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# FIXED VERSUS FLOATING EXCHANGE RATES REVISITED

by

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## ABSTRACT

This article investigates the relative merits of fixed and floating exchange rates using a model that synthesises the recent literature on the optimal degree of exchange rate flexibility. It is shown that the choice between the two regimes is crucially dependent upon four factors: the specification of the objective function of the authorities as between price and output stability, the type and nature of the shock impinging upon the economy, the structural parameters of the economy and institutional factors such as the degree of wage indexation.

Contents

# FIXED VERSUS FLOATING EXCHANGE RATES REVISITED

## Introduction

The debate over the relative merits of fixed and floating exchange rates has a long history in economics. Ragnar Nurkse (1944) asserted that floating exchange rates would be characterised by high exchange rate volatility induced by destabilising speculation with consequent disruption to the real economy. Whereas, Milton Friedman (1953) asserted that there was every reason to believe that private speculation would stabilise exchange rates and ensure a better working of the real economy. The Mundell-Fleming models (1962) showed that with high capital mobility fixed exchange rates would make monetary policy ineffective while fiscal policy was effective, while with floating exchange rates monetary policy would be effective and fiscal policy ineffective. Throughout the 1950s and 1960s as well as the early 1970s the debate remained centred almost entirely on the straightforward choice between allowing the exchange rate to float freely or fixing it. An excellent survey and critical review of the old debate in the light of the first six years of floating exchange rates with a detailed bibliography is contained in Artus and Young (1979).

The more modern debate on exchange rate policy has concentrated upon the relative capabilities of different degrees of exchange rate flexibility to stabilise the domestic economy in the face of various shocks. Among the most important contributions to this literature are: Boyer (1978), Artis and Currie (1981)

Frenkel and Aizenman (1983 and 1985), Henderson (1982 and 1984) and Turnovsky (1983, 1984 and 1987). In this paper we examine the debate over the relative merits of the two regimes by analysing them within the context of a synthesis model of the recent literature on the optimal degree of exchange rate flexibility. The purpose being to highlight the important features and results of these models using a relatively simple model that is ameanable to a diagrammatic analysis rather than reliance soley upon the quite complicated mathematical techniques that are generally utilised. The formal solution of the model for fixed and floating rates is contained in appendix one.

The paper is set out as follows: in section 1 we discuss the objective function of the authorities which proves to be a crucial determinant in the choice of exchange rate regime. Section two outlines a synthesis model for analysing the two regimes. Section three examines the behaviour of the two regimes in the face of a various shocks to an economy in the absence of wage indexation. Section four examines the complications of allowing two or more shocks to impinge simultaneously upon the economy and the importance of covariances among the shocks. Section five analyses the effects of wage indexation on the choice of regime. Section six considers possible complications of introducing permanent disturbances and whether financial indicators may have a useful information content in helping the authorities choose between alternative regimes. The conclusions point to the limitations of the model and possible areas for future research.

## I.1 The Specification of the Objective Function

There are many factors that policy makers have to take into account when designing their policies. Most importantly, they have to decide what are their objectives, the weight to be attached to each of them and then the most efficient means of achieving these aims. Inevitably, the choice is not easy because policy makers are confronted with a wide range of different and often conflicting economic analysis to choose from and even considerable scepticism as to whether they can influence the economy in a predictable fashion (1).

There has been no agreement in the literature on what objectives should be incorporated into the authorities objective function. In their study, Frenkel and Aizenman (1983) specify the sole objective the authorities as the minimisation of the asymptotic variance of steady state consumption. Turnovsky (1983) specifies a somewhat different objective function in two respects: Firstly, instead of seeking to minimise the variance of absorption he incorporates into the objective function the variance of domestic income. Secondly, he also incorporates an additional objective namely the variance of the domestic price level, this introduces the possibility of a trade-off among objectives. The Turnovsky study specifies the objective function of the authorities as the minimisation of the cost function C(Z):

$$C(Z) = w\sigma^2_{Yd} + (1 - w)\sigma^2_{Pd} \qquad 0 \leq w \leq 1$$

Where w denotes the relative weight attached to each of the two objectives in the overall objective function. A value of w = 1 means that the objective involves only domestic income stability, whereas if w = 0 the sole concern is with price stability (2).

The basis of including the reduction of the variance of the domestic price level in preference to reducing the variance of the output level has frequently been questioned because the price level is only a nominal variable while the output level is a real variable and if a choice has to be made between reducing the variance of a real as opposed to a nominal variable one should always go for the former. However, many governments do seem to seek to stabilise the domestic price level and consequently it is not unreasonable to incorporate it into a weighted objective function. Indeed, in the limiting case where government policy has no effect on real variables it is likely that the authorities would make their choice of regime on the basis of seeking price stability. In fact, if nominal wages are assumed to be fixed then real wages will vary inversely with the domestic price level and consequently seeking to stabilise the domestic price level would be equivalent to seeking to stabilise domestic real wages which can be just as valid an objective for the authorities to pursue as stability of real output.

## I.2 The Scope for Systematic Stabilisation Policy

It is now well known from the rational expectations critique of economic policy that there will be little scope for the authorities to achieve their desired real output targets (where these differ from the natural rate) if economic agents possess a full information set, act rationally and are capable of acting instantaneously.

The main approach utilised in the recent literature on stabilisation policy is to accept that economic agents have roughly the same information set as the authorities but that they are prevented from acting immediately while the authorities are not. The way that this is rationalised is to assume that labour is locked into wage contracts that cannot be changed instantaneously because of various costs associated with their revision, as a result labour contracts are only revised periodically. This kind of rigidity is not an absolute rigidity because the contracts will be adjusted as soon as the benefits of a change exceed the cost of recontracting. Thus, the length of the contracts is not exogenously given and they can be revised when sufficiently large shocks occur to the system. The contracts are normally either fixed in nominal terms or allowed to vary according to some indexation formula. In contrast, however, the authorities are assumed to be able to react immediately following a shock to the economy because the costs associated with them adjusting their policy instruments are assumed to be negligible. It is this basis for stabilisation policy that is assumed in the following model.

## II.1 Assumptions of the Model

Before setting out the formal model this section briefly states the assumptions underlying the model:

-The economy is subjected to various transitory shocks which have a zero mean and normal distribution there may be positive or negative covariances among the shocks. Three types of shock are considered; aggregate demand, aggregate supply and money demand.

-There is assumed to be perfect capital mobility and perfect substitutability between domestic and foreign bonds, so that the expected yields on domestic and foreign bonds are equalised. In consequence, under fixed exchange rates the domestic interest rate has to equal the foreign interest rate. While under floating exchange rates the positive nominal interest rate differential between domestic and foreign bonds is equal to the expected depreciation of the currency in accordance with the uncovered interest parity condition (3).

-The model permits transitory deviations of the exchange rate from Purchasing Power Parity because of imperfect goods arbitrage in the relevant time horizon (4).

-Expectations are assumed to be rational in that economic agents have imperfect information on the source of any transitory disturbance impinging upon the economy, however, because they know that the shock is only transitory a variable is always expected to revert to its natural/target value.

-Labour and employers are locked into contracts which may or may not be indexed. In the case where there is no wage indexation the contracts have the effect of keeping nominal wages fixed.

-The authorities have scope for a stabilisation policy because they can intervene costlessly and instantaneously in the foreign exchange market while labour and employers are locked into wage contracts that are costly to revise in the relevant time horizon.

-The wage contracts themselves are fairly simple in nature, the wages that are set by employers and workers are those that are expected to achieve full employment in the following period. Workers agree to supply all the labour demanded by employers in the case where following a shock to the economy there is a change in employers demand for labour. The contracts may or may not allow for wage indexation.

-The objective function of the authorities consists of minimising a weighted average of price and output fluctuations around their natural rates.

-The foreign economy is assumed to be stable so we do not concern ourselves with foreign price and output shocks. In addition, the foreign economy is large in the sense that it is not significantly affected by the shock impinging upon the "small" economy that is the focus of the analysis. Hence, we do not need to explicitly model the foreign economy and trace through the effects of various shocks to it and the resulting additional effects on the domestic economy. This permits us to keep the mathematics relatively simple permitting a clearer understanding of the economic issues than is usual (5).

-The domestic interest rate, exchange rate and aggregate price index are all contemporaneously observable but domestic output is not.

## II.2 The Model

This section sets out a simple but analytically flexible model to investigate the relative merits of fixed and floating exchange rates in the presence of transitory disturbances. The formal solution of the model involves the interaction of three markets, the money market, the goods market and the labour market and is solved for fixed and floating exchange rates appendix one. In the following all variables except interest rates are expressed in logarithms.

The demand for the home country's money is a positive function of the aggregate price index, a positive function of real domestic income and inversely related to the domestic nominal interest rate. That is:

$$Mdt = Pit + \kappa Ydt - \lambda rdt + Utl \qquad [1]$$

Where:
- Mdt = demand to hold money in current period t.
- Pit = currently observable aggregate price index made up of a weighted average of the domestic and foreign price levels as set out in equation [1a].
- Ydt = real domestic income in period t which is not currently observable.
- rdt = domestic nominal interest rate in the current period t, which is a currently observable financial variable.
- Utl = transitory disturbance term with zero mean and normal distribution.

The idea of incorporating the aggregate price index in the demand for money function is derived from the monetarist proposition that the demand to hold money is a demand for real balances related to the purchasing power of money. The aggregate price index is a

weighted average of the domestic price level and the domestic price of the imported foreign good, which is equal to the exchange rate times the price of the foreign good. That is:

$$Pit = \alpha Pdt + (1 - \alpha)(et + Pmt) \qquad [1a]$$

Where: $\alpha$ = weight of the domestic good in the overall consumption basket.
et = exchange rate defined as domestic currency per unit of foreign currency in the current period.
Pdt = price of domestic good in the current period.
Pmt = price of foreign good in the foreign currency in the current period.

The demand for domestic output is a positive function of the real exchange rate and inversely related to the domestic real interest rate and a positive function of the natural rate of income. That is:

$$Ydt = \beta(et + Pmt - Pdt) - \beta(rdt + Pdt - Pdt+1/t) + \varepsilon Yn + Ut2 \qquad [2]$$

Where: Pdt+1/t = the expected price level in one periods time given the information available in the current period.
Yn = natural rate of income.
Ut2 = transitory disturbance term with zero mean and normal distribution.

The real exchange rate is given by the first bracketed expression, an appreciation of the exchange rate would reduce the demand for the domestic good. Similarly, the real domestic interest rate is given by the second bracketed expression and is equivalent to the nominal interest rate minus the expected rate of price inflation.

A rise in the real interest rate will act to reduce the current demand for the domestic good.

The supply of domestic output is derived from a fixed capital stock model with variable labour input. The supply of domestic output depends upon the price at which producers are able to sell their output relative to the wage rate that they must pay per unit of labour. That is:

$$Yst = \sigma(Pdt - Wt) + Ut3 \quad [3]$$

$$Yst = Yst(Lt) \text{ where } \partial Yst/\partial Lt > 0 \text{ and } \partial^2 Yst/\partial^2 Lt < 0 \quad [3a]$$

Where: Yst = supply of domestic good.
Lt = labour input.
Ut3 = transitory disturbance term with zero mean and normal distribution.

Equation [3] says that if the price of the domestic good rises relative to the wage rate domestic producers will increase their output and employment levels as the real wage facing them falls. While equation [3a] says that output is a positive function of labour input but is subject to the law of diminishing returns.

It is assumed that financial capital is perfectly mobile and that domestic and foreign bonds are perfect substitutes. As a result the uncovered interest parity condition is assumed to hold continuously. That is:

$$rdt = rft + (et+1/t - et) \quad [4]$$

Where: rft = foreign interest rate in current period.
et+1/t = expected exchange rate in period t+1 given information available at time t.

The expression (et+1/t - et) gives the expected rate of depreciation of the currency.

The contracting arrangement that determines the setting of nominal wages is central to the short run behaviour of the model. The contracts have a duration of one period and establish a nominal base wage Wt* and also the indexing parameter (V). The contracts for the current period t are written at the end of period (t-1) so that Wt* and (V) are set with imperfect information concerning the transitory shocks likely to occur in period t. It is assumed that the base wage Wt* is set at the level required to generate an expected level of output at the natural rate Yn, which is also the target rate of the authorities for employment.

If we set Yst equal to Yn and Wt to Wt* in equation [3] and use the fact that Pdt/t+1 = Pdt/t-1 and rearrange terms we obtain:

$$Wt^* = Pdt/t-1 - Yn/\sigma \quad [5]$$

Where Pdt/t-1 is the expected domestic price level at time (t-1) for domestic prices in period t. Thus, workers and firms attempt when setting Wt* to ensure full employment in each subsequent period.

The wage rate actually faced by producers in period t will be the base wage plus an adjustment for unexpected changes in the aggregate price level. That is:

$$Wt = Wt^* + V(Pit - Pit/t-1) \quad [6]$$

The extent to which the nominal wage is adjusted for changes in the price level in the current period depends on the value of the indexing parameter V. If V=0, then there is no adjustment of nominal wages to changes in the aggregate price index, so that nominal wages are effectively fixed at Wt* for the contract period so that the real wage varies inversely with the price level. At the other extreme, if V=1, there is full adjustment of the nominal wage for changes in the aggregate price index, in effect, the real wage becomes fixed during the life of the contract. Notice that we use the aggregate price index, this is because workers are concerned with the real purchasing power of their wages which are not spent only on the domestic good. The value of the indexing parameter is important since it determines the extent to which exchange rate changes feed through to nominal wages via the impact on the aggregate price level.

In order to close the model we require the simultaneous fulfillment of the the following two equations: That money demand in the current period (Mdt) equal the current money supply (Mst) and that current aggregate supply equal current aggregate demand. That is:

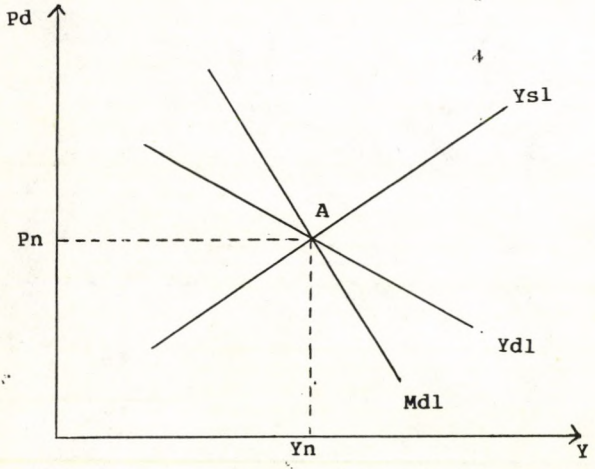
$$Mst = Mdt \qquad [7]$$

$$Yst = Ydt \qquad [8]$$

Under fixed exchange rates perfect capital mobility means that the domestic interest rate equals the foreign interest rate and the money supply is endogenously determined. While under floating exchange rates the money supply is exogenously determined and the domestic interest rate and exchange rate are endogenously determined but tied together via the uncovered interest rate parity condition. We now set out the model using a diagrammatic exposition, the formal solution for fixed and floating exchange rate regimes both with and without indexation is set out in appendix one and appendix two is a useful summary table of the results.

## II.3 Determining Equilibrium

We shall use for the purposes of our exposition aggregate supply and demand curves given by equations [2] and [3] respectively and also make use of the money market curve as set out by equation [1]. Initial equilibrium is found where all three curves intersect (6).




The aggregate demand schedule is given by Yd and is derived from equation [2], it is downward sloping because a rise in the domestic price level leads to a fall in aggregate demand for the domestic good ceteris paribus for two reasons: Firstly, by inducing a decline in net exports and secondly since any rise in the domestic price level leads to a future expected return of the price to its target level, the expected rate of price inflation will be negative which raises the real interest rate. The absolute slope of the Yd schedule is given by the reciprocal of the summation of the elasticities of aggregate demand with respect to

the real exchange rate and real interest rate ($\theta+\beta$) in equation [2].

Md depicts the money demand schedule derived from equation [1] of the model, it also has a negative slope because a rise in the domestic price level increases the demand for money requiring a fall in real income to maintain money demand equilibrium. The absolute slope of the Md schedule is given by the income elasticity of money demand divided by the share of the domestic good in the aggregate price index ie $\eta/\alpha$.

The slope of the Yd schedule may be flatter or steeper than the Md schedule and, as we shall see, this proves to be critical when comparing fixed and floating exchange rates in the face of an aggregate supply shock. The condition for Yd schedule to be flatter than Md schedule is that $\eta(\theta+\beta)>\alpha$. For most of the analysis we shall assume that this condition is satisfied. Obviously, it is more likely to be satisfied the more open the economy (the smaller is $\alpha$) and the greater the elasticity of the demand for the home good with respect to the real exchange rate and real interest rate. However, in order to see the importance of the relative slopes, in the case of an aggregate supply shock both cases are examined.

The aggregate supply curve has a positive slope since a rise in the domestic price level for a fixed nominal wage reduces the real wage facing producers encouraging them to take on more

workers which results in increased output. It has a positive slope given by $1/\sigma$ in the case of no wage indexation. In the instance where wages are index linked, the aggregate supply schedule becomes steeper with a slope given by $1/(\sigma-\sigma V_x)$, this is because a given rise in the domestic price level has less output effect as wages will be increased in line with the degree of wage indexation and the share of the domestic good in workers consumption basket, reducing the attractiveness of employing more labour.

Equilibrium of the system is determined by the simultaneous interaction of all three schedules through a common point. In the absence of unanticipated disturbances to the economy, output is at its natural rate Yn and the price level at the natural rate Pn (7). In the analysis we shall also assume that these are the optimal target values of the authorities, so that the economy is initially in full equilibrium .

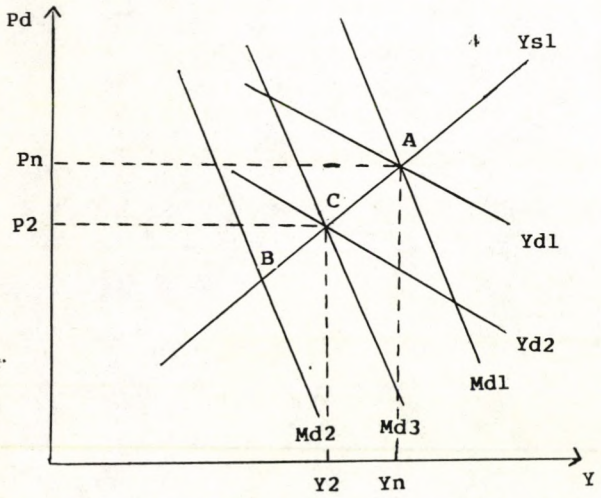
If the system is initially in full equilibrium only unanticipated disturbances will cause the schedules to shift from their equilibrium levels, inducing corresponding adjustments in price and output. Under fixed exchange rates the money stock adjusts passively to shifts in the Ys and Yd schedules because the money stock is endogenously determined. Whereas, under floating exchange rates the exchange rate and interest rate adjust to equilibriate the system causing shifts in both the Md and Yd schedules and if wages are indexed also to the Ys schedule. For example, an appreciation of the exchange rate shifts the Yd

schedule to the left due to a loss of competitiveness with a resulting fall in exports as well as the fact that an appreciation leads to an expected future depreciation as the shocks impinging upon the economy are known to be self-reversing as a result the domestic interest rate is forced up further shifting the Yd schedule to the left. The rise in the domestic interest rate to the extent that the demand for money is interest elastic lowers the demand for money which for a given money stock requires a shift to the right of the Md schedule.

We now turn our attention to comparing the relative performance of fixed and floating exchange rates in the face of various shocks to the economy.

III.1 Money Demand Disturbance

Suppose that there is an unanticipated rise in money demand, this has the effect of shifting the Md schedule to the left, it is assumed that there are no other shocks impinging upon the economy so that Ut2 = Ut3 = 0.



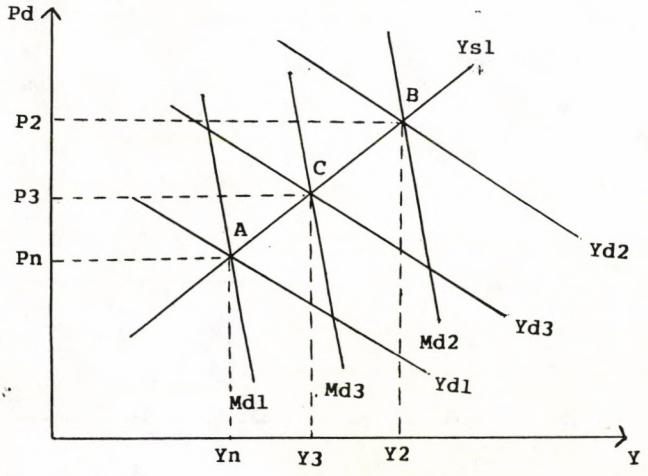

An increase in money demand causes a shift to the left of the money demand schedule from Md1 to Md2. Under fixed exchange rates the excess demand for money will cause a tendency for the currency to appreciate, as a result the authorities have to purchase the foreign currency in the foreign exchange market which expands the domestic money stock the purchases continue until the Md2 schedule shifts back to Md1. Thus, short run equilibrium remains at point A under fixed exchange rates with no disturbance to either domestic prices or domestic output. As Turnovsky (1983) has pointed out

this means that fixed exchange rates prove optimal. In effect, all the authorities do is increase the money stock in line with the increased demand to hold money so that there are no required adjustments to price and output.

If, however, we are in a floating exchange rate regime the appreciation of the exchange rate shifts Yd1 to the left to Yd2 due to the fall off in export demand and rise in the domestic interest rate as there is an expected future depreciation of the currency. The rise in the interest rate leads to a fall off in money demand shifting Md2 to Md3. Temporary equilibrium is attained where all three schedules intersect at point C. Thus, it can be seen that under floating exchange rates a rise in the demand to hold money leads to a fall in both the domestic price and output level. From this, it is obvious that whether the principal objective is price or output stabilisation fixed exchange rates are preferable for dealing with monetary shocks and in fact prove optimal.

## III.2 Aggregate Demand Disturbance

Assume that there is an unanticipated increase in aggregate demand, this has the effect of shifting the Yd schedule to the right, it is assumed that there are no other shocks impinging upon the economy so that Ut1 = Ut3 = 0.




An increase in aggregate demand shifts Yd1 to Yd2. This means that there is an excess demand for money which will cause the exchange rate to appreciate. As a result, the authorities have to intervene in the foreign exchange market to purchase the foreign money with newly created domestic money so that Md1 shifts to Md2 and the excess money demand is eliminated. Thus, under fixed exchange rates short run equilibrium is found at point B with rises in both the domestic price and output level to P2 and Y2 respectively.

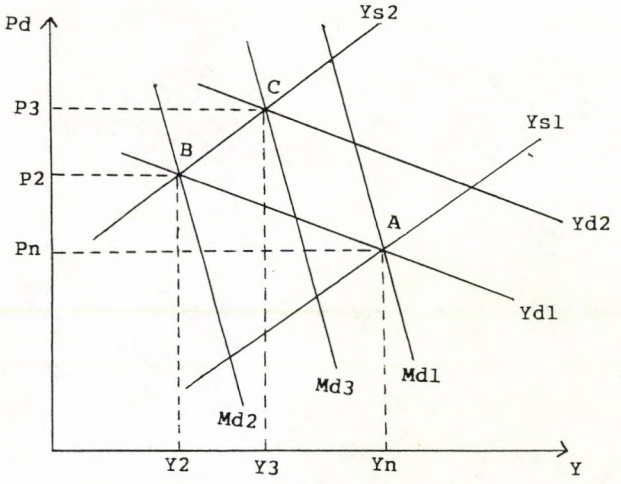
If, however, the authorities allow the exchange rate to float, the excess demand for money will result in an appreciation of the domestic currency which will have two effects: The aggregate demand schedule will shift to the left from Yd2 to Yd3 due to the fall off in exports and the money demand schedule will shift to the right from Md1 to Md3 due to the rise in the domestic interest rate. Equilibrium of the system is obtained at point C with price P3 and output Y3.

From this, it is evident that in the case of an aggregate demand disturbance whether the objective of the authorities is price or output stability floating exchange rates outperform fixed rates.

III.3 Aggregate Supply Disturbance

Assume that there is an unanticipated fall in aggregate supply, this has the effect of shifting the aggregate supply schedule to the left (8). It is assumed that there are no other shocks impinging upon the economy so that Ut1 = Ut2 = 0. Here, it is necessary to distinguish two cases: In case 1, the Md schedule is steeper than the Yd schedule while in case 2 the Yd schedule is steeper than the Md schedule.

Case 1: Md schedule is steeper than the Yd schedule ie $h/(\theta+\beta) > \alpha$




The economy is initially in equilibrium at point A with price Pn and output Yn. The economy is then hit by a transitory inflationary supply shock which shifts Ys1 to Ys2. In this case, point B corresponds to a position of excess supply of money, hence, there is a tendency for the currency to depreciate. In order to maintain a fixed exchange rate the authorities have to

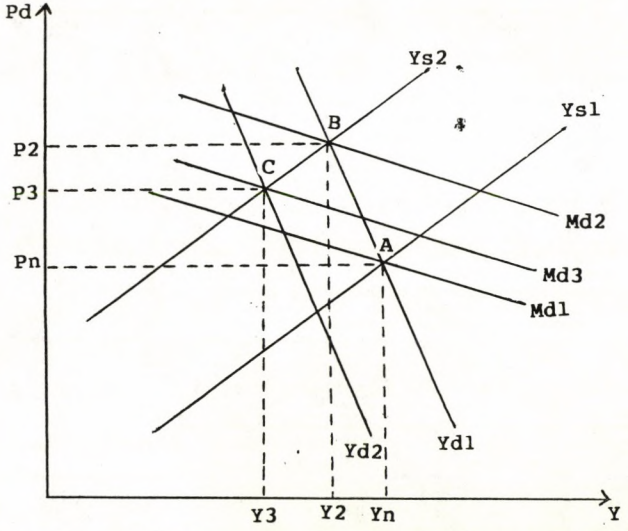
contract the money supply until the excess supply is eliminated, so the Md schedule shifts from Md1 to Md2. Thus, under fixed exchange rates the inflationary supply shock leads to a rise in price to P2 and a fall in output to Y2.

If, however, the authorities allow the exchange rate to float the excess supply of money resulting from the aggregate supply shock will lead to a depreciation of the currency. The depreciation shifts the aggregate demand schedule to the right from Yd1 to Yd2 since it results in increased export sales of the domestic good. Furthermore, the depreciation leads to an expected appreciation and therefore a fall in the domestic interest rate which leads to a increased demand to hold money shifting the money demand schedule from Md1 to Md3. Equilibrium of the system under floating exchange rates is therefore obtained at point C with a rise in price to P3 and a fall in output to Y3.

From this, we notice that our evaluation of the choice between fixed and floating exchange rate regimes would depend primarily upon the objectives of the authorities. This is because fixed exchange rates favour price stability while floating exchange rates favour income stability. Clearly, if the objective function of the authorities is biased towards price stability the authorities would find fixed rates preferable to floating. If, however, the authorities are more concerned with output stability they would find floating rates preferable to fixed.

**Case 2: Yd schedule is steeper than the Md schedule ie $h/(\theta+\beta)<\alpha$**

We again assume that there is a transitory inflationary aggregate supply shock that shifts the aggregate supply function from Ys1 to Ys2, this time, however, the money supply schedule is less steep than the aggregate demand schedule.




In this case, the aggregate supply shock under fixed exchange rates leads to an excess demand for money at point B and consequently there is a tendency for the currency to appreciate. In order to avoid an appreciation of the currency the authorities intervene in the foreign exchange market to purchase the foreign currency resulting in an increase in the domestic money stock until the Md schedule shifts from Md1 to Md2. The end result under fixed exchange rates is that the domestic price level rises to P2 and output falls to Y2.

Under floating exchange rates, the excess demand for money resulting from the shock leads to an appreciation of the exchange rate. This has the effect of shifting the aggregate demand schedule to the left from Yd1 to Yd2. In addition, the appreciation leads to the expectation of a future depreciation which via the uncovered interest rate parity condition raises the domestic interest rate constituting an additional reason for the leftward shift of the Yd schedule. The rise in the domestic interest rate by reducing the demand for money shifts the Md schedule to the right from Md1 to Md3. The result is that short run equilibrium under floating exchange rates is obtained at point C with a rise in the domestic price level to P3 and fall in domestic output to Y3.

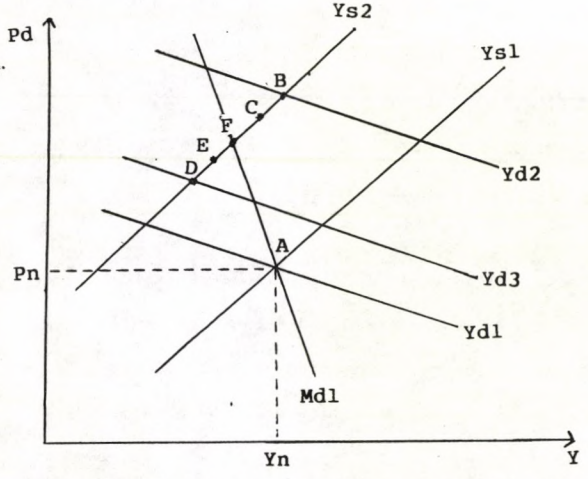
In this case, we again observe a conflict when choosing between fixed and floating exchange rates. The difference is that in this case fixed exchange rates favour output stability while floating exchange rates favour price stability.

The point of including this second case is that it illustrates the point that the choice between fixed and floating rates is very closely related to the structural parameters of the economy. In the first case, greater output stability could be obtained by a floating exchange rate whereas in the second case it is better obtained by a fixed exchange rate. From this, it follows that any policy recommendations should be based upon a study of the characteristics of the particular economy. Even if economies have

similar objectives and face similar shocks we may be led to recommend different policy regimes due to structural differences between economies.

## IV.1 The Economy Subjected to Two or More Shocks

The picture that we have drawn so far has been relatively straightforward in that we have assumed that there is only one shock impinging upon the economy. In general, however, the economy will be subject to more than one shock at any given moment in time and this considerably complicates the picture. To illustrate this, we consider the case where the economy is subjected simultaneously to both an inflationary aggregate supply and inflationary aggregate demand shock.




The above diagram is extremely important to understanding the limitations of this type of model. There is assumed to be an inflationary aggregate supply shock which shifts Ysl to Ys2 and

simultaneously there is also an inflationary aggregate demand shock that shifts Yd1 to the right, we distinguish between two cases - a shift to Yd2 or a shift to Yd3.

If the Yd curve were to shift to the right so that it passed through point F then both fixed and floating exchange rates would have identical effects because point F corresponds to a point where there is no excess demand or supply of money. However, if the Yd schedule shifts further to the right to say Yd2, equilibrium under fixed exchange rates would be obtained at point B. Whereas under floating exchange rates point B would correspond to a position of excess demand for the domestic currency so that there would be an appreciation of the currency so that Yd2 would shift to the left and Md1 to the right and equilibrium would be obtained at a point between F and B on the Ys2 schedule such as point C. In this instance we can see that floating exchange rates definitely involve more price and stability than fixed exchange rates.

Suppose that the shift to the right of the Yd schedule is smaller than that required to shift it through point F, say that it shifts to Yd3. Under fixed exchange rates equilibrium would be obtained at point D. While under floating rates point D corresponds to a point of excess supply of money. Consequently, there will be a depreciation of the currency which shifts the Yd3 curve to the right and the Md1 curve to the left so that equilibrium is obtained on the Ys2 curve at a point between D and

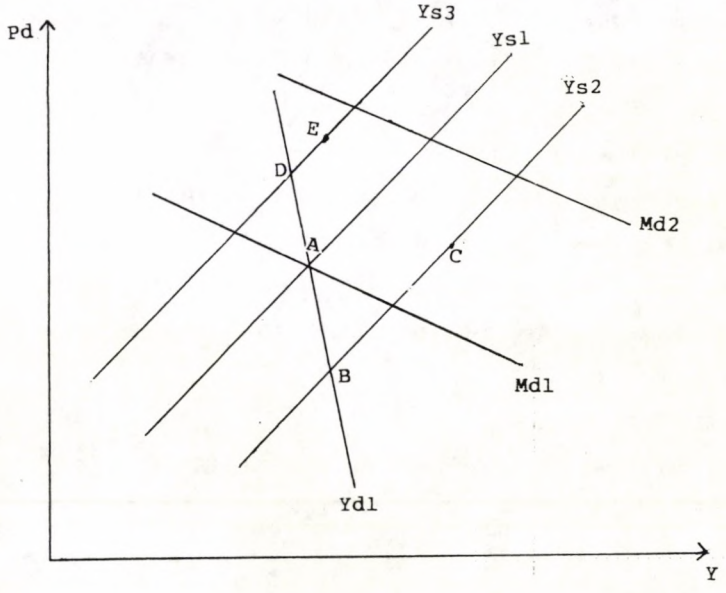
F such as point E. In this case, it is seen that floating exchange rates involve more price instability but more output stability than fixed exchange rates. Thus, it is again the case that depending upon the weighting of the objective function fixed rates may outperform floating or vice-versa.

This example is included in our analysis because from it we can see that for an economy subjected simultaneously to two shocks, it becomes very difficult to say whether the authorities should opt for greater fixity or greater flexibility of the exchange rate. In order to decide the authorities need very precise information not only on the structure of the economy but also on the relative magnitudes of the shocks (9). As the example illustrates, if the principal objective of policy was price stability one would opt towards floating of the exchange rate in the case where the Yd1 schedule shifts to Yd2 (the Yd shift is large relative to the Ys shift) but fixity in the case where it shifts to Yd3 (the Yd shift is small relative to the Ys shift.)

Needless to say, the situation will become enormously complicated when one starts to analyse an economy subject to three or more shocks simultaneously. It should be clear from this example how sensitive these types of models policy prescriptions are to the weighting of the objective function, relative magnitude of the shocks and specification of the model (one could further analyse the case when the Yd schedule is steeper than the Md schedule!).

## IV.2 The Role of Covariances

If the last section made matters look complicated and cast serious doubts upon the usefulness of some of the optimal intervention indices derived from this type of model then things become even more worrisome once one allows for covariances between the various shocks impinging upon the economy (10). To illustrate the potential importance of covariances among shocks we shall consider the case where there are two shocks impinging upon the economy due to a covariance between one shock and another, we shall take the case where there is an unanticipated fall in money demand with an associated supply shock. In the first instance, there is a negative covariance between the money demand shock and the aggregate supply shock and in the second case there is a positive covariance. For the purposes of this example we shall assume that the Yd schedule is steeper than the Md schedule.



In the diagram, we first assume that there is a negative covariance between the money demand shock and the aggregate supply shock. This means that when there is a money shock which shifts Md1 to Md2 due to a fall in money demand, on the average there is a shift to the right of the aggregate supply schedule to say Ys2. Under fixed exchange rates equilibrium is obtained at point B while under flexible exchange rates point B represents a position of excess supply of money so that there is a depreciation of the currency which shifts Yd1 to the right and Md2 to the left so that equilibrium is obtained at a point like C. In this case, floating exchange rates involve more output variation than fixed rates.

If, however, we take the case of a positive covariance between the money demand shock and the aggregate supply shock then a shift of the Md curve to the right will be associated on the average with a shift of the aggregate supply curve to the left to say Ys3. Under fixed exchange rates new equilibrium is obtained at point D, the authorities having to contract the money supply. While under floating exchange rates point D corresponds to a position of excess supply of money, so that there is a depreciation of the currency which shifts Yd1 to the right and Md2 to the left and equilibrium is obtained at a point such as E. In this case, floating exchange rates may lead to less output variation than fixed exchange rates.

From this, we can easily see the importance of covariances among shocks, in the first case greater output stability was

obtained by fixing the exchange rate while in the second floating rates may be superior. The variances of the shocks as drawn were the same but the covariances opposite in sign. It follows that we have to take into account covariances among shocks when choosing between the two regimes.

## V.1 The Effects of Wage Indexation

Until now we have assumed that nominal wages are fixed as a result of labour contracts. Many industrialised countries have at one time or another introduced systems in which wages are index linked and in the limit real wages can be prevented from adjusting when shocks impinge upon the economy.

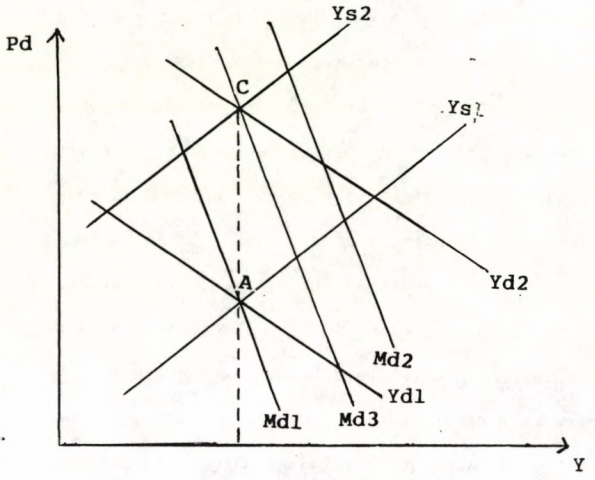
Frenkel and Aizenman (1985) point out that there must be a link between optimal wage indexation and optimal exchange rate management in a small open economy. The closed economy literature has concentrated on how wage indexation may be used to reduce output variation in an economy subjected to monetary and real shocks (eg: Fischer (1977)) while the open economy literature has concentrated on how exchange rate management may be used for similar purposes. The point that Frenkel and Aizenman make is that the optimal degree of wage indexation and optimal degree of exchange rate management must be solved simultaneously. In this section we do not attempt such a complicated simultaneous solution, the reader is referred to the aforementioned study an important extension of which is contained in Turnovsky (1987). Rather, I take the degree of wage indexation in the economy as a

given parameter since our concern is with the choice between fixed and floating exchange rates given the institutional structure of the economy. In what follows, I consider some important ways in which wage indexation affects exchange rate management as an instrument of stabilisation policy (11).

In equation [6] I have allowed for the possibility of wages to adjust in response to movements in the aggregate price index according to a very simple formula (12). In the limit, when V = 1, wages are fully indexed so that following a shock real wages are kept fixed. I now briefly proceed to look at the implications of wage indexation following a monetary, aggregate demand and aggregate supply shock by again using as a point of reference the results obtained from fixed and floating exchange rates. The formal solution with wage indexation is set out in the appendix (13).

## V.2 Money Demand Shock with Indexation

As pointed out earlier wage indexation means that the aggregate supply curve is steeper than in the case of no indexation. There is assumed to be a money demand shock due to a fall in money demand, this has the effect of shifting the Md curve to the right.




A fall off in money demand shifts the money demand schedule from Md1 to Md2. In the absence of wage indexation we have seen that under fixed exchange rates there is perfect stabilisation of both price and output. With the introduction of wage indexation our result for fixed exchange rates remains the same as without wage indexation because neither the exchange rate nor the domestic price level changes, hence, there is no need to adjust nominal wages as the aggregate price index is unaffected.

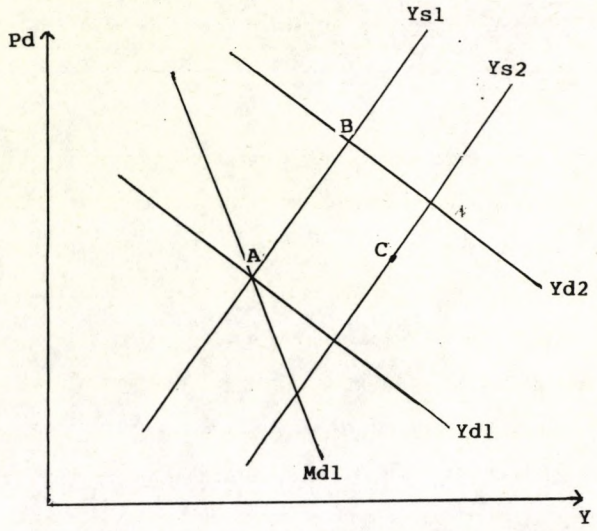
Under floating exchange rates the rise in the domestic price level will involve an automatic increase in wages in the case

where there is wage indexation. In addition because of the effect of the depreciation on the aggregate price index, there will be an upward shift of the aggregate supply schedule which will involve a further excess supply of money and a resultant further depreciation of the currency, the depreciation will now shift all three schedules, the Md schedule will shift to the left as the depreciation leads to an expected appreciation thereby reducing the domestic interest rate and shifting the Yd schedule to the right. In the case of full indexation it is shown in the appendix that equilibrium would be obtained at a point such as C so that under floating exchange rates monetary shocks result in no output variation at all, only in price variability. This is because the expansionary effect of the money demand shock fails to reduce the real wage facing employers as wages are fully indexed so that only the domestic price level rises. Wage indexation improves the output variability performance of floating exchange rates in the face of monetary shocks while increasing the price variability.

An interesting conclusion is that if we built up a model in which the sole concern of the authorities was with output stabilisation and allowed for full wage indexation we would be unable to distinguish between fixed and floating rates. If this is the case, our choice of regime must then be made on the basis of which involves most price stability. On this basis fixed exchange rates remain optimal. Hence, we have a good justification for incorporating price stability into the objective function of the authorities.

## V.3 Aggregate Demand Shock with Indexation

When there is an aggregate demand shock and wage indexation our results become less clear cut than in the case of no indexation.




A positive aggregate demand shock shifts the aggregate demand schedule to the right from Yd1 to Yd2 and this leads to point B under fixed exchange rates. Compared to fixed exchange rates with no wage indexation there is more price instability but less output instability. This is due to the fact that the aggregate supply schedule is steeper with indexation.

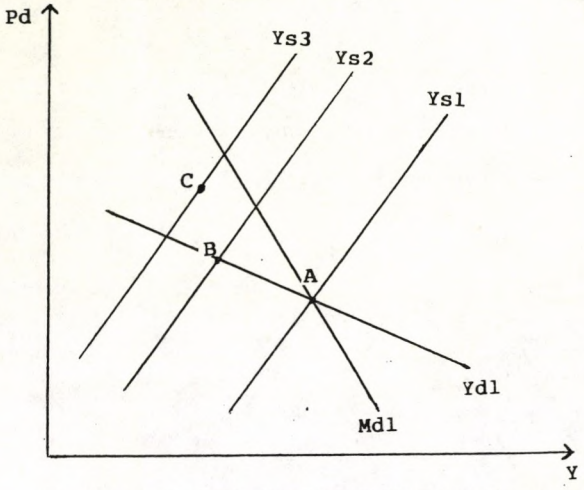
The unambiguous result of the effects of wage indexation for fixed exchange rates stands in contrast to the case of floating exchange rates. This is because if the exchange rate is allowed to appreciate due to the excess demand for money the aggregate supply curve will shift to the right from Ysl to Ys2 and

equilibrium will be obtained at a point like C. Output variability will be greater than in the case of no indexation while price variability may be more or less than in the case of no indexation and it is now possible that the domestic price level could actually fall.

Floating rates with indexation in the presence of an aggregate demand disturbance may or may not provide more price and output stability than fixed exchange rates with indexation. This contrasts with the case of no wage indexation when floating exchange rates definitely involve more price and output stability than fixed exchange rates. From this, it is evident that while one would opt for floating exchange rates in the presence of an aggregate demand disturbance for an economy with no wage indexation, one may well opt for fixed rates if the economy is index linked. Evidently, one should be very careful to take into account not only the relevant parameters of the economy but also its institutional structure before deciding on the appropriate policy response.

## V.4 Aggregate Supply Shock with Wage Indexation

As we saw earlier, with a supply shock impinging upon the economy it is necessary to distinguish between two cases, the case where the Md schedule is steeper than the Yd schedule and the case where the reverse holds. This distinction is also very important in the case of indexation.

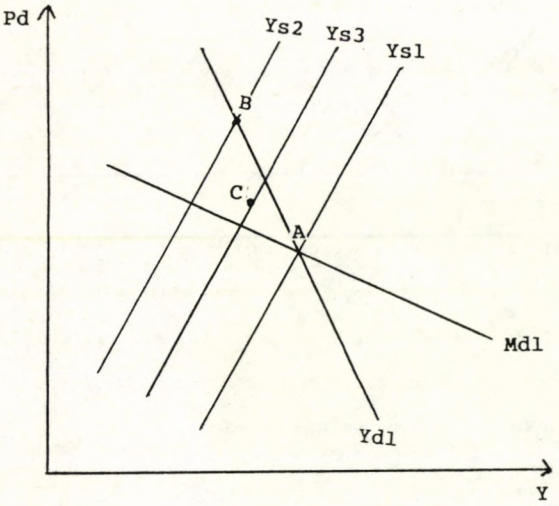



In the above case, the Md schedule is steeper than the Yd schedule and we assume that there is an inflationary aggregate supply shock that shifts Ysl to Ys2. With wage indexation the outcome under fixed exchange rates is given by point B, both price and output are more variable than in the case of no indexation.

With indexation under floating rates there is a depreciation of the currency which raises the cost of the imported foreign good and with it the the aggregate price index still further. The depreciation results in a further shift of the Ys curve from Ys2

to Ys3. Equilibrium under floating exchange rates is obtained at point C. Wage indexation thus leads to a deterioration of the price and output variability performance of both fixed and flexible exchange rates as compared to the case of no indexation. Also, it is now possible that fixed exchange rates may involve less output variability than floating exchange rates with obvious implications for policy makers concerned with stabilising output.

In the following case there is once again a supply side shock and wage indexation in the economy, in this case, however, the Yd schedule is steeper than the Md schedule.




Once one allows for wage indexation, under fixed exchange rates there is an unambiguous rise in the aggregate price index because the domestic price level rises while the price of the foreign good

expressed in terms of the domestic currency remains fixed, equilibrium is obtained at point B. Wage indexation leads to a deterioration of the price and output stabilisation performance of fixed exchange rates as compared to no indexation.

Again, however, under floating exchange rates things are not so clear, this is because of the effect of the appreciation of the domestic currency on the aggregate price index. The appreciation has the effect of reducing the cost of the imported foreign good and in consequence the overall result for the aggregate price index is unclear, it may rise or fall. The appreciation shifts Ys2 to the right to say Ys3, the Yd1 schedule to the left and Md1 schedule to the right so that equilibrium would be obtained at a point such as C. Indexation will result in a deterioration of the performance of floating exchange rates with respect to both price and output although this is less marked than in the case of the Md schedule being steeper than the Yd schedule.

From our analysis of wage indexation, we can see that it is of crucial importance when determining the optimal degree of exchange rate management. We may be led to propose different degrees of flexibility for economies subject to identical shocks, with similar economic structures and similar policy objectives because one economy is index linked and the other is not. In other words, one cannot ignore institutional features such as wage indexation when talking of optimal exchange rate management.

## VI.1 The Effects of Introducing Permanent Disturbances

So far we have considered a model in which the economy is subjected only to transitory disturbances. In reality, however, economies are subjected to both transitory and permanent disturbances. This section briefly considers the significance of this distinction for stabilisation policy.

Let us suppose that the economy is impinged upon by a permanent increase in aggregate demand, the result of a once and for all shift in demand away from the foreign good in favour of the domestic good. If private agents realise that this disturbance has occurred and take this into account when the next contract is drawn up, there will be a once and for all increase in the average level of output, domestic price, real wage and employment levels. However, as Alex Cuikerman (1984) has shown the possibility of permanent disturbances means that private agents will be unsure whether a given shock impinging upon the economy is permanent or transitory. In such circumstances, following a permanent increase in aggregate demand the wage rate will be revised upwards only slowly even though workers possess rational expectations. During these contract periods the average real wage will be lower and level of output and employment higher than the new natural rates under either fixed or floating rates. Although the deviation of output from the full employment level will be smaller under floating rates because of the induced appreciation of the exchange rate.

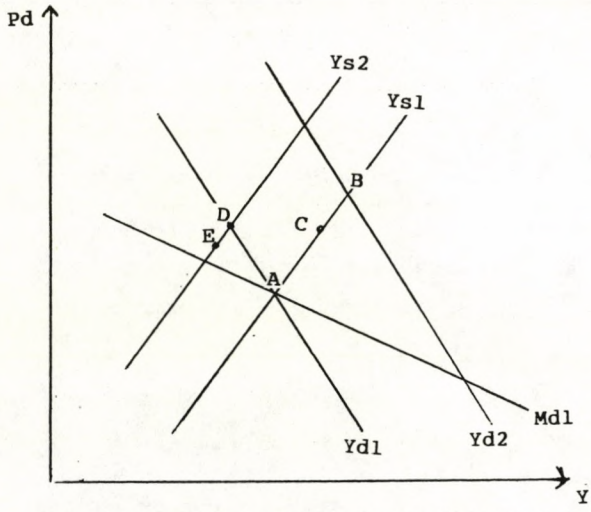
Presumably, after the renewal of contracts for several periods private agents would recognise that levels of output above the full employment level were being observed more frequently than would be suggested by what was known about the joint probability distribution of transitory and permanent disturbances. Accordingly, they would conclude that the economy had been impinged upon by a permanent shock and as such they would start to revise upwards the nominal wage and continue to do this until behaviour returned to more like that expected from the probability distribution of transitory and permanent disturbances.

It would appear to be the case that in the presence of a permanent aggregate demand disturbance floating exchange rates would outperform fixed rates. However, when introducing permanent disturbances it must be realised that they considerably complicate the picture. The perceived possibility of permanent disturbances means that one can no longer identify the original natural rate as the expected value following a shock to the economy because private agents will have to take into account the possibility that the new natural rate is different than in the previous period. Hence, the possibility of permanent disturbances will imply different solutions even for transitory disturbances.

## VI.2 The Search for an Indicator

In the analysis conducted so far, the choice between a fixed and floating rate has been seen to depend crucially upon several factors, two of which are the specification of the objective function and the type of shock(s) impinging upon the economy. While it is not unreasonable to assume that the authorities know what their objective function is we cannot be so sure that they know the type of shock impinging upon the economy at a given moment in time. If the authorities can identify the type of shock impinging upon the economy they would be better placed in deciding between fixed and floating exchange rates and thereby able to achieve better stabilisation results.

From the above, it follows that the authorities require if possible a means of identifying the source of the shock impinging upon the economy. Since asset markets respond very speedily to news and shocks, there has been an increasing interest in the economics profession in searching to extract information from contemporaneously observable financial data information about the likely source of the shock impinging upon the economy (14). We shall not go too deeply into this matter but rather illustrate that things are not at all easy. Consider the case where the Yd schedule is steeper than the Md schedule:




If there was an aggregate demand disturbance this would shift Yd1 to Yd2. As we saw earlier, under fixed exchange rates the outcome would be at point B while under floating rates it would be at point C. Under floating exchange rates the excess demand for the currency results in an appreciation of the exchange rate and with it a rise in the domestic interest rate.

If, however, there is instead an inflationary supply side shock that shifts the aggregate supply curve up to the left from Ys1 to Ys2, then the outcome under fixed exchange rates is given by point D while under floating exchange rates it is given by point E. Under floating exchange rates the excess demand for the currency results in an appreciation of the exchange rate and a rise in the domestic interest rate.

As we can see, in both the case of an aggregate demand disturbance and aggregate supply shock, there is an appreciation of the exchange rate and a rise in the domestic interest rate. Thus, the two financial variables do not in this instance permit us to distinguish between the two types of shock. In this instance the failure to distinguish between the two types of shock is of importance because in the case of an aggregate demand shock floating rates are superior to fixed rates for stabilising output. Whereas, in the case of an aggregate supply shock fixed exchange rates are better than floating rates at stabilising output (15).

From the above example, it is quite clear that extracting information from contemporaneously observable financial data and using this to determine the best regime is not going to be an easy task. Even in the simple case of trying to distinguish between an aggregate demand and an aggregate supply shock things may not be at all clear from financial data. Clearly, two financial variables such as the interest rate and the exchange rate alone are insufficient indicators. From this, it is apparent that the authorities require more indicators to determine precisely the shock impinging upon the economy and it is highly likely that this may require the use not only of financial variables but even domestic and foreign price and monetary data. In fact, Frenkel and Aizenman (1985) suggest that Tinbergen's "instruments - targets" rule (16) should be supplemented with a rule that the number of independent indicators that trigger the intervention rule be equal to the number of possible shocks that impinge upon the economy.

Before finishing this section, it is worth reminding ourselves that things become a lot more complicated if one includes the possibility of two or more shocks impinging upon the economy at the same time and allows for covariances and so forth. Also, as Turnovsky (1984) points out it is not only the source of the shock that is important but also the nature, the economy is subjected to both transitory and permanent disturbances and therefore a means of distinguishing between these two types of shock compounds the problems of using contemporaneous financial data as a guide to the appropriate policy response. All in all, this area is not very well developed and could prove to be an exciting area for future research, although from our discussion here it would seem to be fraught with difficulty.

## Conclusions

This paper has re-examined the relative merits of fixed and floating exchange rates in the light of the recent literature on the optimal degree of exchange rate flexibility. The main contribution consists of a more economic presentation of the issues rather than reliance soley upon rather sophisticated mathematics of the literature in this area, as such, it is hoped to contribute to a better understanding of the issues involved. One clear conclusion that does emerge is that the choice between the two regimes is not as clear cut as their advocates are prone to argue. Given the sensitivity of the choice between the regimes to so many different factors, the authorities should be extremely careful when deciding whether to fix or float the exchange rate.

The analysis has focussed on four crucial factors determining the choice between the two regimes; the specification of the objective function, the type and nature of the shock impinging upon the economy, the structure of the economy and institutional arrangements such as wage indexation. We have, in particular, highlighted the importance of the specification of the objective function and demonstrated how a slight modification to this can completely reverse the ranking of the regimes. This insight is particularly important because it stands in contrast to most studies which generally specify a very limited objective function such as real output or absorption stabilisation and then analyse the importance of various shocks to the economy. Such an approach may be highly misleading because different countries have different priorities and this possibility should be taken into account when making policy prescriptions. Different countries even if they have similar economic structures and face identical shocks may well require different exchange rate regimes simply because their objectives differ.

Also, the analysis has revealed that one should take account of institutional features such as wage indexation before deciding upon which regime is preferable. Thus, even if economies have similar structures, objectives and face identical shocks we may require a fixed rate for one and floating for another because one economy is index linked and the other is not.

It was argued that the authorities will be helped in their choice of regime if they can identify the source and nature of the shock impinging upon the economy. In this context, while the use of information contained in contemporaneously observable financial data may prove useful, it does not prove conclusive as a guide to the appropriate policy response. From this, the authorities are well advised to derive their information from as many different sources as possible using not only financial data but also domestic and foreign money and price data, focussing policy too much on one or two domestic financial variables as proposed by McKinnon (1984) is most unlikely to prove sufficient. The problem is accentuated when the economy is subjected simultaneously to two or more shocks as the number of indicators remains the same while the number of possible combinations rises. In addition, there is the problem of distinguishing between permanent and transitory shocks. Further research in this area is much needed.

Finally, it should not be forgotten that our analysis has examined the two regimes within the context of a small open economy and the policy prescriptions have been derived on this basis. In practice, of course, one of the implications of the analysis is that different countries will need to opt for different degrees of exchange rate flexibility. Consequently, in a two or multi country setting the optimum degree of exchange rate management for one country will be jointly determined with the optimum degree of exchange rate management of other countries and this is likely to prove a fruitful field of research (17).

**Footnotes**

(1) This is known as the Lucas critique - in his celebrated paper of 1976 Lucas argued that econometric model simulation is of little use for examining the outcome of of various policy options because the parameters of the model would themselves vary depending upon the policy option chosen. It is wrong to assume the same fixed parameters when examining alternative policy regimes.

(2) Note that this type of objective function involves only the ultimate objectives of economic policy. Artis and Karakitsos (1985, p.216) include in their analysis of the NIESR and LBS models of the British economy an objective function which includes both the ultimate objectives of economic policy and a set of intermediate targets such as Sterling M3, the PSBR and real exchange rate. The justification that they give being, "They are highly visible to economic agents, play a role in the transmission mechanism, and, being subject to some government control or influence, display for other agents a summary reading of government policy. Hence, governments may wish to formulate policy in terms of such variables, and this in itself is good enough reason for them to appear in the objective function governing policy reaction." We note here that their inclusion would in fact be highly controversial.

(3) Dornbusch (1976a) uses the uncovered interest parity as a cornerstone to his analysis of the phenomenon of exchange rate "overshooting". Following an increase in the domestic money stock the domestic interest rate falls and the exchange rate overshoots its long run equilibrium value with expectations of an expected appreciation of the domestic currency condition compensating for the lower interest rate on domestic assets via the uncovered parity.

(4) The studies of Frenkel and Aizenman (1983) and Turnovsky (1983) assume continuous PPP. However, Frenkel (1981) has shown that as an empirical fact PPP has performed very poorly since the adoption of floating exchange rates and therefore it is preferable to incorporate deviations from PPP into the model.

(5) From Henderson's (1984) model it is evident that it would be highly misleading to allow for foreign price and interest rate shocks in a small country model. This is because it is necessary to trace through the effects of a disturbance on the foreign economy first and having done this one would find that a foreign shock would impinge upon the economy through several channels. For example, a positive foreign money supply shock would impinge upon the domestic economy in a variety of ways, by raising the foreign price level it will lead to increased aggregate demand for the domestic good, also by raising foreign output it would lead to an increased demand for the domestic good. However, it also leads to an

appreciation of the domestic currency and this leads to the expectation of a future depreciation of the domestic currency raising the domestic interest rate which in turn will affect the money demand schedule in the small economy. In this case, the single foreign shock is transmitted to the domestic economy via a price channel, output channel and interest rate channel.

(6) For an excellent treatment of many issues in open economy macroeconomics utilising aggregate demand and supply schedules supplemented with an absorption schedule the reader is referred to De Grauwe (1983). Much of the inspiration for the presentation of this paper was derived from that book.

(7) In the appendix to this paper we also make reference to the natural exchange rate en. That is simply the exchange rate which corresponds to the simultaneous solution of the domestic price and output level at their natural rates.

(8) For an informal but very illuminating discussion of the supply side shocks that have afflicted the industrialized countries during the 1970s the reader is referred to Sachs (1982).

(9) It is necessary to be clear as Frenkel and Aizenman (1983) point out that the absolute size of the shocks has very little effect on the optimum degree of flexibility. What is important, as the example reveals, is the relative size of the shocks. To understand why the absolute size of the shocks has little effect we could in the example double the shifts of the curves keeping the relative shifts the same and our conclusions will hardly be affected.

(10) Boyer (1978), Frenkel and Aizenman (1983) and Henderson (1984) all draw attention to the important role of covariances among shocks in determining the optimal intervention policy.

(11) Canzoneri and Underwood (1985) examine intervention policy under two types of wage contracting regimes. A "Neoclassical Wage Contracting Model" whereby all wage contracts are revisable in the following period and workers are concerned about the value of their real wages in relation to a price index. Another regime, is a "Neo-Keynesian Wage Contracting Model" of staggered wage contracting, whereby labour is concerned about its relative wages compared to other labour groups and in each period only a proportion of all wage contracts can be revised. The two types of models give rise to quite different results thereby emphasising the importance of the nature of the contracting regime. The point is that although our wage contracts are in line with the neo-classical approach, the optimum degree of exchange rate management will certainly be affected by the precise nature of the wage contracting regime.

(12) The Frenkel and Aizenman (1985) study reveals that the optimum wage indexation formula is likely to prove to be extremely complex. In practice, however, a simple wage indexation formula such as that employed in equation (6) is generally used.

(13) Flood and Marion (1982) point out that the private sector wage indexation scheme will not in general be invariant to the authorities choice of exchange rate regime. In our case, this would mean that the indexation parameter V may be different depending upon whether the authorities choose a fixed or floating exchange rate regime. In what follows, we ignore this problem since it considerably complicates the analysis. Thus, we assume that the indexation parameter V is invariant to the intervention policy of the authorities permitting us to make a straightforward comparison of the two regimes.

(14) Turnovsky (1985) emphasises the need to base intervention policy on a wide set of contemporaneously observable indicators. He demonstrates that the incorporation of this additional information simplifies the determination of the optimal intervention rule. However, he also demonstrates the possibility that a feedback rule based on past information of the target variable (output) can outperform a rule based on contemporaneously observable financial variables. An important result because it suggests that policy makers may achieve greater output stability by ensuring that reliable information is obtained on past fluctuations of the economy than by using financial data. Nevertheless, it is likely that using both together would lead to superior results.

(15) OECD (1985, pp.27-8) likewise demonstrates the ambiguity of using only two financial indicators for determining the type of shock impinging upon the economy.

(16) Tinbergen's famous rule is that policy makers will generally require as many independent instruments as they have targets.

(17) For some pioneering work in a two country setting see Canzoneri (1982) and Henderson (1984), while Marston (1985) examines an exchange rate union in a three country stochastic setting.

**Appendix One: The Solution of the Model Under Fixed and Floating Rates**

In this appendix we formally solve the model for fixed and floating exchange rates. Firstly, we set out the equations of the model and then describe the formal solution both with and without wage indexation.

$$Mdt = Pit + \eta Yt - \lambda rdt + Ut1 \qquad [1]$$

$$Pit = \alpha Pdt + (1-\alpha)(et + Pmt) \qquad [1a]$$

$$Ydt = \theta(et + Pmt - Pdt) - \beta(rdt + Pdt - Pdt+1/t) + \varepsilon Yn + Ut2 \qquad [2]$$

$$Yst = \sigma(Pdt - Wt) + Ut3 \qquad [3]$$

$$rdt = rft + (et+1/t - et) \qquad [4]$$

$$Wt^* = Pdt/t-1 - Yn/\sigma \qquad [5]$$

$$Wt = Wt^* + V(Pit - Pit/t-1) \qquad [6]$$

$$Mst = Mdt \qquad [7]$$

$$Yst = Ydt \qquad [8]$$

In order to solve the model we have to take the expectations of the system and then solve for the endogenous variables. In this respect there are a number of useful devices we can employ to ease the solution of the model.

The natural level of output is fixed so that $\varepsilon dYn = 0$.

Under fixed exchange rates perfect substitutability ensures that:

$$drdt = rdt - rdt/t-1 = 0$$

$$det = et - et/t-1 = 0$$

Under floating exchange rates, the money supply is fixed so that:

$$dMt = Mt - Mt/t-1 = 0$$

Also because all the shocks to the system are assumed to be only transitory with a zero mean and the economy is initially in full equilibrium this means that:

$$Pdt+1/t = Pdt/t-1 = Pn$$

and

$$Yt+1/t = Yt/t-1 = Yn$$

and

$$et+1/t = et/t-1 = en$$

From this it follows that:

$dPdt = Pdt - Pdt+1/t$ (ie Pt - Pn)

and

$-det = et+1/t - et$ (ie en - et)

With the possibility of indexation $0 \leq V \leq 1$ and we have to take account of this when placing the system in difference form. In the case where there is no wage indexation in the economy the solution is found by setting V = 0.

We now proceed to place the whole system in difference form

$$dMt = \alpha dPdt + (1-\alpha)(det + dPmt) + \eta dYt - \lambda drdt + Ut1 \quad [9]$$

$$dYdt = \theta(det + dPmt - dPdt) - \beta(drdt + dPdt) + Ut2 \quad [10]$$

$$dYst = \sigma[dPdt - V\{\alpha dPdt + (1-\alpha)(det + dPmt)\}] + Ut3 \quad [11]$$

$$drdt = drft - det \quad [12]$$

**Solution for Fixed Exchange Rates with Indexation**

Under fixed exchange rates with indexation we know that det=dPmt=drdt=drft=0 we can substitute these values into equations [9] to [12] and we obtain:

$$dMt = \alpha dPdt + \eta dYt + Ut1 \quad [13]$$

$$dYt = -(\theta+\beta)dPdt + Ut2 \quad [14]$$

$$dYt = \sigma(1-V\alpha)dPdt + Ut3 \quad [15]$$

We can now rearrange [13] to [15] and place it into matrix form and use Cramers rule to solve the system:

$$\begin{aligned} dMt - \alpha dPdt - \eta dYt &= Ut1 \\ (\theta+\beta)dPdt + dYt &= Ut2 \\ -\sigma(1-V\alpha)dPdt + dYt &= Ut3 \end{aligned}$$

In matrix form:

$$\begin{bmatrix} 1 & -\alpha & -\eta \\ 0 & (\theta+\beta) & 1 \\ 0 & -\sigma(1-V\alpha) & 1 \end{bmatrix} \begin{bmatrix} dMt \\ dPdt \\ dYt \end{bmatrix} = \begin{bmatrix} Ut1 \\ Ut2 \\ Ut3 \end{bmatrix}$$

$$|A| = \begin{vmatrix} 1 & -\alpha & -\eta \\ 0 & (\theta+\beta) & 1 \\ 0 & -\sigma(1-V\alpha) & 1 \end{vmatrix} = [\theta+\beta] + \sigma[1-V\alpha]$$

$$|A1| = \begin{vmatrix} Ut1 & -\alpha & -\eta \\ Ut2 & (\theta+\beta) & 1 \\ Ut3 & -\sigma(1-V\alpha) & 1 \end{vmatrix} = Ut1[\theta+\beta+\sigma(1-V\alpha)] + Ut2[\alpha+\eta\sigma(1-V\alpha)] + Ut3[-\alpha+\eta(\theta+\beta)]$$

$$|A2| = \begin{vmatrix} 1 & Ut1 & -\eta \\ 0 & Ut2 & 1 \\ 0 & Ut3 & 1 \end{vmatrix} = Ut2 - Ut3$$

$$|A3| = \begin{vmatrix} 1 & -\alpha & Ut1 \\ 0 & (\theta+\beta) & Ut2 \\ 0 & -\sigma(1-V\alpha) & Ut3 \end{vmatrix} = Ut2\sigma[1-V\alpha] + Ut3[\theta+\beta]$$

## Results Fixed Exchange Rates with Indexation

### Money Demand Shock: $Ut1 \neq 0$, $Ut2 = Ut3 = 0$

$$dMt = \frac{|A1|}{|A|} = \frac{Ut1[\theta+\beta+\sigma(1-V\alpha)]}{[\theta+\beta+\sigma(1-V\alpha)]} = Ut1$$

$$dPdt = \frac{|A2|}{|A|} = \frac{0}{[\theta+\beta+\sigma(1-V\alpha)]} = 0$$

$$dYt = \frac{|A3|}{|A|} = \frac{0}{[\theta+\beta+\sigma(1-V\alpha)]} = 0$$

### Aggregate Demand Shock: $Ut2 \neq 0$, $Ut1 = Ut3 = 0$

$$dMt = \frac{|A1|}{|A|} = \frac{Ut2[\alpha+\eta\sigma(1-V\alpha)]}{[\theta+\beta+\sigma(1-V\alpha)]}$$

$$dPdt = \frac{|A2|}{|A|} = \frac{Ut2}{[\theta+\beta+\sigma(1-V\alpha)]}$$

$$dYt = \frac{|A3|}{|A|} = \frac{Ut2\sigma[1-V\alpha]}{[\theta+\beta+\sigma(1-V\alpha)]}$$

### Aggregate Supply Shock: $Ut3 \neq 0$, $Ut1 = Ut2 = 0$

$$dMt = \frac{|A1|}{|A|} = \frac{Ut3[-\alpha+\eta(\theta+\beta)]}{[\theta+\beta+\sigma(1-V\alpha)]}$$

$$dPdt = \frac{|A2|}{|A|} = \frac{-Ut3}{[\theta+\beta+\sigma(1-V\alpha)]}$$

$$dYt = \frac{|A3|}{|A|} = \frac{Ut3[\theta+\beta]}{[\theta+\beta+\sigma(1-V\alpha)]}$$

**Solution for Floating Exchange Rates with Indexation**

Under floating exchange rates with indexation we know that dMt=dPmt=drft=0 we can substitute these values into equations [9] to [12] to obtain:

$$0 = \alpha dPdt + (1-\alpha)det + \eta dYt - \lambda drdt + Ut1 \qquad [16]$$

$$dYdt = \theta(det - dPdt) - \beta(drdt + dPdt) + Ut2 \qquad [17]$$

$$dYst = \sigma[dPdt - V\{\alpha dPdt + (1-\alpha)det\}] + Ut3 \qquad [18]$$

$$drdt = -det \qquad [19]$$

We can now substitute equation [19] into equations [16] and [17] rearrange and place into matrix form and then use Cramers rule to solve the system.

$$\begin{aligned} -(1-\alpha+\lambda)det \quad & -\alpha dPdt \quad -\eta dYt = Ut1 \\ -(\theta+\beta)det \; + \; & (\theta+\beta)dPdt \; + \; dYt = Ut2 \\ V\sigma(1-\alpha)det \quad & -\sigma(1-V\alpha)dPdt \; + \; dYt = Ut3 \end{aligned}$$

In matrix form:

$$\begin{bmatrix} -(1-\alpha+\lambda) & -\alpha & -\eta \\ -(\theta+\beta) & (\theta+\beta) & 1 \\ V\sigma(1-\alpha) & -\sigma(1-V\alpha) & 1 \end{bmatrix} \begin{bmatrix} det \\ dPdt \\ dYt \end{bmatrix} = \begin{bmatrix} Ut1 \\ Ut2 \\ Ut3 \end{bmatrix}$$

$$|B| = \begin{vmatrix} -(1-\alpha+\lambda) & -\alpha & -\eta \\ -(\theta+\beta) & (\theta+\beta) & 1 \\ V\sigma(1-\alpha) & -\sigma(1-V\alpha) & 1 \end{vmatrix} = -[\theta+\beta][1+\lambda+\eta\sigma(1-V)] \\ -\sigma[1-\alpha+\lambda(1-V\alpha)]$$

$$|B1| = \begin{vmatrix} Ut1 & -\alpha & -\eta \\ Ut2 & (\theta+\beta) & 1 \\ Ut3 & -\sigma(1-V\alpha) & 1 \end{vmatrix} = Ut1[\theta+\beta+\sigma(1-V\alpha)] \\ + Ut2[\alpha+\eta\sigma(1-V\alpha)] \\ + Ut3[-\alpha+\eta(\theta+\beta)]$$

$$|B2| = \begin{vmatrix} -(1-\alpha+\lambda) & Ut1 & -\eta \\ -(\theta+\beta) & Ut2 & 1 \\ V\sigma(1-\alpha) & Ut3 & 1 \end{vmatrix} = Ut1[V\sigma(1-\alpha)+(\theta+\beta)] \\ + Ut2[-(1-\alpha+\lambda) +\eta V\sigma(1-\alpha)] \\ + Ut3[(1-\alpha+\lambda)+\eta(\theta+\beta)]$$

$$|B3| = \begin{vmatrix} -(1-\alpha+\lambda) & -\alpha & Ut1 \\ -(\theta+\beta) & (\theta+\beta) & Ut2 \\ V\sigma(1-\alpha) & -\sigma(1-V\alpha) & Ut3 \end{vmatrix} = Ut1[\sigma(\theta+\beta)(1-V)] \\ - Ut2[1-\alpha+\lambda(1-V\alpha)] \\ - Ut3[1+\lambda][\theta+\beta]$$

## Results Floating Exchange Rates with Indexation

### Money Shock $Ut1 \neq 0$, $Ut2 = Ut3 = 0$

$$\det = \frac{|B1|}{|B|} = \frac{-Ut1[\theta+\beta+\sigma(1-V\alpha)]}{[(\theta+\beta)(1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$$

$$dPdt = \frac{|B2|}{|B|} = \frac{-Ut1[\theta+\beta+V\sigma(1-\alpha)]}{[(\theta+\beta)(1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$$

$$dYt = \frac{|B3|}{|B|} = \frac{-Ut1\sigma[\theta+\beta][1-V]}{[(\theta+\beta)(1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$$

### Aggregate Demand Shock $Ut2 \neq 0$, $Ut1 = Ut3 = 0$

$$\det = \frac{|B1|}{|B|} = \frac{-Ut2[\alpha+\eta\sigma(1-V\alpha)]}{[(\theta+\beta)(1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$$

$$dPdt = \frac{|B2|}{|B|} = \frac{Ut2[1-\alpha+\lambda-\eta V\sigma(1-\alpha)]}{[(\theta+\beta)(1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$$

$$dYt = \frac{|B3|}{|B|} = \frac{Ut2[1-\alpha+\lambda(1-V\alpha)]}{[(\theta+\beta)(1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$$

### Aggregate Supply Shock $Ut3 \neq 0$, $Ut1 = Ut2 = 0$

$$\det = \frac{|B1|}{|B|} = \frac{Ut3[\alpha-\eta(\theta+\beta)]}{[(\theta+\beta)(1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$$

$$dPdt = \frac{|B2|}{|B|} = \frac{-Ut3[1-\alpha+\lambda+\eta(\theta+\beta)]}{[(\theta+\beta)(1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$$

$$dYt = \frac{|B3|}{|B|} = \frac{Ut3[1+\lambda][\theta+\beta]}{[(\theta+\beta)(1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$$

Appendix Two: Summary Table of Results

| Shock | Fixed Exchange Rate | Floating Exchange Rate |
|---|---|---|
| **NO INDEXATION** | | |
| Money Demand | $dPdt = 0$ | $dPdt = \frac{-Ut1[\theta+\beta+\sigma]}{[\theta+\beta][1+\lambda+\eta\sigma]+\sigma[1-\alpha+\lambda]}$ |
| $Ut1 \neq 0$ | $dYdt = 0$ | $dYdt = \frac{-Ut1\sigma[\theta+\beta]}{[\theta+\beta][1+\lambda+\eta\sigma]+\sigma[1-\alpha+\lambda]}$ |
| Aggregate Demand | $dPdt = \frac{Ut2}{[\theta+\beta+\sigma]}$ | $dPdt = \frac{Ut2[1-\alpha+\lambda]}{[\theta+\beta][1+\lambda+\eta\sigma]+\sigma[1-\alpha+\lambda]}$ |
| $Ut2 \neq 0$ | $dYdt = \frac{Ut2\sigma}{[\theta+\beta+\sigma]}$ | $dYdt = \frac{Ut2[1-\alpha+\lambda]}{[\theta+\beta][1+\lambda+\eta\sigma]+\sigma[1-\alpha+\lambda]}$ |
| Aggregate Supply | $dPdt = \frac{-Ut3}{[\theta+\beta+\sigma]}$ | $dPdt = \frac{-Ut3[(1-\alpha+\lambda)+\eta(\theta+\beta)]}{[\theta+\beta][1+\lambda+\eta\sigma]+\sigma[1-\alpha+\lambda]}$ |
| $Ut3 \neq 0$ | $dYdt = \frac{Ut3[\theta+\beta]}{[\theta+\beta+\sigma]}$ | $dYdt = \frac{Ut3[1+\lambda][\theta+\beta]}{[\theta+\beta][1+\lambda+\eta\sigma]+\sigma[1-\alpha+\lambda]}$ |
| **WITH INDEXATION** | | |
| Money Demand | $dPdt = 0$ | $dPdt = \frac{-Ut1[\theta+\beta+\sigma(1-V\alpha)]}{[\theta+\beta][1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$ |
| $Ut1 \neq 0$ | $dYdt = 0$ | $dYdt = \frac{-Ut1\sigma[\theta+\beta][1-V]}{[\theta+\beta][1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$ |
| Aggregate Demand | $dPdt = \frac{Ut2}{[\theta+\beta+\sigma(1-V\alpha)]}$ | $dPdt = \frac{Ut2[1-\alpha+\lambda-\eta V\sigma(1-\alpha)]}{[\theta+\beta][1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$ |
| $Ut2 \neq 0$ | $dYdt = \frac{Ut2\sigma[1-V\alpha]}{[\theta+\beta+\sigma(1-V\alpha)]}$ | $dYdt = \frac{Ut2[1-\alpha+\lambda(1-V\alpha)]}{[\theta+\beta][1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$ |
| Aggregate Supply | $dPdt = \frac{-Ut3}{[\theta+\beta+\sigma(1-V\alpha)]}$ | $dPdt = \frac{-Ut3[1-\alpha+\lambda+\eta(\theta+\beta)]}{[\theta+\beta][1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$ |
| $Ut3 \neq 0$ | $dYdt = \frac{Ut3[\theta+\beta]}{[\theta+\beta+\sigma(1-V\alpha)]}$ | $dYdt = \frac{Ut3[1+\lambda][\theta+\beta]}{[\theta+\beta][1+\lambda+\eta\sigma(1-V)]+\sigma[1-\alpha+\lambda(1-V\alpha)]}$ |

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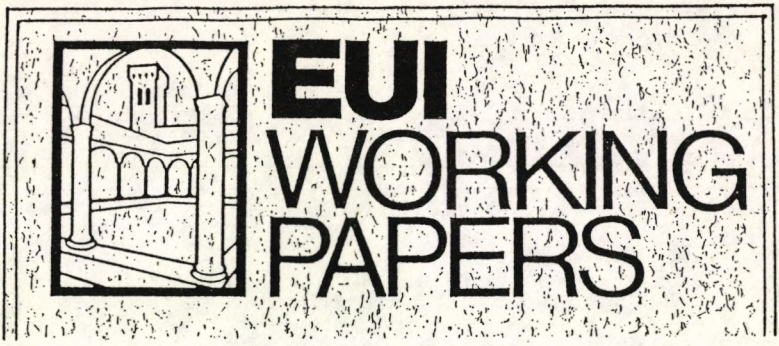


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