are shown in the following table, where the first set of statistics indicates the desirability of the policy in question, as measured by the coefficient of variation of real income, the price level, the rate of inflation and the exchange rate relative to a nine-quarter moving average trend, as well as the coefficient of variation of the rate of inflation and of the exchange rate relative to their means. The second set of statistics indicates the feasibility of the policy in question, as measured by the range of foreign exchange reserves (both net and including valuation adjustments and SDR allocations), by the range of real income, the range of the interest rate and by the final (1981 II) price level index. If these lie excessively far outside the actual values, then, whatever the stability measures indicate, the assumptions of the model may not all hold, and the feasibility of the policy becomes questionable. In each case the appropriate comparison is with the simulation of actual policies where the relevant variables are set equal to their actual values. Thus, policies 1A and 1B should be compared with Regime 2A and 2B; and policies 2A and 2B with Regime 3A and 3B.

Simulation of Freely Floating Exchange Rates

Policy	inflation equation	Coefficient of Variation						Range of				Final level of P
		relative to trend			rel. to mean			Real Reserves				
		Y	P	$\frac{dp}{dt} / P$	E	$\frac{dp}{dt} / P$	E	Net	Net + adjusts.	Y	R	
1A) $T=0, M_S^t = M_S^*$	A	3.82	1.03	13.39	5.33	22.99	9.23	980 only	960 to 4745	5531 - 8125	3.18 to 35.22	1785
1B)	B	3.80	1.05	11.31	5.37	17.66	10.27	"	"	5533 - 8237	3.13 to 29.84	2040
2A) $T=0, R=R^*$	A	4.62	1.02	10.61	10.11	13.58	14.78	"	"	5674 - 8004	-	2151
2B)	B	4.60	1.99	22.33	10.00	21.56	14.12	"	"	5647 - 8108	-	2184

Both policy combinations considered here are likely to have been feasible. By their nature these policies lead to a smaller variation in reserves. What is particularly interesting is that there is no evidence that freely floating rates would have increased the variation of the exchange rate, whether that variation is measured relative to a trend or not, and whether monetary policy is directed towards interest rates or towards the money supply. The variation in real income would have been very similar to what actually occurred, while there is some indication that if floating rates were combined with the same money supply target as used with the actual exchange-rate regime, the rate of inflation would have been slightly more volatile. With monetary policy directed towards interest rates, there is no evidence for increased price instability.

(v)

The second set of exchange-rate policies considered involve some sort of managed floating, in which E, the exchange rate, is set equal to a target value according to a particular rule. Four of the policies considered here are adjustable pegs: to the basket defined in this paper for calculating the effective exchange rate for South Africa; to the

U.S. dollar; to the pound sterling; and to the S.D.R. The fifth policy consists of setting the exchange rate equal to the "past market rate", defined as the average of the exchange rate for the previous three quarters that would have resulted under free floating.¹ In the case of the first four, adjustable peg, policies, one then has to decide on the basis on which the peg will be altered, since a rigid peg to any of these baskets or currencies would have been infeasible for the period considered. Here we choose a subset of the rules for managed floating suggested by Peter B. Kenen.²

The first adjustment rule, to which Kenen "gives good marks", employs an indicator based on changes in reserves.³ Under this rule, if Q_t represents the level of reserves at the end of period t , and ΔQ_t the change in the level of reserves over the period, then we have the following sets of rules.

First set (small changes):

Whenever ΔQ_{t-1} and ΔQ_{t-2} are larger than 1% of the initial level of reserves, revalue by 2%.⁴

Whenever ΔQ_{t-1} and ΔQ_{t-2} are smaller than -1% of the initial level of reserves, devalue by 2%.

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1. This policy is adapted from Kenen's "parity at equilibrium" rule. See Peter B. Kenen, "Floats, Glides and Indicators, A Comparison of Methods for Changing Exchange Rates", *Journal of International Economics*, Vol.5, May 1975 (reprinted as Princeton Reprint in *International Finance*, No.18, June 1975), p.117.
 2. Ibid., pp.116-119.
 3. It is interesting to note that in the opinion of L.C. Geldenhuys, the South African managed float since early 1979 seems to have been related to changes in cash foreign reserves. See L.C. Geldenhuys, "The South African Exchange Rate System - A Note", *South African Journal of Economics*, Vol.48, Dec. 1980, p.417.
 4. relative to the appropriate basket or currency.

Second set (large changes):

Whenever ΔQ_{t-1} and ΔQ_{t-2} are larger than 6% of the initial level of reserves, revalue by 12%.

Whenever ΔQ_{t-1} and ΔQ_{t-2} are smaller than -6% of the initial level of reserves, devalue by 12%.

One requires both ΔQ_{t-2} and ΔQ_{t-1} to be beyond the trigger level, so as to prevent parity changes being signalled after reserves have started to change in the required direction. The reserve changes allowed before parity changes are signalled are based on what seems to have been the behaviour of the South African authorities before and during the period of managed floating in the case of the large and small changes respectively.

This rule is simulated using both a measure of net reserves excluding and one including valuation adjustments and S.D.R. allocations.

The second adjustment rule uses an indicator based on the level of reserves relative to a desired level. The desired level is taken to be the initial level of reserves adjusted upwards in proportion as the average level of real income for the previous four quarters exceeds the average level for the year 1973. The rules then are:

First set (small changes):

If Q_{t-1} is larger than 115% of desired reserves and $Q_{t-1} \geq Q_{t-2}$, revalue by 2%.

If Q_{t-1} is smaller than 85% of desired reserves and $Q_{t-1} \leq Q_{t-2}$, devalue by 2%.

Second set (large changes):

If Q_{t-1} is larger than 130% of desired reserves and $Q_{t-1} \geq Q_{t-2}$, revalue by 12%

If Q_{t-1} is smaller than 70% of desired reserves and $Q_{t-1} \leq Q_{t-2}$, devalue by 12%.

This rule is also simulated using a measure of net reserves excluding valuation adjustments and S.D.R. allocations, and using a measure including them.

Each of the five basic exchange-rate policies can be combined with a monetary policy based on a money-supply or an interest-rate rule. Furthermore, in the case of a money supply rule the sterilization coefficient also becomes a matter of policy - eight possible levels of u are used in the simulations, ranging from $u_1 = 0$ (complete sterilization of intervention in the foreign exchange markets), through $u_2 = -0.17925$, $u_3 = -0.35849$ (the average value estimated to have actually held), $u_4 = -0.53774$, $u_5 = -0.71698$, $u_6 = -0.89662$ (this value representing no sterilization if the liquidity base money multiplier is used¹), $u_7 = -2$, $u_8 = -3.3$ (representing no sterilization if the cash base money multiplier is used).

With 5 exchange-rate rules, 2 adjustment rules, 2 sizes of adjustment under each rule, 2 measures of net reserves, 2 types of monetary policy, 2 alternative specifications of the inflation equation, 8 possible values of the sterilization coefficient, - with all these it will be apparent that there are a large number of possible policy combinations. In fact, with a monetary policy targeted to the interest rate there are 66 and with it targeted to the money supply there are 528.²

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1. E. Shostak, "The Monetary Block of the Standard Bank Econometric Model: An Application of the Portfolio Approach to Monetary Analysis in South Africa", Studies in Economics and Econometrics, No.4, March 1979, p.21.
 2. The money supply rule might have been specified either in terms of levels or changes, but, as for Regime 5, only the form of the rule with target changes in the money supply proved appropriate for this latter combination of policies.

It soon became clear that in the case of a monetary policy aimed at a money supply target an important J-curve effect was operating, so that with any significant degree of sterilization of intervention in the foreign-exchange market, a devaluation initially led to a decline in foreign exchange reserves in that quarter. The reason for this lay partly in the fact that trade reacts only very little in the current period to exchange-rate changes, but mainly in the operation of the money market: with the money supply able to be varied relatively little, the positive n (see the discussion of section (vi) in Part One of this chapter), i.e. the negative effect of a deterioration in the terms of trade on the demand for money, was leading to an immediate decrease in the demand for money as a result of a devaluation and so to a tendency for foreign exchange reserves to be run down. This effect was more marked to the extent that there was sterilization of the effects of changes in foreign-exchange reserves on the money supply. Consequently, there was a tendency under this policy regime for cumulative devaluations or revaluations until finally the current account effects predominated, followed by cumulative exchange-rate movements in the opposite direction.

Modifications were tried to the adjustment rule to try to allow for the J-curve effect by altering the reference reserve levels or changes following an exchange-rate change, but better results were obtained simply by imposing the restriction that there could be no more than one exchange-rate change in consecutive quarters. Since the J-curve effect from the demand for money operated only for one quarter, this modification substantially eliminated cumulative devaluations or revaluations.

Simulations were carried out with this modified rule for all 528 possible combinations in the case of a money supply target, although some simulations were also carried out with the original rule and with other modifications. In the case of a monetary policy targeted to the interest

rate, all 66 simulations were run for the unmodified rule, and, although the J-curve problem was very much less serious in this case, also with the modified rule.

The following tables report summaries of all the results for the simulations using exchange-rate and interest-rate targets.¹

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1. To make the feasibility measures more useful, in the statistics for the range of real output an asterisk is placed beside extreme values when the lowest value or a value close to the lowest value occurred anywhere but near the beginning of the period, or when the highest value or a value close to the highest value occurred anywhere but towards the end of the period.

Simulation of Managed Floating with an interest rate target

$$R = R^*, M_S^t = M_S^*, \text{ Unmodified adjustment rule}$$

Peg to Weighted Basket

adjustment criterion	inflation equation	Coefficient of Variation						Range of			Final level of P
		relative to trend				rel. to mean		Real Reserves			
		Y	P	$\frac{dp}{dt} / P$	E	$\frac{dp}{dt} / P$	E	Net	Net + adjusts.	Y	
small changes, net only	A	3.55	1.09	11.23	1.24	17.41	9.55	-1944 to 1850	-	5689 - 8631	2084
	B	3.63	1.15	13.29	1.21	18.15	11.18	-1881 to 1848	-	5674 - 8845	2126
large changes, net only	A	5.12	1.06	12.45	7.60	15.20	13.43	- 81 to 2266	-	5577 - 8440	2129
	B	4.91	1.45	18.06	6.82	21.08	12.61	452 to 2272	-	5589 - 8472	2136
small changes, net +	A	3.72	1.09	12.46	1.67	20.96	7.58	-	-1545 to 1842	5644 - 8389	1959
	B	3.84	1.10	13.45	1.67	19.12	7.58	-	-2895 to 1840	5629 - 8114	2046
large changes, net +	A	6.20	0.76	8.56	9.99	12.27	14.24	-	742 to 4154	5837 - 8249	2070
	B	5.48	1.34	15.78	8.54	19.78	12.51	-	695 to 3632	5828 - 8028	2111
levels, small, net only	A	3.60	1.23	11.78	0.89	22.54	12.63	-2770 to 1768	-	5559 - 9040	2118
	B	3.76	1.16	13.32	0.89	18.92	13.46	-3872 to 1767	-	5536 - 9082	2111
levels, large, net only	A	4.49	1.20	12.98	7.35	17.90	15.14	16 to 2145	-	5119 - 8068	2177
	B	4.99	1.25	16.05	5.12	18.89	16.30	- 88 to 2483	-	5087 - 8246	2111
levels, small, net +	A	3.66	1.16	12.24	0.93	21.98	10.12	-	-2077 to 1750	5559 - 8694	2022
	B	3.81	1.11	13.17	1.01	18.93	10.76	-	-2942 to 1749	5536 - 8594	2073
levels, large, net +	A	5.70	1.15	13.09	7.12	22.29	13.89	-	85 to 2593	5119 - 7888	1992
	B	5.22	1.22	16.05	6.06	19.72	14.24	-	- 20 to 2757	5087 - 8022	2104

Peg to U.S. dollar

small changes, net only	A	4.05	1.29	12.83	2.48	23.69	12.43	-2266 to 1755	-	5599 - 8775	2130
	B	3.96	1.19	13.00	2.43	18.04	13.21	-2972 to 1754	-	5575 - 8986	2122
large changes, net only	A	6.07	0.90	9.55	9.17	12.64	15.49	- 188 to 2116	-	5755 - 8745	2128
	B	5.84	1.31	15.19	9.22	19.54	16.03	625 to 3033	-	5760 - 8849	2121
small changes, net +	A	4.57	1.26	14.55	2.55	27.95	8.53	-	-3135 to 1736	5726 - 8385	1908
	B	4.31	1.11	12.91	2.16	18.55	10.30	-	-2914 to 1735	5575 - 8394	2063
large changes, net +	A	7.13	0.93	8.87	11.42	15.84	16.19	-	-466 to 3246	5755 - 9079	2052
	B	5.96	1.31	14.27	9.37	19.59	12.97	-	-1447 to 2112	5546 - 8072	2042
levels, small, net only	A	4.01	1.42	13.22	1.94	31.35	14.75	-4216 to 1685	-	5344 - 9313	2119
	B	4.15	1.20	13.06	1.76	19.90	17.00	-5540 to 1683	-	5043 - 9576	2109
levels, large, net only	A	4.42	1.15	11.40	5.91	20.41	16.85	- 339 to 2395	-	5013 - 8597	2176
	B	4.60	1.39	16.27	6.87	18.56	18.15	- 401 to 3048	-	4971 - 8791	2133
levels, small, net +	A	4.03	1.36	13.23	1.77	29.93	13.40	-	-3396 to 1666	5344 - 9111	2077
	B	4.15	1.16	13.03	1.66	19.23	14.16	-	-4410 to 1664	5043 - 9056	2082

adjustment criterion	inflation equation	Coefficient of Variation						Range of			Final level of P
		relative to trend				rel. to mean		Real Reserves		Y	
		Y	P	$\frac{dp}{dt} / P$	E	$\frac{dp}{dt} / P$	E	Net	Net + adjusts.		
levels, large, net +	A	5.08	1.23	11.84	6.63	29.14	17.36	-	- 423 to 3518	4915 - 8473	1962
	B	4.83	1.27	15.78	6.85	17.79	17.79	-	- 331 to 3531	4971 - 8442	2088

Peg to Sterling

small changes, net only	A	3.48	0.94	10.28	2.59	14.78	8.36	131 to 2159	-	5939 - 7961	2101
	B	3.47	1.21	14.04	2.61	18.50	8.27	750 to 2162	-	5942 - 8077	2142
large changes, net only	A	4.55	1.09	13.00	6.63	16.11	10.67	1417 to 2526	-	5889 - 8026	2152
	B	5.61	1.75	20.48	10.49	25.24	12.12	534 to 2536	-	5919 - 8250	2143
small changes, net +	A	3.61	0.89	10.41	2.67	20.12	7.95	-	915 to 2348	5938*- 7429	1974
	B	3.68	1.19	14.30	2.85	19.67	7.84	-	279 to 2390	5692*- 7393	2084
large changes, net +	A	7.10	1.04	13.07	9.00	20.35	13.47	-	163 to 3064	5672*- 8378	1991
	B	5.96	1.50	18.36	7.54	24.79	10.44	-	579 to 2529	5770 - 7892	2091
levels, small, net only	A	3.38	0.98	10.38	2.35	12.68	9.69	540 to 1988	-	5826 - 8153	2146
	B	3.56	1.21	13.98	2.40	18.25	9.14	557 to 1988	-	5821 - 8269	2137
levels, large, net only	A	8.75	1.80	19.78	9.92	28.74	16.39	- 943 to 2522	-	5431 - 9300	2217
	B	8.03	1.72	20.44	9.08	26.60	17.44	470 to 2935	-	5417 - 8904	2114
levels, small, net +	A	3.44	0.93	11.12	2.50	16.34	8.09	-	263 to 1908	5714 - 7500	1970
	B	3.57	1.18	14.11	2.36	18.39	8.33	-	241 to 1907	5704 - 7654	2084
levels, large, net +	A	6.32	1.18	12.99	6.59	24.73	11.92	-	-539 to 2062	5171*- 8252	1960
	B	6.32	1.55	19.23	7.62	24.59	12.88	-	-533 to 2441	5417 - 8027	2055

Peg to S.D.R.

small changes, net only	A	3.53	1.13	11.39	1.47	18.23	10.55	-2150 to 1755	-	5596 - 8737	2098
	B	3.64	1.15	12.91	1.42	17.98	12.22	-2295 to 1754	-	5573 - 8954	2128
large changes, net only	A	7.81	1.17	12.75	11.84	17.54	15.37	-302 to 2130	-	5752 - 8731	2130
	B	7.72	1.89	21.36	11.84	26.74	15.37	-194 to 2134	-	5758 - 8763	2090
small changes, net +	A	3.71	1.12	12.31	1.89	20.17	8.75	-	-1528 to 1736	5596 - 8501	2010
	B	3.82	1.10	12.87	1.89	18.47	8.79	-	-2058 to 1735	5573 - 8311	2067
large changes, net +	A	6.14	0.78	8.76	9.83	12.24	13.99	-	- 9 to 3105	5752 - 8350	2044
	B	6.23	1.35	15.40	9.83	20.16	13.99	-	-173 to 2818	5758*- 8443	2072
levels, small, net only	A	3.62	1.28	12.22	1.26	25.58	13.54	-3834 to 1685	-	5450 - 9140	2093
	B	3.82	1.16	13.24	1.15	19.26	14.38	-5424 to 1683	-	5418 - 9103	2094
levels, large, net only	A	5.20	1.22	13.11	5.30	19.26	16.87	-327 to 2648	-	5010*- 8521	2208
	B	5.13	1.40	16.69	7.60	19.01	16.75	-475 to 3005	-	4969 - 8453	2185
levels, small, net +	A	3.64	1.19	12.33	1.31	23.47	11.66	-	-2664 to 1666	5435 - 8809	2034
	B	3.82	1.12	13.11	1.38	18.92	12.33	-	-3703 to 1664	5418 - 8715	2072

adjustment criterion	inflation equation	Coefficient of Variation						Range of			Final level of P
		relative to trend				rel. to mean		Real Reserves			
		Y	P	$\frac{dp}{dt} / P$	E	$\frac{dp}{dt} / P$	E	Net	Net + adjusts.	Y	
levels, large, net +	A	6.15	1.16	13.16	9.33	18.94	15.25	-	-259 to 2954	5010 - 8372	2054
	B	5.86	1.43	17.08	8.71	21.33	14.71	-	-406 to 2211	4969 - 7997	2108

Rate set at "past
market rate"

A	4.12	0.99	10.02	5.44	12.21	12.47	-118 to 1770	305 to 4978	5338 - 8530	2167
B	4.22	1.33	14.79	5.44	17.51	12.47	-503 to 1769	- 21 to 4780	8308 - 8761	2128

Simulation of Managed Floating with an interest rate target

$$R = R^*, M_s^t = M^*, \text{ Modified adjustment rule}$$

Peg to Weighted Basket

<u>Peg to Weighted Basket</u>		Coefficient of Variation						Range of			Final level of P
adjustment criterion	inflation equation	relative to trend				rel. to mean		Real Reserves		Y	
		Y	P	$\frac{dp}{dt} / P$	E	$\frac{dp}{dt} / P$	E	Net	Net + adjusts.		
small changes, net only	A	3.70	1.17	12.71	0.73	24.49	7.46	-5048 to 1850	-	5640 - 8663	1947
	B	3.83	1.15	13.81	0.68	20.35	7.65	-6756 to 1848	-	5585 - 8230	2051
large changes, net only	A	4.84	0.89	9.41	5.78	12.18	10.73	-352 to 2266	-	5837 - 8467	2112
	B	4.80	1.37	16.16	5.78	19.98	10.73	-201 to 2272	-	5876 - 8574	2135
small changes, net +	A	3.83	1.14	13.19	0.86	25.96	5.55	-	-3045 to 1842	5529 - 8473	1880
	B	3.91	1.14	13.84	0.84	20.64	6.15	-	-4930 to 1840	5641 - 8041	2021
large changes, net +	A	4.53	0.82	9.96	5.86	16.91	8.86	-	-166 to 2259	5837 - 7899	1943
	B	4.45	1.33	14.56	6.02	20.60	9.36	-	- 78 to 2265	5828 - 8029	2117
levels, small, net only	A	3.71	1.17	13.21	0.64	26.21	7.65	-6592 to 1768	-	5540 - 8659	1896
	B	3.89	1.15	13.70	0.64	20.67	7.89	-8912 to 1767	-	5429 - 8111	2015
levels, large, net only	A	4.96	1.20	11.94	5.03	19.94	17.71	-523 to 2934	-	5119*- 8597	2227
	B	4.88	1.48	16.01	4.73	19.22	17.56	-888 to 3881	-	5087 - 9166	2187
levels, small, net +	A	3.74	1.14	13.24	0.70	25.69	6.68	-	-3676 to 1750	5525 - 8527	1870
	B	3.91	1.12	13.60	0.70	20.74	7.25	-	-5913 to 1749	5429 - 8031	2018
levels, large, net +	A	4.29	1.13	11.78	4.73	22.22	14.25	-	-580 to 2027	5119 - 8142	1983
	B	4.62	1.32	16.72	4.41	18.75	16.28	-	-1049 to 2902	5087 - 8265	2050

Peg to U.S. dollar

small changes, net only	A	4.28	1.40	13.92	1.91	32.43	11.16	-4980 to 1755	-	5599 - 9237	2007
	B	4.29	1.20	13.20	1.98	20.62	11.66	-6998 to 1754	-	5006 - 8894	2055
large changes, net only	A	3.97	0.92	9.29	6.11	11.42	14.01	295 to 2724	-	5755 - 8344	2207
	B	3.71	1.28	14.08	4.93	16.27	12.81	166 to 2090	-	5734 - 8087	2141

adjustment criterion	inflation equation	Coefficient of Variation						Range of			Final level of P
		relative to trend				rel. to mean		Real Reserves		Y	
		Y	P	$\frac{dp}{dt} / P$	E	$\frac{dp}{dt} / P$	E	Net	Net + adjusts.		
small changes. net +	A	4.22	1.27	13.96	1.82	29.83	8.36	-	-3325 to 1736	5223 - 8383	1923
	B	4.31	1.14	13.08	1.82	20.33	8.36	-	-5304 to 1735	5006 - 8275	2024
large changes, net +	A	4.51	0.89	10.39	5.81	17.20	10.11	-	-1492 to 2108	5588 - 7953	1940
	B	4.65	1.26	14.53	5.81	19.61	10.11	-	-2773 to 2071	5452*- 7842	2058
levels, small, net only	A	4.23	1.43	14.56	1.74	36.29	11.82	-6826 to 1685	-	5381 - 9324	1951
	B	4.35	1.20	13.47	1.64	21.36	12.20	-9696 to 1683	-	4734 - 8758	2021
levels, large, net only	A	4.36	1.39	11.48	4.25	25.58	20.09	-1511 to 3465	-	5013*- 9079	2295
	B	4.45	1.34	13.75	4.07	16.36	21.09	-2181 to 5297	-	4971 - 9639	2213
levels, small, net +	A	4.23	1.37	14.56	1.60	35.04	10.47	-	-4835 to 1666	5050 - 9123	1914
	B	4.38	1.14	13.34	1.59	21.18	11.13	-	-6996 to 1664	4734 - 8602	2013
levels, large, net +	A	4.49	1.23	12.05	4.28	22.63	17.15	-	-1682 to 3602	5410*- 8688	2115
	B	4.54	1.38	14.28	4.59	15.70	20.73	-	-1821 to 5483	4971*- 9145	2090

Peg to Sterling

small changes, net only	A	3.61	0.93	10.40	2.89	18.18	8.24	280 to 2526	-	5984 - 7668	2071
	B	3.56	1.24	14.42	2.89	19.12	8.22	1302 to 2569	-	5987 - 7814	2141
large changes, net only	A	4.51	1.07	12.72	6.45	16.47	10.35	1523 to 2660	-	5908 - 8007	2154
	B	4.90	1.60	19.50	6.25	23.55	9.68	752 to 2681	-	5840 - 8379	2135
small changes, net +	A	3.61	0.91	10.42	2.77	21.99	8.60	-	1361 to 3187	5803*- 7447	1996
	B	3.57	1.21	14.47	2.64	19.81	8.19	-	1362 to 3700	5633*- 7475	2098
large changes, net +	A	3.87	0.88	10.41	4.36	23.18	8.38	-	1501 to 4071	5897*- 7307	1993
	B	3.72	1.35	15.77	4.70	20.41	8.55	-	1502 to 4714	5781*- 7511	2103
levels, small, net only	A	3.45	0.96	10.75	2.42	14.60	8.42	-391 to 2009	-	5854 - 7876	2077
	B	3.47	1.19	13.98	2.42	18.21	8.42	- 75 to 2008	-	5849 - 7985	2121
levels, large, net only	A	6.81	1.29	13.05	7.02	21.72	14.48	-755 to 2578	-	5358*- 8632	2132
	B	6.53	1.55	17.84	7.09	23.81	14.17	-355 to 2493	-	5417 - 8745	2140
levels, small, net +	A	3.47	0.94	11.39	2.56	19.80	7.42	-	-579 to 1938	5796*- 7158	1931
	B	3.51	1.20	14.27	2.50	19.18	7.21	-	-402 to 1938	5788*- 7438	2073
levels, large, net +	A	5.98	1.18	13.22	5.61	27.51	12.64	-	-1147 to 2062	5431 - 8127	1916
	B	5.94	1.50	19.05	6.74	24.92	11.44	-	176 to 2035	5417 - 8029	2088

Peg to S.D.R.

small changes, net only	A	3.70	1.20	13.02	1.03	25.79	8.30	-5647 to 1755	-	5596 - 8754	1938
	B	3.83	1.16	13.34	0.96	20.28	8.71	-7722 to 1754	-	5334 - 8301	2036
large changes, net only	A	5.02	1.02	10.81	6.02	13.41	12.69	513 to 2130	-	5752 - 8647	2186
	B	4.78	1.37	16.41	5.79	20.21	12.12	457 to 2134	-	5738 - 8657	2135

adjustment criterion	inflation equation	Coefficient of Variation						Range of			Final level of P
		relative to trend				rel. to mean		Real Reserves		Y	
		Y	P	$\frac{dp}{dt} / P$	E	$\frac{dp}{dt} / P$	E	Net	Net + adjusts.		
small changes, net +	A	3.70	1.12	13.33	1.29	25.39	5.82	-	-3640 to 1736	5493 - 8377	1858
	B	3.90	1.12	13.33	1.08	20.32	7.43	-	-5131 to 1735	5279 - 8117	2025
large changes, net +	A	4.60	0.93	10.27	6.33	15.88	9.50	-	-929 to 2123	5752 - 8356	1968
	B	4.80	1.33	14.98	6.54	20.16	10.35	-	-1253 to 2126	5758 - 8116	2078
levels, small, net only	A	3.73	1.21	13.73	1.04	28.77	8.64	-7659 to 1685	-	5373 - 8760	1872
	B	3.95	1.15	13.63	1.05	20.97	8.89	-(9999+) to 1683	-	5062 - 8131	1999
levels, large, net only	A	4.66	1.18	11.65	4.37	20.58	17.98	-1170 to 3405	-	5010 - 8792	2306
	B	4.29	1.25	13.80	4.07	16.11	19.03	-1749 to 4597	-	4969 - 9125	2167
levels, small, net +	A	3.76	1.18	13.76	1.02	28.10	7.62	-	-4808 to 1666	5373 - 8627	1847
	B	3.97	1.11	13.48	1.04	21.01	8.23	-	-7478 to 1664	5062 - 8052	2002
levels, large, net +	A	4.44	1.06	11.46	4.09	18.88	15.06	-	-1250 to 2997	5010*- 8160	2088
	B	4.24	1.33	16.36	3.85	18.18	15.09	-	-1892 to 3007	4969 - 8663	2130

Certain general results emerge from these simulations.

1) Apart from the peg to sterling, the modified rule (at most one exchange-rate change in any six-month period) is not generally feasible for small changes, since it does not permit the exchange rate to be devalued fast enough to prevent impossibly large reserve losses. (Even with the unmodified rule, the 2% devaluation allowed per quarter was sometimes not enough when the peg was to a strong currency or basket.) On the other hand, the modified rule was almost always superior where large changes of the exchange rate operated.

2) Though no adjustment rules based on reserves were very efficient at stabilizing the level of foreign exchange reserves, the rules based on changes in reserves were generally better at doing this than were the rules based on the levels of reserves. This confirms Kenen's findings in this regard.

3) For small changes, rules based on changes in or the level of net reserves alone were generally (though not always) superior to rules based on net reserves plus S.D.R.'s and valuation adjustments. No such effects on stability were evident with large changes, perhaps because of the higher threshold before exchange-rate changes were mandated, but attempts to stabilize the net reserves plus valuation adjustments generally led to a more appreciated exchange rate and lower price and output levels at the end of the period (when valuation adjustments were important) than with the alternative measure.

4) Of the adjustable peg rules, those based on the pound sterling clearly performed better over the period considered than those based on the trade-and-transactions-weighted basket, the U.S. dollar or the S.D.R., all of which were generally too strong relative to the equilibrium value of the South African rand. Sterling, on the other hand, was similarly weak over the first part of the period, while in the second half the similar price movements of oil and gold and their influences on the two economies would have made a peg to sterling perform relatively smoothly.

5) The "past market" rate performed better in every respect than the floating rate (policies 2A and 2B) on which it was based, though it was not better than the Regime 4 simulation of actual policy, having as it did greater variability of output and the exchange rate, although slightly greater stability of the price level and the inflation rate.

6) Obviously, ex post it would always be possible to construct some rule for managed floating superior to the actual policy pursued. (The best would perhaps have involved an adjustable peg to sterling with changes intermediate between our small and large changes.) But the policies examined here, apart from the J-curve modification of the adjustment rule, were chosen before the results were examined. Of these

policies, an adjustable peg using small changes and responding to changes in the net reserves would have improved stability whether based on the basket, sterling or the S.D.R. - only with the dollar would stability have been impaired. (But some of these lead to levels of net reserves below actual values at some point, so that larger changes in exchange rates might have been needed and therefore the results for the basket and the S.D.R. are not decisive.) Alternatively any rule based on sterling with small changes and net reserves only would have been feasible and superior to the actual policy pursued. One reason for the indifferent showing of actual policy is that for much of the period it was based on an adjustable (or a supposedly fixed) dollar peg, which in retrospect was clearly the worst of these four currencies or baskets for South Africa to have followed.¹

7) As a generalization, it seems to have been the case that policies which stabilised the exchange rate also stabilised the level of real output. As a rule the association of these with price and inflation stability was less marked, though more noticeable when influences via the money supply were taken into account than when they were omitted. And it is true that very unstable exchange rates and output levels seem regularly to have been associated with a less stable price level.

(vi)

The next set of tables summarize some of the simulations when the policy instruments determined were the exchange rate, changes in the money supply and the sterilization coefficient. 528 simulations were run using the modified rule (at most one exchange-rate change in any six

1. and this despite the fact that our measure of the effective exchange rate index gives a very large weighting to the dollar.

month period), 32 using the original rule (one exchange-rate change allowed per quarter), as well as some which tried to allow for the J-curve effect in setting reserve level targets and some in the case of large exchange-rate changes allowing only one exchange-rate change in any nine-month period. The modified rule proved uniformly superior to the others which were tried, and only results using that rule are summarized. Even so, the number is so large that only the following are recorded for each currency or basket: (i) The results using small changes of the exchange rate based on changes in net reserves excluding S.D.R. alterations and valuation adjustments, and with a sterilization coefficient, $u_3 = -0.35849$, (the average value estimated to have actually held), (ii) the best results using the same adjustment rule as in (i) with any of the eight sterilization coefficients tried, (iii) the best results using any adjustment rule and sterilization coefficient, (iv) other interesting or typical results. Of course, the choice of the "best" results in (ii) and (iii) is sometimes a little arbitrary and, in particular, simulations with not very different sterilization coefficients sometimes differ by very little; but generally if stability of one variable improves so does that of others,¹ and generally the more stable results are also the more "feasible" in the sense that the variables do not diverge far outside the limits set by the simulation of the actual policy pursued and therefore not unreasonably far outside the limits experienced by the actual economy.

1. As for the simulations with an interest-rate target, price level and inflation stability sometimes worsened slightly when output and exchange-rate stability improved.

Simulation of Managed Floating with no interest rate target

$$M_S^t = M_S^* - (M_{S-1}^* - M_{S-1}), \quad u = u_i^*, \quad \text{Modified Adjustment Rule}$$

Peg to Weighted Basket

		Coefficient of Variation						Range of				Final level of P
adjustment criterion	inflation equation	relative to trend				rel. to mean		Real Reserves				
		Y	P	$\frac{dp}{dt} / P$	E	$\frac{dp}{dt} / P$	E	Net	Net + adjusts.	Y	R	
small changes, net only, u_3	A	4.73	1.23	16.05	1.01	42.32	2.17	-2743 to 1613	-	4837 - 7645	-8.62 to 49.59	1679
	B	5.17	1.41	15.79	0.88	28.27	3.01	-2420 to 1512	-	3930 - 6869	-8.63 to 55.74	1912
small changes, net only, u_7	A	3.75	1.07	13.04	0.78	33.63	3.84	-599 to 1097	-	5480 - 7559	-3.39 to 42.27	1764
	B	3.93	1.34	14.59	0.78	22.26	3.84	-501 to 1096	-	5006 - 7036	-3.39 to 55.68	1988
levels, small, net only, u_7	A	3.76	1.20	13.26	0.73	29.78	6.94	-625 to 1114	-	5650 - 8394	-11.49 to 35.71	1870
	B	4.03	1.34	14.40	0.73	22.61	6.94	-630 to 1114	-	5056 - 7470	-2.07 to 47.14	1973

Peg to U.S. dollar

small changes, net only, u_3	A	7.07	1.72	22.08	2.31	56.33	6.44	-1878 to 1952	-	4020 - 8611	-5.51 to 64.68	1724
	B	7.78	1.66	17.62	2.12	36.62	7.09	-1735 to 2284	-	2684 - 8055	-5.41 to 76.87	1875
small changes, net only, u_7	A	4.66	1.47	15.24	1.90	36.53	8.68	-599 to 1126	-	5137 - 9036	-9.05 40.04	1939
	B	4.87	1.54	16.07	1.90	28.56	8.68	-453 to 1125	-	5012 - 8382	-1.89 to 50.30	1970
large changes, net only, u_8	A	4.96	1.42	10.07	4.73	16.28	16.71	-692 to 1109	-	6087 - 9011	-31.24 8.62	2856
	B	4.08	1.66	18.60	4.06	24.04	7.44	-492 to 1108	-	6087 - 8622	-29.47 13.90	2247

Peg to Sterling

small changes, net only, u_3	A	3.64	1.02	9.04	2.66	33.42	10.27	-2011 to 1588	-	5502*- 7809	-21.41 to 35.33	2114
	B	3.26	1.40	13.55	2.68	14.20	10.95	-1527 to 2028	-	5308*- 8951	-28.49 to 27.78	2313
small changes, net only, u_7	A	3.45	1.14	8.63	2.54	32.83	12.22	-660 to 1053	-	5061*- 8432	-21.51 to 28.03	2281
	B	3.10	1.45	13.15	2.53	15.07	12.40	-807 to 1052	-	5389*- 9479	-34.19 to 7.34	2434
levels, small net only, u_6	A	3.37	1.02	8.61	2.35	22.76	12.10	-802 to 596	-	6065 - 8055	-19.38 to 15.19	2417
	B	3.02	1.44	13.09	2.35	14.37	12.10	-995 to 1000	-	6065 - 9237	-31.22 to 1.43	2409
levels, small, net only, u_7	A	3.38	1.03	8.65	2.43	22.26	12.43	-678 to 1071	-	5978 - 8383	-18.75 to 14.78	2421
	B	3.04	1.46	13.10	2.43	15.08	12.43	-811 to 1070	-	6060 - 9298	-30.10 to 3.74	2419

Peg to S.D.R.

small changes, net only, u_3	A	5.22	1.33	17.94	1.36	45.65	3.30	-2878 to 1703	-	4488 - 7846	-10.92 to 51.75	1654
	B	5.43	1.42	15.80	1.05	29.53	4.89	-2643 to 1634	-	3668 - 7192	-5.41 to 58.00	1892
small changes, net only, u_7	A	3.78	1.12	13.72	1.13	31.30	4.79	-602 to 1126	-	5409*- 7886	-1.93 37.66	1778
	B	4.04	1.33	14.74	1.26	23.68	4.17	-547 to 1125	-	4925*- 6765	-1.89 to 57.81	1952
levels, small, net only, u_7	A	3.77	1.25	13.92	1.20	31.28	7.85	-650 to 1143	-	5408*- 8551	-14.06 to 37.43	1845
	B	4.16	1.33	14.51	1.20	24.24	7.85	-677 to 1143	-	4757*- 7555	-0.58 to 50.74	1937
levels, large, net +, u_6	A	6.25	1.89	15.10	4.07	40.67	18.68	-	-910 to 5244	4903 - 10416	-25.93 to 36.46	2342
	B	6.23	2.16	16.81	4.01	41.17	19.17	-	-621 to 4297	4411 - 11136	-30.68 to 45.63	2188

adjustment criterion	inflation equation	Coefficient of Variation						Range of				Final level of P
		relative to trend				rel. to mean		Real Reserves		Y	R	
		Y	P	$\frac{dp}{dt} / P$	E	$\frac{dp}{dt} / P$	E	Net	Net + adjusts.			
large changes, net only, u_8	A	4.36	1.21	9.00	4.29	16.02	14.82	-686 to 1109	-	6087 - 8734	-24.02 to 3.64	2672
	B	3.65	1.46	16.79	3.33	20.51	7.00	-532 to 1108	-	5243*- 8550	-28.69 to 32.59	2243

Rate set at "past market rate"

u_3	A	3.85	0.98	12.24	2.06	22.07	7.15	-1610 to 1333	-398 to 3633	5330 - 8016	-10.90 to 36.46	1811
	B	3.83	1.50	15.04	2.13	21.82	9.39	-1546 to 1406	-199 to 3608	5442 - 8049	-16.98 to 33.67	2020
u_6	A	3.70	1.00	12.64	2.06	22.99	7.15	-706 to 1024	-175 to 3939	5621 - 8027	-2.39 to 35.62	1804
	B	3.78	1.50	15.01	2.13	22.12	9.39	-607 to 1025	-76 to 3910	5429 - 8069	-4.27 to 33.44	2014

Certain of the conclusions derived from the simulations when monetary policy is directed towards an interest rate target carry over to the case when monetary policy is directed towards changes in the money supply alone. For example, Sterling remains the best currency or basket to which to have linked the rand, and the dollar the worst. But there are certain additional observations.

1) Stability was usually worse with a monetary target involving money supply changes alone than when interest rates were predetermined. One has to take into account that simulations of the actual course of the economy with such a regime (Regime 5) gave slightly more unstable results than with interest rates fixed (Regime 4), but even so the difference seems quite marked particularly for rules which were not the most appropriate. The main reason seems to be that with interest rates completely unrestricted the external sector exerted rather little stabilizing influence, and the economy could quite readily embark for a time on a course of high output, high inflation, exchange-rate depreciation and high interest rates, or on a course of low output, low

inflation, exchange-rate appreciation and negative interest rates before eventually the effects of the interest rate on output or of the money supply on inflation began to reverse the trend.

2) The complete flexibility of interest rates was also the cause of the fact that the level of reserves was more effectively stabilized with this type of monetary policy; indeed, from the point of view of stability excessively so, since for example, high interest rates would stabilize the level of reserves and prevent further devaluations being signalled before the exchange rate had reached its equilibrium value. This suggests that if interest rates are not considered an objective of monetary policy, then they should at least be taken into account in framing exchange-rate policy.

3) In all cases stability was improved with a high sterilization coefficient (representing little sterilization of the effects of reserve changes on the money supply). For most rules the best sterilization coefficient was $u_7 = -2$, implying an increase in the money supply of twice the increase in foreign-exchange reserves (versus the estimated actual value of $u_3 = -0.35849$). But it is worth noting that an increase of the sterilization coefficient to -3.3 almost always worsened stability. The force of this conclusion is weakened, although certainly not eliminated, if we note that simulation of the actual course of the economy was closest to the actual outcome not with the estimated value of -0.35849 but with the higher value of -0.71698 . But a greater willingness to let reserve changes affect the money supply would certainly seem to improve stability.

4) The rule using an average of "past market" rates (derived in this case from the simulation of free floating using policies 1A and 1B) performed better than the comparable rule coupled with an interest rate target (except as to stability of the inflation rate) and better than

the Regime 5 simulation of actual policy. Compared to the freely floating regime on which it was based (1A and 1B), it was generally slightly inferior using u_3 (apart from greater exchange-rate stability, of course), and slightly better when the optimum sterilization coefficient, u_6 , was employed.

DATA APPENDIX

(i) South African Data

The sources for the South African data were various issues of the South African Reserve Bank Quarterly Bulletin from 1972 to 1981 and "A Statistical Presentation of South Africa's National Accounts for the Period 1946 to 1980" - supplement to the September 1981 S.A.R.B. Quarterly Bulletin. For the financial rand exchange rate, quarterly averages were taken of the weekly figures provided by the Financial Mail. The series or derived data series used are reproduced in section (iii) of this appendix. Certain observations need to be made.

1) In conformity with most South African econometric work, seasonally unadjusted data are used whenever possible. For its seasonally adjusted data the S.A. Reserve Bank uses a method of seasonal adjustment based on the X-11 package of the U.S. Census Method II but with subjective adjustments.

2) The figures for exports and imports are taken from the balance-of-payments rather than the national accounts series, so that they include exports and imports of factor services. The income aggregate is therefore the gross national product rather than the domestic measure. It is calculated from its components as $Y = C + I + G + \Delta H + X - M$ and therefore ignores the small "residual item" in the national accounts series.

3) South African trade figures omit trade in oil and arms. The S.A.R.B. series used are of "customs figures adjusted for balance-of-payments purposes" and certainly add back in the oil and almost certainly the arms figures. Mention should be made of the fact that during the period of very large current account surpluses in 1979/80 there was a deliberate additional stockpiling to an undisclosed extent of oil and

other strategic imported commodities as an alternative to increasing foreign exchange reserves even further, so that to some, probably fairly small, extent the trade figures reflect this aspect of balance-of-payments policy.

4) Real values for consumption, investment, inventory changes, non-gold exports, gold production and imports were obtained by dividing the appropriate nominal variables by the gross national expenditure deflator implied in the national accounts data (this is equal to the implied GDE deflator according to the S.A.R.B.). The real measures are therefore constant value rather than constant volume measures, which is appropriate for a mainly demand-determined model of output fluctuations such as used here.¹ The alternative would have been to have measured each component in constant volume terms, i.e. deflated by its own price index. But these individual deflators are likely to be more unreliable than the overall price measures (see point 5 below), and the model does not extend to the determination of prices for each of the components of national income, which would then have been necessary for a proper specification of, for example, the balance of payments identity.

5) The price series used are among the less satisfactory data series. The S.A.R.B. has published quarterly national income statistics at constant prices only since 1978, but estimated them for its own use earlier,² and recently published quarterly estimates at constant prices for the period from 1960 onwards. The implied GNE (GDE) deflator for our sample period, 1972 I to 1981 II seems a little erratic but is used

1. It means that in the terms recently current in official South African circles we are using the measure for real national product rather than real domestic product (for which the volume measure is more usual). The difference can be substantial if a rise in national income is due, for example, to a rise in the price of gold rather than changes in the volume of production.

2. Supplement to the Sept. 1981 S.A.R.B. Quarterly Bulletin, p.1.

for want of anything better. For the domestic price series, which is the only price series determined in the model and which (as argued in Chapter One) is probably the best target for price-stabilization policy, it had been intended to use a price deflator formed by taking the value of (GNE - Imports) at current prices as a proportion of (GNE - Imports) formed from the series for GNE and for Imports at constant prices. But such a series provided a very spiky measure of prices with seven quarter to quarter declines in the price level over the period 1974 I to 1981 II (not all associated with particular seasons, either). We therefore used instead the "wholesale price index of goods produced in South Africa for domestic use", which is based on price data collected by the Department of Statistics, although it is unfortunately seasonally adjusted. As an alternative, though less satisfactory in terms of the theoretical base of the model, the estimations were also performed using the GNE deflator as the domestic price series, without substantial differences, though the wholesale index performed slightly better overall and so was retained. The two series are closely enough related to suggest that the wholesale price data might have formed the basis for the estimates of the quarterly GNE deflator.

$$A(i)1 \quad P_{\text{GNE}} = 69.32454 + 0.92142 P_{\text{wholesale}} \\ (59.44)$$

$$+ 15.01939 S_1 - 3.73924 S_2 - 17.29523 S_3 \\ (0.91) \quad (0.23) \quad (1.02)$$

$$R^2 = 0.99301$$

$$DW = 1.3898$$

(Both price series have 1975 = 1000.)

Or, in logs:

$$A(i)2 \quad \log P_{\text{GNE}} = 0.42746 + 0.93721 \log P_{\text{wholesale}} \\ (60.66)$$

$$+ 0.01348 S_1 - 0.00390 S_2 - 0.01665 S_3 \\ (1.12) \quad (0.33) \quad (1.35)$$

$$R^2 = 0.99328$$

$$DW = 1.365$$

(Adding a term representing foreign prices adjusted for exchange rate changes to the above equations failed to provide a significant coefficient and in fact lowered the coefficient of multiple correlation adjusted for degrees of freedom, whether a current value was used or a value lagged as for the trade estimates.)

(ii) Foreign Data

We require indices for the effective exchange rate of the rand, for foreign interest rates, for the foreign price level and for foreign real income. The eight foreign countries used in compiling these indices are the United States, the United Kingdom, West Germany, France, Japan, Switzerland, Italy and Zimbabwe.

The same weights are used in the compilation of all four indices. The only real argument in favour of this course is its simplicity. Knight and Mathieson¹ have put forward the argument that only such a procedure allows for the possibility of long-run interest-rate parity (and, they might have added, purchasing-power parity, too). This is true enough if one has a single index for each variable, particularly if one wishes to allow interest-rate parity and purchasing-power parity to hold simultaneously using the aggregate indices. But since, as was argued in Chapter One, section xiii, interest-rate parity and purchasing-power parity are unlikely to hold simultaneously even in a two-country world except as a very long run tendency, one should probably not attach too much importance to this criterion. In fact the compilation of true

1. Malcolm D. Knight and Donald J. Mathieson, "Model of an Industrial Country under Fixed and Flexible Exchange Rates", Chapter 4 in John P. Martin and Alasdair Smith (eds.), "Trade and Payments Adjustment Under Flexible Exchange Rates", Macmillan for the Trade Policy Research Centre, London 1979, p.101.

effective indices would require different effective exchange-rate indices for trade and capital transactions, if the foreign countries involved are not of the same importance in each, and perhaps even different exchange-rate indices for interest-arbitrage and spot-speculation capital flows if these tend to go to different countries. If foreign prices were assumed to influence only trade and their index had the same weights as that used in compiling the effective exchange rate for trade, and if foreign interest rates were assumed to affect only capital flows and were compiled with the appropriate weights, one could have both interest-rate parity and purchasing-power parity holding between pairs of indices so defined. However, in practice it is convenient to have a single effective exchange-rate index so that one can speak unambiguously about the exchange rate appreciating or depreciating, and in the absence of powerful arguments to the contrary it is simplest to use the same weights for foreign interest rates, prices and income.

The weights chosen were designed to take into account trade, service payments and capital flows. In the case of trade, its importance was measured by the sum of merchandise exports and imports and gold production, and was allocated to countries according to the trade flows reported in the I.M.F.'s Direction of Trade Yearbook. Trade with countries other than the eight included in the index (which typically was less than 20% of total trade, excluding oil and arms) was allocated in the case of European countries according to the groupings suggested by John Heywood,¹ with the Guilder group included with the Deutschmark, the Norwegian Krone group with Sterling and the SDR group with the dollar. Outside Europe, New Zealand, Hong Kong and Sri Lanka were allocated to

1. John Heywood, "Foreign Exchange and the Corporate Treasurer", Adam and Charles Black, London, 1979, pp.51-52.

Sterling, half of Africa to the Zimbabwe dollar and half to the French franc group (which includes the escudo area), and all the rest not in the index to the dollar group. There are two peculiarities to South African trade: firstly, the gold production, which following the S.A. Reserve Bank practice was allocated to the dollar; secondly, the large discrepancy between the Direction of Trade figures for imports which are based on customs figures, and S.A. imports "adjusted for balance of payments purposes". This discrepancy consists mainly of oil and to a lesser extent arms imports, and was allocated to the dollar.

The importance of service payments and capital flows was measured by the sum of the absolute values of: payments for services + receipts from services + net changes in private foreign liabilities of South Africa + net changes in private foreign assets of South Africa + net official capital flows + net semi-official capital flows. These flows were allocated to currencies according to the foreign ownership of South African assets plus South African ownership of foreign assets as reported by the South African Reserve Bank for the year in question. Where broad categories used by the S.A.R.B. had to be broken down into the currencies used in the index and no guidance was available from years when different classifications were used (this applies mainly to the non-sterling E.E.C. currencies) this was done according to the trade proportions established above.

In view of the relatively stable pattern of payments over the period, apart from the growth of the import discrepancy, and in view of the necessarily arbitrary treatment of gold receipts and the import discrepancy, fixed weights were used for the whole sample period. Weights were calculated as described above for the beginning, middle, and end years of the period, and an average of these three years taken. The weights used were: US dollar 42.4 (excluding gold and the import

discrepancy 20.4), UK pound 24.2, Deutschemark 11.7, French franc 6.2, Japanese yen 6.0, Swiss franc 4.2, Italian lire 2.8, Zimbabwe dollar 2.5. (On average, trade was given a 71.6% weight in calculating these weights, and service payments and capital flows 28.4%. Had trade alone been used, the weights would have been: US\$ 46.75 (excluding gold and the import discrepancy 16.15), UK£ 16.15, DM 14.3, FF 6.7, ¥ 7.8, SwF 2.9, L It 2.9, Zim\$ 2.5).

The rand-foreign currency exchange rates used in compiling the exchange rate index were taken from the S.A.R.B. Quarterly Bulletin, an adjustment being made to the rates from 1979 IV onwards to convert them from middle rates to selling rates for foreign currencies, as used in previous periods.

The interest rates used in compiling the foreign interest rate index were: US, eurodollar rate; UK, Treasury Bill rate; W.Germany, call money rate; France, call money rate; Japan, call money rate; Switzerland, government bond yield; Italy, medium-term government bond yield - all taken from International Financial Statistics - and Zimbabwe, discount rate on fine 90-day acceptances, taken from the Zimbabwe/Rhodesian Monthly Digest of Statistics.

The real income measures used were: US, W.Germany, Japan, Switzerland, Zimbabwe real GNP; UK, France, Italy real GDP taken from the same sources. In the case of Switzerland, and of France and Italy in the early years, quarterly figures were interpolated on the basis of the quarterly indices of industrial production. In the case of Zimbabwe, quarterly figures were interpolated on the basis of a smoothed curve fitted graphically to the annual figures.

The price index was compiled on the basis of the wholesale price indices (line 63 of the IFS tables), except in the case of Zimbabwe where the implicit GNP deflator was used.

(iii) Data Series Used

		C O N S P U R M I P V T A I T O E N	C O N S P U R M N P M T E I N O T N	T O I T N A V L E S F T I M X E E N D T	P R I V I A N T V E E S F T I M X E E N D T	I N C V H E A N T G O E R I E N S	E X P O R T H S A N O T G H O E L R D	R L A D N D P R O A D U C T I O O F N
1972	I	2205	523	1014	497	-49	630	256
	II	2322	451	1026	574	-15	750	274
	III	2444	532	1107	575	-87	778	317
	IV	2719	491	1185	599	-71	769	314
1973	I	2526	560	1115	544	-60	857	363
	II	2751	493	1216	632	141	867	438
	III	2817	640	1283	705	112	962	505
	IV	3269	598	1413	778	181	787	465
1974	I	2945	733	1385	709	140	898	602
	II	3239	598	1472	805	548	1174	643
	III	3363	788	1584	880	336	1152	606
	IV	3832	767	1717	894	131	1079	714
1975	I	3408	936	1698	853	71	1195	638
	II	3721	845	2012	1015	392	1137	615
	III	3948	1021	2064	1066	237	1261	644
	IV	4439	980	2336	1132	83	1229	643
1976	I	4035	1165	2161	989	-280	1416	598
	II	4299	1042	2304	1131	272	1558	603
	III	4350	1222	2271	1140	18	1782	567
	IV	4797	1108	2485	1137	-207	1527	578
1977	I	4477	1332	2332	1037	-323	1815	600
	II	4643	1133	2162	1061	284	2042	701
	III	4832	1321	2370	1161	-63	2143	668
	IV	5316	1310	2469	1217	-103	1887	817
1978	I	4986	1469	2195	1036	-562	2199	830
	II	5265	1194	2488	1332	74	2306	903
	III	5307	1410	2469	1153	386	2622	1012
	IV	5915	1439	2898	1503	-180	2254	1118
1979	I	5567	1548	2600	1208	-359	2759	1238
	II	5945	1375	2647	1295	673	2500	1245
	III	6256	1677	3115	1431	-198	3100	1504
	IV	7095	1700	3340	1580	567	2819	2016
1980	I	6790	1902	3175	1547	13	3265	2795
	II	7287	1804	3673	1857	1237	3117	1971
	III	7812	2092	4142	2093	647	3107	2885
	IV	8910	2097	4199	2177	839	2915	2490
1981	I	8334	2175	3934	1978	-114	2998	2123
	II	8857	2185	4565	2259	1586	2995	1903

			M O N E Y M I L Y A V E R G E S		O U N D E R T H L E S P L E N D O R M W		T O P I C A L S A H O R O U M W		P R I V A T E S A L T F R O M W		N E T F O R F I G N I X C H A N G E	
1972	I	978	2349									
	II	994	2467									
	III	1016	2599									
	IV	1155	2690									
1973	I	1139	2746									
	II	1186	2983	3000								
	III	1323	3036	3126	-115	87	18	134				
	IV	1465	3183	3387	191	145	118	243				
1974	I	1574	3414	3507	-213	93	105	-46				
	II	1939	3554	3565	-227	-250	229	145				
	III	2098	3506	3550	-241	-1	-33	98				
	IV	2203	3778	4019	-123	-278	-342	9				
1975	I	2262	3885	3911	-238	-202	-201	-11				
	II	2244	4029	4121	-411	172	66	253				
	III	2280	4073	4206	-294	50	115	111				
	IV	2484	4169	4290	-569	66	-108	109				
1976	I	2622	4041	4120	-249	-83	25	276				
	II	2730	4257	4410	-365	237	249	441				
	III	2522	4371	4471	-161	186	260	198				
	IV	2578	4324	4438	-258	-74	-96	141				
1977	I	2477	4222	4291	-88	197	286	162				
	II	2507	4455	4670	-64	313	259	13				
	III	2654	4458	4553	-108	273	280	8				
	IV	2594	4526	4662	-73	124	210	-59				
1978	I	2609	4439	4501	41	332	345	-47				
	II	3045	4614	4783	135	-17	50	-46				
	III	3039	4745	4699	-183	617	614	-161				
	IV	3195	4946	5135	-66	23	162	-220				
1979	I	2918	5013	5234	118	649	755	-312				
	II	3373	5329	5443	-79	488	375	37				
	III	3908	5475	5547	127	302	482	-267				
	IV	4144	5848	6203	622	145	250	76				
1980	I	4076	6046	6410	516	1238	1199	-230				
	II	4927	6493	6906	109	418	431	366				
	III	5374	7316	7594	-220	-838	-297	-1161				
	IV	5632	8149	8423	-91	358	354	494				
1981	I	5303	8614	8669	-234	419	304	367				
	II	6304	9433	9672	-221	-629	-736	556				

CURRENT R. MILLIONS

ALL INDICES HAVE 1975 = 1000
(EXCEPT FINANCIAL RAND INDEX WHICH HAS
COMMERCIAL RAND INDEX 1975 = 1000)

			W E I G H T E R I A L N E	I N T E R S T R U C T U R E E	D E F E C T I V E E R	G O D S O P E R P C E D I C T E D X
	F O R E I G N I R E A L	I N C O R P O R A T E D X				
1972	I	939	667	4.88	8.27	639
	II	965	674	4.75	6.72	649
	III	971	683	5.22	5.72	667
	IV	1006	694	6.13	5.50	686
1973	I	1009	718	7.13	5.57	714
	II	1024	741	8.02	4.28	737
	III	1029	768	10.13	4.44	761
	IV	1044	790	10.24	6.41	788
1974	I	1012	851	10.05	7.50	817
	II	1027	893	10.65	8.27	857
	III	1029	934	11.70	10.77	899
	IV	1033	962	10.32	12.20	923
1975	I	980	975	8.36	10.51	964
	II	987	991	7.43	8.52	983
	III	1002	1010	7.61	7.82	1030
	IV	1032	1024	7.51	8.38	1064
1976	I	1033	1044	6.42	9.99	1091
	II	1040	1071	6.93	10.63	1133
	III	1055	1095	7.30	10.76	1179
	IV	1074	1117	7.85	9.52	1223
1977	I	1069	1151	7.11	9.75	1275
	II	1076	1182	6.32	9.15	1314
	III	1095	1193	6.23	8.90	1332
	IV	1115	1204	6.20	8.87	1355
1978	I	1110	1226	6.41	9.32	1401
	II	1129	1250	7.04	8.62	1432
	III	1144	1267	7.58	8.25	1455
	IV	1169	1288	8.98	7.75	1503
1979	I	1154	1328	9.19	7.22	1552
	II	1165	1375	9.31	5.83	1606
	III	1176	1425	10.52	5.07	1689
	IV	1199	1469	12.62	4.29	1738
1980	I	1190	1536	14.13	4.68	1783
	II	1167	1578	11.97	5.13	1841
	III	1177	1614	11.92	4.82	1925
	IV	1196	1643	13.66	5.78	2022
1981	I	1208	1687	13.10	8.90	2071
	II	1206	1732	13.91	11.36	2118

ALL INDICES HAVE 1975 = 1000

(iv) Ordinary Least Squares Estimates
of Equations II 1 to II 9

II 1 Consumption

$$C = 784.2 - 554.7S_1 - 136.5S_2 - 244.2S_3$$

(8.15) (2.53) (4.74)

$$+ 0.13493Y + 0.62511 C_{-1}$$

(3.60) (5.39)

$$R^2 = 0.895$$

$$DW = 1.578$$

II 2 Private Fixed Investment

$$I = 557.7 - 126.8S_1 - 12.7S_2 - 1.5S_3$$

(4.05) (0.40) (0.04)

$$+ 0.04753 \sum_{i=0}^7 w_i Y_{-i}$$

(2.14)

$$- 20.29050 \sum_{i=0}^7 w_i \left\{ R_{-i} - 400 [\log P_{-i} - \log P_{-i-1}] \right\}$$

(4.50)

$$R^2 = 0.698$$

$$DW = 1.104$$

II 3 Imports

$$M = 28030.1 - 118.1S_1 + 34.6S_2 + 36.6S_3$$

(1.73) (0.51) (0.52)

$$+ 0.50629 \sum_{i=0}^4 x_i Y_{-i} - 4223.5 \sum_{i=0}^8 y_i \log \left(\frac{E \cdot P_a^*}{P} \right)_{-i}$$

(10.66) (5.64)

$$R^2 = 0.845$$

$$DW = 1.145$$

II 4 Exports

$$X = -26949.1 + 106.6S_1 + 138.5S_2 + 233.6S_3$$

(2.07) (2.68) (4.38)

$$+ 1.45029 \sum_{i=0}^4 x_i F_{-i}^* + 3875.1 \sum_{i=0}^8 y_i \log \frac{E.P_a^*}{P} - i$$

(4.30) (5.92)

$$R^2 = 0.860$$

$$DW = 1.702$$

II 5 Changes in Inventories

$$\Delta H = -1099.8 - 90.0S_1 + 465.1S_2 - 46.2S_3$$

(0.92) (4.54) (0.45)

$$+ 0.18153Y - 0.08528H_{-2} + 0.36846 \Delta H_{-1}$$

(2.75) (1.63) (2.09)

$$R^2 = 0.720$$

$$DW = 2.399$$

II 6(i) Private Short-Term Capital Flows

$$K = -221.2 + 315.6S_1 + 170.7S_2 + 163.4S_3$$

(2.98) (1.69) (1.59)

$$+ 66.43 \left\{ (R_a^* - R) - (R_{a-1}^* - R_{-1}) \right\} + 0.25364 (Y - \bar{Y})$$

(2.66) (1.81)

$$+ 520.0 (\log FR^* - \log E)$$

(1.40)

$$R^2 = 0.433$$

$$DW = 1.948$$

II 6(ii)

$$K = -2441.7 + 557.8S_1 + 212.7S_2 + 146.9S_3$$

(3.40) (2.00) (1.39)

$$+ 44.6 (R_a^* - R) - 57.6 (R_{a-1}^* - R_{-1}) + 0.44245Y$$

(1.33) (1.96) (1.97)

$$- 0.71437F^* + 566.9 (\log FR^* - \log E)$$

$$(1.74) \quad (1.04)$$

$$- 117.6 (\log FR_{-1}^* - \log E_{-1})$$

$$(0.21)$$

$$R^2 = 0.491$$

II 7 Money Demand

$$M_d = 1019.1 - 16.6S_1 + 122.2S_2 - 11.2S_3$$

$$(0.23) \quad (2.06) \quad (0.19)$$

$$+ 0.15348Y + 1767.1 \log P - 1957.2 \log \left(\frac{P_a^* E}{1000} \right)$$

$$(2.22) \quad (3.18) \quad (3.80)$$

$$+ 0.80384 M_{d-1}$$

$$(9.17)$$

$$R^2 = 0.928$$

$$DW = 1.786$$

II 8 Change in Money Supply

$$\Delta M_s = 262.4 - 265.0S_1 + 19.0S_2 - 221.9S_3$$

$$(3.38) \quad (0.24) \quad (2.67)$$

$$- 0.23153T$$

$$(1.43)$$

$$R^2 = 0.435$$

$$DW = 1.243$$

II 9A Inflation

$$\log P - \log P_{-4} = 0.03372 - 0.00345S_1 - 0.00294S_2 - 0.00057S_3$$

$$(0.45) \quad (0.39) \quad (0.07)$$

$$+ 0.00000698(Y - \bar{Y}) + 0.76032 (\log P_{-1} - \log P_{-5})$$

$$(0.71) \quad (5.74)$$

$$R^2 = 0.638$$

$$DW = 1.781$$

II 9B

$$\log P - \log P_{-4} = 0.12401 - 0.00362S_1 - 0.00478S_2 - 0.00019S_3$$

(0.39) (0.52) (0.00)

$$+ 0.26010 (\log N_{-4} - \log N_{-8})$$

(2.82)

$$+ 0.0000069 \sum_{i=0}^3 \frac{1}{4} (Y - \bar{Y})_{-i}$$

(0.27)

$$- 0.28243 (\log P_{-4} - \log P_{-8})$$

(1.12)

$$R^2 = 0.493$$

$$DW = 0.738$$

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