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Exchange Rates, Capital, Output and Debt When Nominal Interest Rates are Policy Parameters

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I INTRODUCTION

Recent years have witnessed a growing number of attempts to reduce inflation by a policy of raising nominal interest rates. Since 1988, such measures have been particularly pronounced in Australia, Canada and the United Kingdom. It is important to ask how higher interest rates can help to lower inflation, what factors determine the speed and reliability of the mechanisms involved, and, above all, what the side-effects of such policies may be.

The purpose of this paper is to explore various mechanisms through which nominal interest rates may affect the course of inflation, in the context of an open economy model where exchange rates are freely floating. The main focus of attention is upon how output and income react, in the short run and the long, to a change in the nominal rate of interest. This calls for an explicit treatment of the markets for capital and labour, as well as for money. None of these markets is assumed to clear instantaneously. International capital mobility, and the authorities' ability to influence the evolution of the nominal

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money stock, are both taken to be qualified rather than perfect. This paper aims to incorporate important features of the world into the story. The task of keeping matters as simple as possible has necessitated a somewhat cavalier treatment of microfoundations. Rational expectations and optimising behaviour are not wholly absent, but play a limited role. The complexity of the model makes it appropriate to concentrate chiefly on the impact and steady-state effects of policy changes, but there is some discussion of the character of the transition between them.

Inflation cannot persist indefinitely without some accommodating increases in the nominal money supply. To the extent that sustained inflation depends ultimately on the growth rate of the nominal stock of money, this paper argues that there are two possible routes from a higher nominal rate of interest to slower inflation. One takes the form of a negative effect from the real rate of interest on the rate of monetary growth. We might think of the central bank buying indexed bonds, for example: such open market operations would tend to exert downward pressure on real interest rates and, at least temporarily, raise the nominal money growth rate. Some commentators have argued that the great post-World War II inflation is ultimately traceable to central bank attempts to hold interest rates down in the 1950s and 1960s. To this "Wicksellian" view we may add a second, rival account of how higher interest rates could depress money growth. This postulates that the money market need not clear instantaneously. In accordance with the monetary approach to the balance of payments, or the buffer stock theory of money, money demand and money supply may temporarily diverge. An increase in the nominal rate of interest should lower money demand. If an excess supply of money results, the money supply growth rate may shrink. A different, but similar agument is traditionally propounded by the Bank of England: cutting the growth of monetary aggregates calls for reduction in the growth of banks' assets, and this in turn requires a higher rate of interest to cut the demand for loans and advances. In this paper, both mechanisms are allowed for.

The major claim of this paper is that the policy of increasing the nominal rate of interest should succeed in lowering inflation, certainly in the long run, and probably in the short run and the transition, but at substantial cost. Permanently higher nominal interest rates imply a lower long-run level of the stock of capital, and hence lower natural output. They also lead to a rise in net overseas debts, and hence to a fall in the long-run real exchange rate (competitiveness has to improve to create the trade balance improvement necessary to defray higher foreign debt charges). However, output could go up in the short run, since an initial excess supply of money could spill over into increased consumption, and even increased investment. In the transition between impact effects and long-run effects, inflation is squeezed as a result of falling money wage rates in the face of unemployment, but boosted by downward pressure on the exchange rate.

The paper is organised as follows. Section II discusses a number of features of standard simple exchange rate models which appear at variance with the facts of the world, and in need of modification. Section III then proceeds to lay out the equations of a model designed to reflect those concerns, and in which, in particular, the domestic nominal interest rate becomes a policy parameter. Section IV examines the long-run solutions of the model in the steady state. In Section V, attention switches to the impact effects on the key variables of interest, and to the transition. Section VI offers some important qualifications and concludes.

II SOME FACTORS THAT A MODEL OF FLOATING RATES NEEDS TO TAKE INTO ACCOUNT

Standard exchange rate models that allow for sluggish price adjustment (such as Dornbusch (1976) and Buiter and Miller (1981)) have many virtues. But some of their features are controversial. Here is a list of nine respects in which there is a case for seeking to generalise them:

(a) The nominal money supply is treated as a policy parameter, that can be set costlessly by the authorities at any desired level. This assumption was regarded as innocuous in the 1970s. But the 1980s saw a major shift away from monetary targetry towards interest rate manipulation in many financial centres. The collapse, in 1982, of the Fed's New Operating Procedures which had been introduced in 1979, is perhaps the most celebrated example of this.

(b) Factor markets are only implicit in the standard models. There is a need to incorporate markets for capital and labour, and hence production functions. Once money wage rates make their appearance, it seems desirable to allow for possible (at least partial) indexation, and also hysteresis effects that associate money wage growth to the rate of change, and not just the level, of unemployment.

(c) The standard models treat "natural output", or productive potential, as exogenous, and typically constant over time. On the other hand, aggregate demand is deemed to fall as interest rates rise. The problem here is that if it is investment that responds to interest rates, and natural output varies with the stock of capital, natural output must become endogenous.

(d) Foreign goods prices are generally not treated as an influence upon home nominal money demand. But if there is positive domestic spending on foreign goods, the expenditure price index to which nominal money demand, and, perhaps, money wage rates reacts, needs to display a link with the home currency value of foreign goods prices. At one extreme, one might wish to allow the possibility of inertia in the consumption real wage rate, for instance.

(e) International capital mobility is deemed to be perfect. It seems wise to allow this to be high but finite, and not necessarily infinite.

(f) The interest parity condition is generally assumed independent of the home country's net foreign asset position. But countries deep in external debt may have to offer a premium on their interest rates.

(g) The trade balance is only implicit, and the role of net interest, profits and dividends in the current account of the balance of payments is ignored. There is a case for modelling the trade account explicitly, and adding net interest flows to it.

(h) When forward exchange rates are introduced, the premium on forward foreign currency is taken to reflect agents' expectations of the spot exchange rate drift perfectly. But bankers often claim that forward foreign exchange premia are aligned on interest differentials (to thwart arbitrage), rather than the reverse, and particularly so in the thinner and longer markets.

(i) The price of (domestically produced) goods is assumed sluggish, to reflect sluggishness in money wage rates that are only implicit. In practice, there seems much to be said for the view that goods prices adjust faster than money wage rates, and some case for exploring the idea that goods prices are "jump" variables while money wage rates are not. "Menu costs" appear to be most serious in labour markets.

What follows is a model that tries to extend the standard story to allow for these nine issues.

III THE MODEL

The model proposed here consists of fifteen equations. Unless specified to the contrary, upper case Roman letters refer to levels of variables, and lower case to their natural logarithms, while Greek lower case letters denote parameters. An overdot is a time derivative. An asterisk denotes overseas, with the value of the variable defined in foreign currency. Overbars and tildes are defined as they occur.

The equations are as follows:

$$\dot{m}_s = \mu_0 - \mu_1 R + \mu_2(m_d - m_s) \tag{1}$$

$$Q(t) = \overline{Q}(t) + \dot{K}(t) + B(t) + \epsilon(m_s - m_d) \tag{2}$$

consumption: $\overline{Q}(t) + \epsilon(m_s - m_d)$ $\quad \epsilon \geqslant 0$.

$$\dot{K}(t) = \theta K(\rho - R) = \theta(\alpha Q(t) - RK(t)) \tag{3}$$

$\theta > 0$. ρ: rate of profit (= $\alpha Q/K$ from production function (9)).

$$B(t) = \beta_1 c(t) - \beta_2(Q(t) - \overline{Q}(t)) - RZ(t) \tag{4}$$

$\beta_1, \beta_2 > 0$. Z(t): net overseas debts (real).

$$m_d(t) = \eta_0 + \eta_1 q(t) - \eta_2 r + p(t) + (1-\phi)c(t) \tag{5}$$

$$\widetilde{p} = \phi p + (1-\phi)(p^* + s) = p + (1-\phi)c \tag{6}$$

$$(c(t) = p^*(t) + s(t) - p(t)).$$

$$\overline{Q}(t) = YK^{\alpha}(t)\overline{N}^{1-\alpha} \tag{7}$$

$$\overline{Q}(\infty) = YK^{\alpha}(\infty)\overline{N}^{1-\alpha} \tag{8}$$

$$Q(t) = YK^{\alpha}(t)N(t)^{1-\alpha} \tag{9}$$

$$w - p = \ln(1-\alpha) + q - n = \ln(1-\alpha) + (y + \alpha(k-q))/(1-\alpha) \tag{10}$$

w-p: log product real wage; k,n logs of current capital and employment; y: log technology index.

$$w(t) = w_0(t) + \kappa_1(p(t) + (1-\phi)c(t)) + \kappa_2 n(t) \tag{11}$$

κ_1: indexation coefficient; κ_2: hysteresis coefficient.
$1 \geqslant \kappa_1 \geqslant 0$; $\kappa_2 \geqslant 0$.

$$\dot{w}_0(t) = (1-\kappa_1)\pi + \delta(n(t) - \overline{n}) \tag{12}$$

$$\dot{z}(t) = \zeta(r - r^* - f(t) - \gamma Z(t)) \tag{13}$$

$\zeta > 0$. f = forward premium on foreign exchange.

$$f(t) = \lambda(\pi - \pi^* + \chi(c(\infty) - c(t))) + (1-\lambda)(r - r^* - \gamma Z(t)) \tag{14}$$

$1 \geqslant \lambda > 0$. $c(\infty)$: log competitiveness in long run, rationally foreseen.

$$B(t) + \dot{Z}(t) = 0. \qquad (15)$$

Equation (1) describes the evolution of the money supply. It specifies the growth rate of the nominal money supply (M_s;m_s in logs) in terms of the real rate of interest, R, and the money market disequilibrium (as reflected by the difference between m_s and m_d, the logarithm of nominal money demand). Equation (2) closely resembles the short-run money *demand* growth equation postulated, and very successfully estimated for the United States, by Baba, Hendry and Starr (1990). The disequilibrium term is an error correction mechanism. It captures the idea that money supply growth rises when there is excess demand for money, and more slowly in the presence of excess supply. The money supply growth rate is assumed to fall if the real interest rate goes up; as we shall see later, that will happen following a rise in the nominal rate of interest. So (1) is built on the notion that raising the nominal rate of interest will succeed in cutting money supply growth, at least in the long run.

Equation (2) defines the level of real aggregate demand (Q(t) at date t). This consists of domestic consumption and investment spending (the latter equals $\dot{K}(t)$: capital does not depreciate, so that gross and net investment are equal, and government current and capital spending, if any, is aggregated with the private sector's) and the current account surplus, B(t). Consumption spending is modelled as current natural output with the current value of the capital stock ($\overline{Q}(t)$), which is a myopic form of permanent income. (It is myopic in that households are not assumed to look ahead to future levels of natural output when the capital stocks may differ.) Consumption is also assumed to react to money market disequilibrium.

Investment is given by Equation (3). Here I follow Tobin (1969). Investment is taken to be proportional to the gap between the current rate of profit (the marginal product of capital, derived from the Cobb-Douglas production function) and the real rate of interest. Equation (4) presents the current account surplus, B(t), which includes real interest income on net overseas assets (-RZ(t)), and the trade surplus. The trade surplus is deemed to be linear in two variables – the log of competitiveness (c(t)), and the difference between current real aggregate demand, Q(t), and its current equilibrium value of natural output, $\overline{Q}(t)$. This gap can be thought of as the imbalance in the product market.

The money supply growth Equation, (1), is complemented by an equation for the level of nominal money demand, (5). This relates the log of nominal money demand to the level of the nominal rate of interest, r, and to the logs of current real income (q) and a domestic expenditure price index ($\widetilde{p}$), which is defined in (6) as the weighted average of the home currency values of domestic and foreign goods prices. Equation (6) also defines competitiveness, in log form.

Equations (7), (8) and (9) all give different production functions for output. All are based on the Cobb-Douglas, in constant returns form. Equation (7) defines current productive potential in terms of current capital (K(t)), and the supply of labour, $\overline{N}$, which is taken to be stationary and exogenous. Equation (9) relates actual current output to current capital and current employment, N(t). The demand for labour and the supply of labour can differ. By contrast, (8) describes long run productive potential, $\overline{Q}(\infty)$, which relates output in the long run to the long-run capital stock, $K(\infty)$ and the supply of labour $\overline{N}$.

Various features of the labour market appear in the next three equations, (10), (11) and (12). Equation (10) defines the product real wage confronting producers, on the assumption of perfect competition. In (11), the money wage rate (w(t) at t in logs) has a core element, $w_0(t)$, and may also vary with the expenditure price index to allow for possible indexation, and with the level of employment. This last term introduces a possible hysteresis effect. Hysteresis in the labour market is modelled most simply by the notion that the rate of increase in money wage rates may vary with the *rate of change*, and not just the level, of unemployment. If this relationship is linear, it can be integrated into a link between the levels of the money wage and employment. Finally, (12) gives the dynamics of the core element of the money wage rate, in terms of domestic goods price inflation (π) and the excess supply of labour, $\overline{n}-n(t)$ in logs.

The last three equations return to external aspects of the system. Equation (13) gives the net inflow of international capital, the surplus on the capital account of the balance of payments. The parameter ζ reflects the interest-elasticity of capital flows. It embraces the standard case of perfect international capital mobility at one extreme ($\zeta = \infty$) as well as total immobility at the other ($\zeta = 0$). The parameter γ captures, in the simplest linear fashion, the risk premium coefficient to be attached to a country with a negative net foreign asset position. The variable f(t) is the forward premium on foreign exchange, which is defined by (14). Here, the parameter λ denotes the extent to which the forward premium is governed by expectations of relative inflation and the evolution of competitiveness. In the standard models, λ is set implicitly at unity. But (14) allows λ to fall below unity, to reflect the "bankers' story" described in point (h) above: according to that account, forward rates are simply aligned on interest differentials. Lastly, (15) states that the exchange rate is freely floating with no intervention on the part of the authorities (other than in the form of interest rate manipulation).

IV LONG RUN ANALYSIS

We proceed now to study the long-run consequences of a permanent rise in the nominal rate of interest. In the long run, the gap between the supply of labour and the demand for labour ($\overline{n}$ - n) disappears. So does that between aggregate demand (Q(t)) and long-run productive potential ($\overline{Q}(\infty)$). The capital stock adjusts to set the rate of profit equal to the real rate of interest. So K vanishes, as does $\dot{Z}$.

It follows that the money supply growth rate, $\dot{m}$, equals the rate of inflation. There is no drift in technology, labour supply or capital, so that $\overline{Q}(\infty)$ is stationary. Because (1) implies that

$$\dot{m} = \mu_0 - \mu_1(r-\pi)$$

once the money market imbalance vanishes, the rate of inflation settles down to $(\mu_0-\mu_1 r)/(1-\mu_1)$, and the real interest rate to $(r-\mu_0)/(1-\mu_1)$. Since $1 > \mu_1$ by assumption, inflation and money growth both decrease in the nominal interest rate, and the real rate of interest increases in the nominal rate.

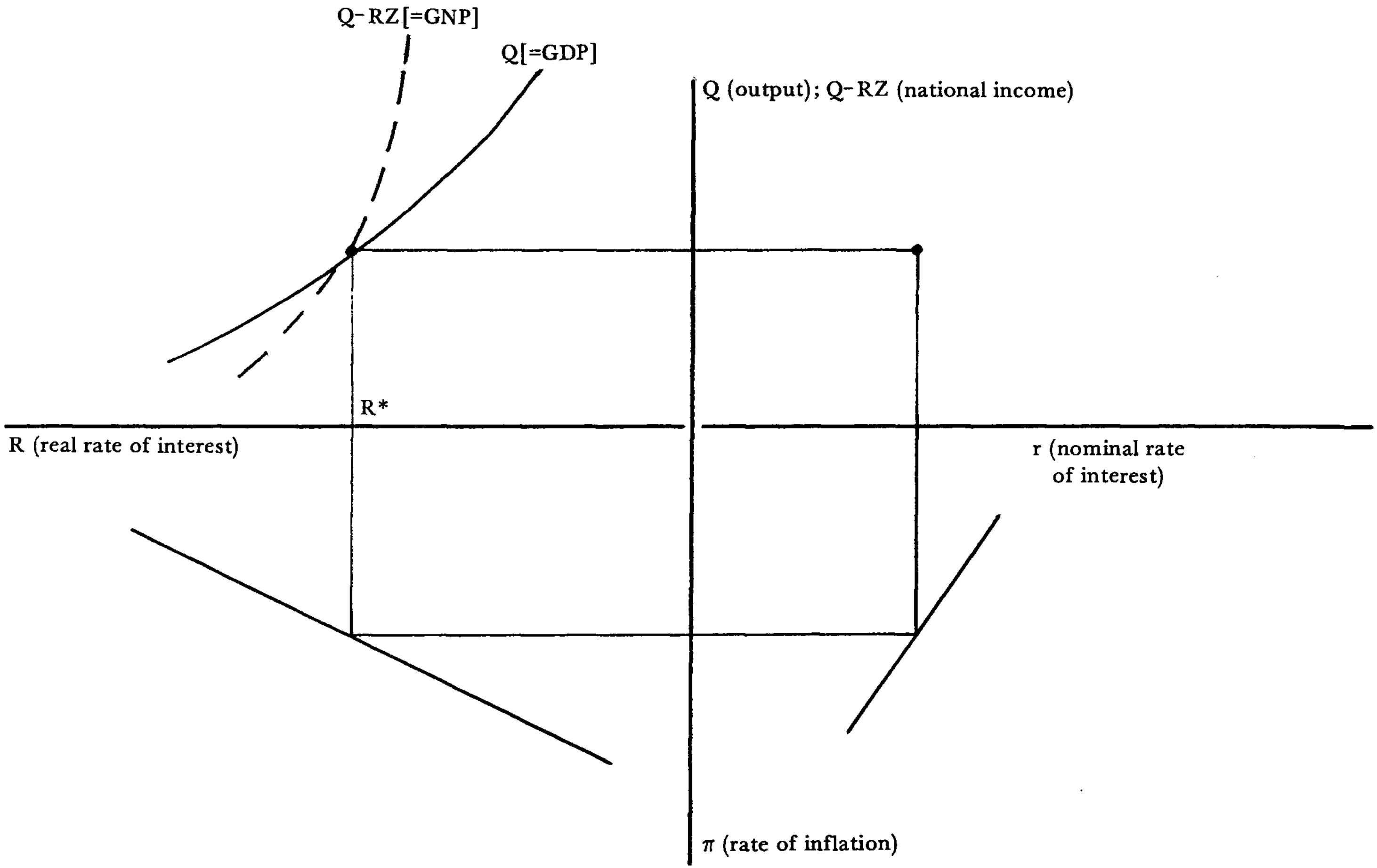
The increased nominal rate of interest therefore raises the real rate of interest. This means that the long-run stock of capital, and hence the long-run level of output, both drop. $\dot{K} = 0$ implies, from (2), that $\alpha\overline{Q}(\infty) = RK(\infty)$. Hence $K(\infty) = \overline{N}(\alpha Y/R)^{1/(1-\alpha)}$ and $\overline{Q}(\infty) = Y\overline{N}(\alpha Y/R)^{\alpha/(1-\infty)}$. Turning to the external variables, begin by combining (13) and (14) to yield

$$\dot{Z}(t) = \zeta\lambda(r-r^*-\gamma Z(t)-\pi+\pi^*-\chi(c(\alpha)-c(t))) \quad (16)$$

Next define R*, the foreign real rate of interest, as $r^*-\pi^*$, and set c(t) equal to c(∞). Now make $\dot{Z}$ vanish, as it must in the steady state. Equation (16) now furnishes solutions for the long-run values of net debts, Z, and the logarithm of competitiveness: $Z = (R-R^*)/\gamma$ and $c(\infty) = RZ/\beta_1$). This implies that our increased nominal rate of interest will serve to raise net overseas debts and depress the real exchange rate in the long run. (The first of these results always happens; the second, provided only that the domestic real interest rate is at least half as great as the overseas real rate, a condition guaranteed unless the home country has sufficiently large net overseas assets.) The reasoning for this is clear: a higher nominal interest rate attracts capital from overseas, as well as making existing debts more expensive to service. So it tends to drive down the real exchange rate in the long run, in order to generate the necessary trade balance improvement required to make room for the enhanced debt servicing costs.

Figure 1 illustrates some of these relationships. The lower right quadrant depicts the negative link between π and r. This line slopes up given that $1 > \mu_1$, with a gradient of $\mu_1/(1-\mu_1)$. The lower left quadrant portrays the link between R, the real rate of interest, and π. This slopes down, with a

Figure 1: *The Long-Run Links Between Nominal and Real Interest Rates, Inflation, and Domestic and National Product.*



gradient of $-(1-\mu_1)$. In the upper left quadrant the negative influence of the real rate of interest on long-run domestic product, $\overline{Q}(\infty)$, appears as an unbroken curve, while that for national product ($\overline{Q}(\infty)$-RZ) as a broken one. The two curves intersect where R=R*, since at this point net overseas debts, and hence debt servicing costs, vanish. Combining these three relationships running from the nominal rate of interest to domestic product establishes a downward sloping curve, which presents itself in the upper right quadrant. Its elasticity is $-\alpha r/(1-\alpha)(1-\mu_1)(r-\mu_0)$.

These long-run effects of a permanent rise in the home country's nominal rate of interest are essentially *ceteris paribus*. That is to say, that is what happens when other variables are kept fixed. In particular, the values of μ_0 (the constant term on the money growth equation) and R* (the foreign real rate of interest) have been held constant. There are two important cases where some of the effects of a higher nominal rate of interest are neutralised. One of these arises when the jump in domestic interest rates matches rises in overseas rates. Suppose R* increases, once and for all, by a given amount, and that r is raised enough to bring R up by the same amount, so that R=R* throughout. In this case, none of the external effects materialise. Net overseas debts, and the real exchange rate remain unchanged. But the internal effects continue to operate. Inflation drops. The real cost of capital facing domestic firms has risen. So the domestic stock of capital keeps dwindling until the rate of profit has climbed up to it. Output (both domestic and national, for they are equal now) must also go down as a result of the squeeze on capital.

In the second case, neither the internal nor the external repercussions of the higher domestic nominal interest rate arise. This is so, at least, for the *real* variables in the system. That is the position when the jump in the home nominal rate of interest offsets a parallel rise in μ_0, the autonomous intercept on the money supply growth equation. In that event, the real rate of interest stays unchanged. So there is no alteration in the equilibrium values of capital or natural output, and no effect, either, on long-run competitiveness or net indebtedness. There is some effect, however, on the nominal variables. The steady state rate of inflation rises by the increase in μ_0. It would have gone up still more had r not increased. The nominal exchange rate will depreciate faster, or appreciate slower, to match the higher domestic inflation rate. But, as (16) testifies, nothing happens to the capital account of the balance of payments, at least in the longer run, since the changes in r and π offset each other exactly. On the other hand, had the level of r been raised enough to keep inflation constant, the real rate of interest would have gone up, with qualitative effects on the real variables in the system resembling what happened in the initial case where μ_0 and R* were given.

These findings invite comparison with the results of standard closed economy models. The classic paper to display a positive long-run link between the rate of money growth and the level of real output is Tobin (1965). There, faster money growth tilts portfolios in favour of real as opposed to financial assets, and stimulates savings, so that the capital-output ratio rises and the real rate of interest declines. Hence, a reduction in steady state inflation is associated with a rise in the real interest rate and a squeeze on output. The only difference between our results and Tobin's is the fact that Tobin makes the rate of nominal money growth the key policy parameter, while the nominal rate of interest is assumed independent of the rate of inflation. In the present model, of course, money supply growth is endogenous, and inflation is governed, in the long run, by the nominal rate of interest.

In the Optimum Quantity of Money family of models that begin with Friedman (1969), on the other hand, the real rate of interest is generally governed independently of monetary variables by the forces of demography, productivity and thrift. The nominal rate of interest diverges from it by an amount necessarily equal to expected inflation, if foresight is perfect. In a steady state that obeys the golden rule, the nominal interest rate equals the rate of money growth; and the latter is of course taken to be exogenous. When labour supply is endogenous in a Ramsey-type model of intertemporal optimisation with money, faster money growth typically lowers output. If the government finances its spending from seignorage and other forms of distortionary taxation, as in Poterba and Rotemberg (1990) or Sinclair (1990), the door is left ajar for the possibility that output and inflation rise together in the long run, so long as the rate of inflation is low enough. But a low nominal interest rate is always associated with low money growth. The benefits of plentiful real balances to which it gives rise are the reward for sustained abstinence in the money growth rate. A high nominal interest rate indicates rapid inflation. It is not a device for reducing it. This is essentially the view that predominates, also, in recent work on interest rate targeting, such as Barro (1989).

In practice, the nominal interest rate is both an indicator of anticipated inflation and an instrument for cutting actual inflation. The term structure of interest rates provides a forum within which this paradox can be resolved. A downward sloping yield curve on unindexed bonds, for example, can point to tight monetary policy being applied now to cut inflation, a policy that agents believe will succeed. Nearly all the existing literature concentrates on the nominal interest rate's role as pointer to future inflation. Buiter and Miller (1981) is a rare exception: for them, a high nominal interest rate generally reflects a reduced money growth rate, rather than a high one. If the present paper errs in stressing the inflation brake role of nominal interest rates too strongly, I can plead that this view requires more exposure and detailed analysis, before work can proceed on a richer model with an explicit term structure that allows one to study *both* roles together.

V THE IMPACT EFFECTS

This section moves from the steady state to the impact effects of an increase in the nominal rate of interest. I shall assume that the nominal rate is raised once and for all, and unexpectedly. Agents have enough knowledge of the model to infer the long-run consequences this will have for the real rate and the real exchange rate, $c(\infty)$. Investment proceeds according to Equation (3) above, subject to the proviso that R is the steady state real cost of capital (and not r less the current, or anticipated immediate rate of inflation as captured by $\dot{p}$). This assumption allows us to compute the impact effects of the rise in r directly, without having to solve backwards for the course of anticipated inflation. In its defence, it can be said that the absence of depreciation makes a "permanent" cost of capital concept a little more palatable.

Start with Equations (2) to (4). Total differentiation establishes that

$$(1-\alpha\theta+\beta_2)dQ = -(\theta K+Z)dR - \epsilon dm_d + \beta_1 dc. \tag{17}$$

We may think of (17) as an IS curve in derivative form. Given that r (and R) are now parametric, it would be wrong to go on to eliminate dR from (17) to establish an expression for aggregate demand, as one would with Dornbusch (1976) for example. What has to be eliminated from (17) is the money demand term (we have assumed, in deriving (17), that the money supply level was not affected immediately by the higher r). Equation (5) implies

$$dm_d = \eta_1 dq - \eta_2 dr + dp + (1-\phi)dc. \tag{18}$$

The short run supply side of the system can be gleaned from (10) and (11). They imply

$$(1-\kappa_1)dp = \frac{\alpha+\kappa_2}{1-\alpha} dq + \kappa_1(1-\phi)dc. \tag{19}$$

Meanwhile, the key competitiveness — output — interest rate links can be set out from (4), (15) and (16), which together yield

$$(\beta_1 + \chi\zeta\lambda)dc = \beta_2 dQ + (Z-\zeta\lambda)dR + \chi\zeta\lambda dc(\infty). \tag{20}$$

Next, recall the long-run results from Section IV. These tell us that $dR = (1-\mu_1)^{-1}dr$, and $dc(\infty) = \dfrac{2R-R^*}{\beta_1\gamma} dR$. It is now easy to express the RHS of

(20) in terms of Q and r alone, while (17)-(19) can be combined to eliminate dp and dm_d and obtain a second equation linking c to Q and r. Remember that the price of domestically produced goods is a jump variable, not a predetermined sluggard as in Dornbusch (1976). The end result is a system

$$\begin{bmatrix} dQ \\ dc \\ dp \\ d\tilde{p} \end{bmatrix} = \begin{bmatrix} A_1 \\ A_2 \\ A_3 \\ A_4 \end{bmatrix} dr \tag{21}$$

which gives the impact effects upon the domestic goods price level, p, and the domestic expenditure price index, $\tilde{p}$, as well as domestic output and the real exchange rate. In (21), $A_1 = (x_5 - x_1 x_4)/(1-\mu_1)(\beta_2 x_1 + x_2 + x_3)$; $A_2 = (\beta_2 A_1 + x_4/(1-\mu_1))/(\beta_1 + \chi\zeta\lambda)$; $A_3 = A_1(\alpha+\kappa_2)/Q(1-\alpha)(1-\kappa_1) + A_2\kappa_1(1-\phi)/(1-\kappa_1)$ and $A_4 = A_3 + A_2(1-\phi)$; and x_1 to x_5 are defined as:

$$x_1 = \frac{\epsilon(1-\phi)/(1-\kappa_1) - \beta_1}{\beta_1 + \chi\zeta\lambda}$$

$$x_2 = 1 - \alpha\theta + \beta_2$$

$$x_3 = \frac{\epsilon}{Q}\left(\eta_1 + \frac{\alpha+\kappa_2}{(1-\alpha)(1-\kappa_1)}\right)$$

$$x_4 = Z - \zeta\lambda(1-\chi(2R-R^*)/\beta_1\gamma)$$

$$x_5 = \epsilon\eta_2(1-\mu_1) - \theta K - Z.$$

The immediate impression one gains from inspecting (21) is that pretty well anything can happen. This is true. Domestic output, competitiveness, and the price level – with or without the foreign goods – can go up or down on impact following a jump in the nominal rate of interest. But the results are easier to understand and interpret than may seem at first sight.

Begin with A_1, the coefficient that tells us how domestic output reacts to the higher nominal rate of interest. There are five channels of influence running from r to Q:

(a) via investment, $\dot{K}$
(b) via debt charges and competitiveness

(c) via capital inflows and competitiveness
(d) from foreseen steady state competitiveness to competitiveness now (the $c(\infty)$ term)
(e) via the imbalance in the money market created by higher r. This channel can be subdivided into:

(e(i)): a direct consumption effect
(e(ii)): an indirect consumption effect running from debt charges to competitiveness and the expenditure price index
(e(iii)): as (e(ii)), but originating from the change in capital inflow
(e(iv)): as (e(ii)), but originating from the foreseen change in steady state competitiveness.

Each of these channels needs to be explained in turn. Channel (a) is simple. The higher nominal interest rate betokens a permanently higher real cost of capital. That now stands above the current rate of profit, if they were previously equal. So there will be downward pressure on investment, depressing aggregate demand in the short run. Channel (b) squeezes aggregate demand directly if the country has net foreign debts: a higher real interest rate on these debts worsens the current account of the balance of payments. Channel (c) is also straightforward. Higher interest attracts capital from abroad, improving the capital account of the balance of payments at the previous exchange rate: and, since there is free floating, the spot exchange rate should tend to appreciate. The consequent reduction in competitiveness worsens the trade balance and squeezes aggregate demand. Channel (d) is a little harder to grasp. We know that the higher interest rate will increase the country's net overseas debts, and that servicing them will call ultimately for a *lower* real exchange rate in order to generate the necessary improvement in the trade balance. We know this; and the agents in the model are also assumed to know this. So, depending on the magnitude of the parameter χ (which is the coefficient on the current/long-run exchange rate discrepancy in the forward premium equation, (14)), there will have to be some negative pressure on the real exchange rate now in anticipation of the long-run effect. Any tendency for depreciation now qualifies, or even reverses, the mechanism outlined for channel (c): the trade balance improves, and aggregate demand recovers.

We now get to the most intricate part of the story, the various effects operating under channel (e). The central idea is that domestic expenditure is boosted when there is an excess supply of money. This is *not* the same thing as a real balance effect, which would make consumption react to $m-p$ or $m-\tilde{p}$. Now a jump in the nominal rate of interest cuts money demand ($\beta_2>0$). So the excess supply of money increases (or excess demand is cut). Effect e(i) captures this exactly. Effects e(ii) to e(iv) inclusive also impact finally on aggregate demand via consumption, but the way in which they generate changes in excess money balances differs. All of them affect the excess supply of money through the price level. So e(ii), which induces downward pressure on the exchange rate if the country has negative net overseas assets, acts to squeeze consumption by boosting the price level (expenditure definition, $\tilde{p}$) and making for an excess demand for money. The same happens with e(iv): the expectation of higher future debt charges acts to depress the exchange rate now, with similar consequences. But e(iii) runs in the opposite direction: a capital inflow worsens competitiveness, trimming $\tilde{p}$ and making for an excess supply of money. None of these four mechanisms under the (e) heading operates if ϵ vanishes. Effect e(ii) is the excess money balances counterpart of channel (b), e(iii) of channel (c), and e(iv) of channel (d).

The next task is to identify each of these effects and channels with particular terms in A_1, the coefficient for dQ in (21). Channel (a) can be pinpointed as the $-\theta K$ term in x_5. It is clear that this imparts a negative influence on Q. Channel (b) operates through the $-Z$ term in x_5, again an unambiguously negative effect;[1] this is qualified, but never reversed, by the product of Z in x_4 with $-(1+\chi\zeta\lambda/\beta_1)^{-1}$ term in x_1. Channel (c) is captured by the product of $-\zeta\lambda$ in x_4 and the same term in x_1, and (d) by the product of that same term in x_1 with the expression $\chi\zeta\lambda(2R-r^*)/\beta_1\gamma$ in x_4. It is clear that channel (c) imparts a negative influence of r on Q, and (d) a positive one. Finally, the (e) channel. This is identifiable to all terms in A_1 that contain the parameter ϵ. Effect e(i) operates through the $\epsilon\eta_2(1-\mu_1)$ term in x_5; e(ii) can be traced to the product of Z in x_4 with the ϵ term in x_1, and e(iii) and e(iv) likewise to the other elements in x_4 multiplied by that term in x_1. We have focused upon the numerator of A_1 in this discussion; the denominator is just the familiar multiplier, which has to be positive for stability.

The coefficients A_2, A_3, and A_4, which tell us how competitiveness, and the home country's factor cost and expenditure price indices react to the higher rate of interest, are easier to interpret. The numerator of A_2 contains two terms: a direct effect, $x_4(1-\mu_1)^{-1}$, which we saw operating in channels (b), (c) and (d), and an indirect effect, $\beta_2 A_1$, which reflects the fact that if Q rises (falls), the trade balance will worsen (improve), so that a cleanly floating exchange rate will have to depreciate (appreciate). The denominator of A_2 reminds us that the magnitude of all these competitiveness effects will be smaller, the greater the international mobility of capital (the higher is ζ), the more the forward rate reflects expectations of future exchange rate changes (the higher is λ) and the faster the process of convergence on the steady state (the higher is χ). The home goods price index p rises or falls with

1. Assuming that both Z and $\chi\zeta\lambda$ are strictly positive.

domestic output, as the A_1 term testifies; we can interpret $(\alpha+\kappa_2)/(1-\alpha)(1-\kappa_1)$ as the reciprocal of the elasticity of aggregate supply. Both the indexation coefficient κ_1 and the hysteresis coefficient κ_2 serve to make home supply less price elastic. But there is also a second term in A_3, which reflects the indexation link from foreign goods prices in home currency and the level of domestic money wage rates. Lastly, the home country's expenditure price index, $\tilde{p}$, is a little more sensitive to r than p, by virtue of the exchange rate term $A_2(1-\phi)$ that is added to it: often, not always, A_2 and A_3 will have the same sign.

It is interesting to examine the roles played in shaping these results by the exotic parameters which are absent from simple, standard models. They include:

- ζ, the interest-sensitivity of international capital flows
- λ, the sensitivity of the forward premium on foreign exchange to the expected exchange rate trend
- κ_1, the money wage indexation coefficient
- κ_2, the money wage hysteresis coefficient
- κ, the coefficient of the exchange rate drift on the gap between the current and long-run expected exchange rates
- ϵ, the sensitivity of spending to excess money
- μ_1, the real-interest sensitivity of money growth
- θ, the sensitivity of investment to the profit/interest gap.

The impact of these parameters is as follows. We shall focus attention on the implications each of them has for the magnitude and sign of the short-run effect of the rate of interest on Q, given by the value of A_1 in Equation (21).

First, ζ and λ. These two parameters have qualitatively identical effects, since they only enter as a product. Greater international capital mobility (ζ) therefore has just the same implications as an increase in the sensitivity of the forward rate to the expected exchange rate trend (λ). The sign of dQ/dr responds ambiguously to a rise in ζ or λ. There are two things that matter here. First, whether the exchange rate is driven up or down by the increase in the rate of interest. That depends on whether $\chi(2R-R^*)$ exceeds or falls short of $\beta_1\gamma$. If it exceeds it, the depressive effect of the knowledge of a lower long-run exchange rate – which has to drop, to improve the trade balance enough to defray the higher debt charges – dominates the direct effect, and depreciation ensues. But with low enough χ, there will be appreciation. The other factor which matters here is how output reacts to an exchange rate change. If the exchange rate appreciates, competitiveness declines; that hurts the trade balance; and domestic aggregate demand goes down. On the other hand, appreciation pushes down the cost of living (since foreign goods become cheaper in domestic currency). If money wage rates are linked to the cost of living by a powerful indexation scheme, this effect will be all the stronger, since the prices of home produced goods will tend to be forced down too, but it will be present even without indexation. The drop in the cost of living will cut the domestic demand for money, and that in turn generates an excess supply of money if the money market initially cleared; and so long as $\epsilon > 0$ that implies higher aggregate demand. The normal view is that higher interest rates at home induce the exchange rate to appreciate and this will be deflationary for output. In that case, higher ζ or λ make for an increased likelihood of a negative effect of r on Q. This will also be so if the exchange rate falls (in anticipation of those higher future debt charges) and aggregate demand is squeezed by the money market effects of higher prices at home. But if either the exchange rate depreciates or appreciation is expansionary for aggregate demand (and only one of these conditions applies), raising ζ or λ will make dQ/dr likelier to be positive. Finally, ζ and λ also appear on the denominator of A_1; here, their role is to dampen (enhance) the value of the multiplier depending on whether $\epsilon(1-\phi) > (<) \beta_1(1-\kappa_1)$.

Next, coefficients κ_1 and κ_2, which capture the way money wage rates respond to the cost of living $\tilde{p}$, and the level of employment. We have termed them the "indexation" and "hysteresis" coefficients. The indexation coefficient makes the supply of domestic goods less elastic. A rise in the price level gets transmitted into money wage rates, and so prices rise even further. The implication of this is that the size of the multiplier for Q is cut. So much is plain from one of the ways κ_1 enters the denominator of A_1 (in the term x_3). To this extent, κ_1 lowers the size of $|A_1|$. It also plays a second role, so long as $\epsilon > 0$. A higher value of the indexation coefficient makes it likelier that a real exchange rate depreciation cuts output, by raising the price level more – and hence money demand more – than would have occurred otherwise. Increased money demand means lower spending, given that $\epsilon > 0$. This effect is evident from the numerator of A_1, and also its denominator.

The hysteresis coefficient, κ_2, simply makes supply less elastic. An increase in domestic employment pushes up wage rates. (The hysteresis effect is more familiar in the time derivatives, as a link between money wage growth and the rate of change in unemployment.) So the result of raising κ_2 is to reduce the size of the multiplier for Q. This can be seen from its presence in the x_3 term in the denominator of A_1.

Now for χ. This variable reflects the strength of the link between the anticipated speed of depreciation and the size of the gap between the current and long-term equilibrium real exchange rates. Under rational expectations, the size of χ is highly sensitive to that of δ, the slope of the short-run Phillips Curve. When money wage rates are sluggish, real exchange rates move only slowly towards their long-run equilibrium levels. In our model, the really important effect of raising the value of χ is to make depreciation likelier when the interest rate goes up. This is so because of the negative long-run link between the rate of interest and the real exchange rate (higher interest means higher debt charges, hence a larger trade surplus, which can only be engineered in the long run by increasing competitiveness). Higher χ strengthens the pull of this long-run effect on the current value of the exchange rate. That result – higher χ makes for an increased change of depreciation after a jump in interest rates – assumes that the real interest rate at home is no less than half its foreign value. Now whether an increased chance of depreciation makes it likelier that output goes up turns on the relative size of $\epsilon(1-\phi) - \beta_1(1-\kappa_1)$, as we saw in our discussion of ζ and λ.

The next parameter to consider is ϵ. This gives the sensitivity of spending to excess money balances. If ϵ were zero, a higher rate of interest would almost certainly imply a lower level of Q. The only force tending to raise output in such circumstances is the downward pressure on the exchange rate that would come through anticipation of higher future long-run debt charges. So the chief significance of ϵ is to make it much likelier that a higher rate of interest has a perverse, positive impact on aggregate demand. The simplest way this can happen is through reduction in money demand stemming directly from the higher rate of interest (effect (e(i)) above). Higher ϵ also makes it more probable that depreciation squeezes aggregate demand, as we have seen; and since the exchange rate impact of higher r is uncertain, the significance of that effect for the sign of dQ/dr is uncertain.

Next, μ_1. This coefficient captures the feedback from the real rate of interest on the rate of money growth. It shapes the link between the nominal and real rates of interest. Higher μ_1 means that the long-run inflation rate drops more – and that the real interest rate therefore goes up more – following a given jump in the nominal rate. Unlike the other parameters considered here, μ_1 has important long-run implications, and plays only a minor role in the short run. The other parameters have bearing only on the short run.

Finally, θ, the coefficient in the investment equation. Increasing the value of θ means making the capital stock close the gap between the rate of profit and the cost of capital more quickly. The role of θ is a simple one. It determines the size of the direct, negative effect of a higher rate of interest on aggregate demand running through investment. So higher θ must make a negative value of A_1 likelier.

This section concludes with some remarks on the character of the transition from the short run to the long. Will it be one of falling output? Or could the transition witness a recovery in levels of production and employment? And what does the time-structure of inflation look like?

We know from Section IV that output and capital both have to fall in the long run as a consequence of a higher rate of interest. We also know that output can rise or fall in the short run. For the transition to display rising levels of output, it is sufficient that aggregate demand should decline in the short run by more than in the long. Is this case of "output overshooting" possible?

The answer is yes. It is possible for the jump in the rate of interest to force aggregate demand down so much at once that it then goes up subsequently. A comparison of the long-run results for Q in Section IV with A_1 in (21) reveals that this is likeliest when two parameters are particularly high (β_1, the derivative of the trade balance with respect to log competitiveness, and θ, the multiplicative constant in the investment equation), given that the exchange rate appreciates initially. The precise condition for this to happen simplifies, when both ϵ and χ go to zero, to $\theta\beta_1 > 1 - \beta_1\zeta\lambda(1-\alpha)/K$. In these circumstances, the levels of output and employment rise over time during the transition, while the capital stock shrinks. The fact that employment collapses early and climbs back later means that money wage increases fall away very quickly, and tend to rise a little later. The appreciation in the exchange rate which occurs at once, and is subsequently unwound, also imparts a negative influence on inflation early and a positive one later. So this is a case where the good and the bad news from the higher rate of interest are concentrated right at the beginning.

It is also possible for aggregate demand to jump so much on impact that the stock of capital actually rises initially. For this to occur, the positive pressure from higher output on the rate of profit must exceed the increase in the real cost of capital to which the higher rate of interest gives rise. This state of affairs is not probable, but it can happen. It is at its likeliest when the interest-elasticity of money demand is much greater than the income elasticity, aggregate supply is price elastic, and spending is highly sensitive to excess money. The exact condition for investment to rise in the short term, in the face of the higher rate of interest, is

$$R\eta_1(1-\mu_1) > \eta_2 + \frac{\alpha + \kappa_2}{(1-\alpha)(1-\kappa_1)} + \frac{\alpha\bar{N}}{R\epsilon} Y^{1/(1-\alpha)} \left[1 + \frac{\beta_2\epsilon(1-\phi)}{\beta_1(1-\kappa_1)}\right]$$

when the initial value of Z is zero. The intuition here is not hard: the higher rate of interest creates a big excess supply of money, boosting spending, and the size of this effect is greatest when money demand is highly interest elastic and spending reacts strongly to excess money.

The case where output and the capital stock both rise early and fall back later displays increased wage pressure to start with. So as far as this influence on the course of inflation is concerned, the process of disinflation will be liable to delay. The condition for the capital stock to rise initially is a great deal more stringent than for a positive impact effect on output. The latter is necessary but not sufficient for the former. A variety of possible time paths for domestic output and the stock of capital are illustrated in the different panels of Figure 2.

We have seen that output can exhibit overshooting behaviour, changing on impact by more than is needed to achieve long-run equilibrium. Is the same true of the real exchange rate? It turns out that competitiveness can go up on impact by more than the long-run equilibrium requires. The idea here is that the higher rate of interest generates a large excess supply of money, which calls for a high value of η_2, the interest semi-elasticity of money demand. Spending then jumps sharply. The parameter β_2, which does duty for the "marginal propensity to import" in standard Keynesian models, is big enough to ensure a major surge in imports. This imparts negative pressure on the spot exchange rate, and all the more so if ζ and λ are small (so that it is largely the current account of the balance of payments, not the capital account, that determines the exchange rate). For the real exchange rate to overshoot, the effect just described has to dominate the various other mechanisms at work. When the initial value of Z is zero, real exchange rate overshooting will arise if and only if

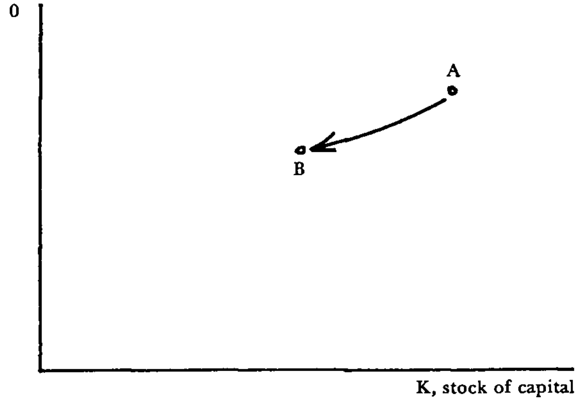
$$\beta_2\epsilon\eta_2(1-\mu_1) > \theta K\beta_2 + \zeta\lambda(x_2+x_3) + (R/\gamma)[1-\alpha\theta+x_3 + \frac{\beta_2\epsilon(1-\phi)}{\beta_1(1-\kappa_1)}].$$

Except in this strange and somewhat unlikely case, the real exchange rate depreciates during the transition to long-run equilibrium. This tends to raise the rate of inflation during the transition, and especially so when $(1-\phi)$, the expenditure weight for foreign goods, and κ_1, the indexation coefficient, are both large. There is another factor working in the same direction. The stock of capital is shrinking. This exerts upward pressure on the price level of domestically produced goods, relative to the money wage rate. However, transitional inflation is lowered by two other mechanisms. Unemployment is inevitable at some stage in the transition, and quite likely throughout it; this cuts the growth of money wage rates. And the higher rate of interest leads at once to an excess supply of money. That automatically lowers the rate of money growth, as long as it lasts, via parameter μ_2.

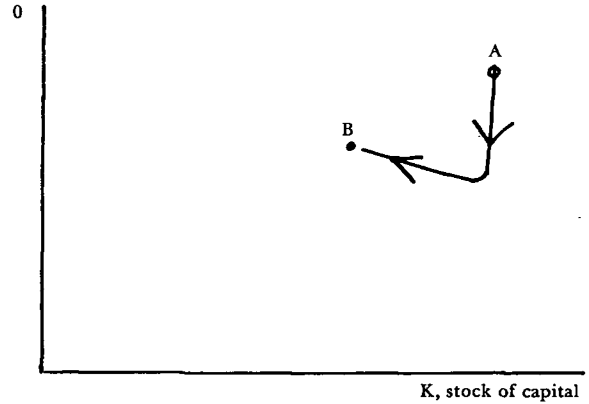
VI CONCLUSIONS AND QUALIFICATIONS

Conventional wisdom has it that a higher rate of interest should stimulate saving, squeeze investment and thereby improve the current account of the balance of payments and/or induce the exchange rate to appreciate (on top

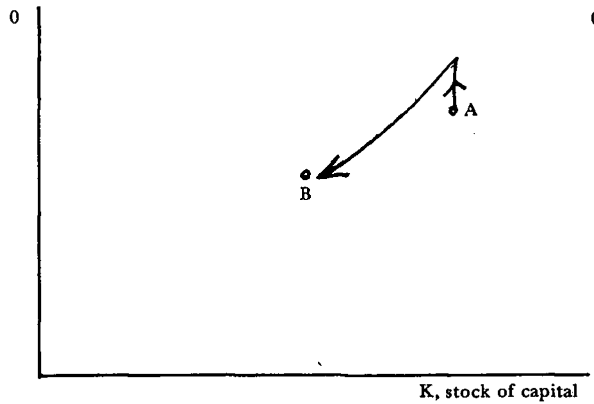
Figure 2: *Various Possible Time Paths for Capital and Domestic Output Following a Rise in the Nominal Rate of Interest*



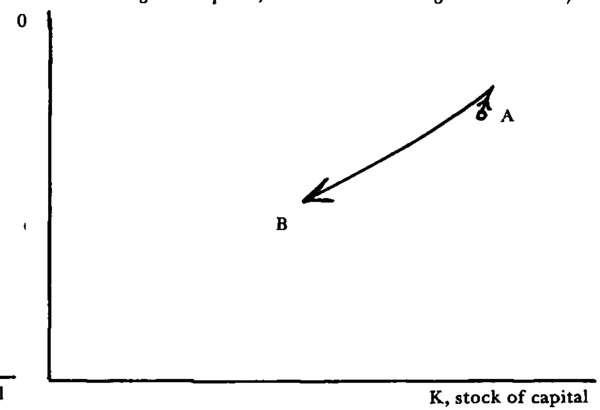
case a: the normal case: Q falls on impact, and Q and K both fall in the transition



case b: output overshooting (Q falls on impact by more than the long run requires, so it recovers during the transition)



case c: impact effect on Q positive, but Q and K both fall in the transition



case d: investment increases initially, but later K and Q decline of direct capital account effects pointing in that direction). It is also widely believed that the rate of monetary growth has negligible long-run real effects in either open or closed economies.

In the framework of the model proposed in this paper, all these propositions become doubtful, and three of them are definitely controverted. A higher rate of interest does not boost savings; if anything, it tends to squeeze them, temporarily, by inducing an excess supply of money. The short-run impact of a higher rate of interest upon investment is qualitatively ambiguous: it is just possible that the jump in consumption lifts the rate of profit enough to offset – however briefly – the rise in the cost of capital. If that happens, investment goes up initially. Far from improving the current account of the balance of payments, the higher rate of interest will almost certainly worsen it in the short run (it must do so if the country has negative net overseas assets) through a number of mechanisms: higher debt charges; pressure on the exchange rate, which may well result in lower competitiveness; the stimulus to consumer spending via excess money. Recent experience in Australia and the United Kingdom, where policies of high interest rates have failed to lower massive current account balance of payments deficits, or dent private sector spending, seem to corroborate these findings well. In the long run, a higher rate of interest will definitely lead to a lower real exchange rate (in order to improve competitiveness enough to provide the trade surplus that defray the extra overseas debt servicing costs). And there are real long-run effects from the policy of higher interest rates and lower monetary growth: an unambiguous decline in the domestic capital stock, domestic output, net overseas assets and national income.

These are among the paper's key findings. What should be said by way of qualification? The most serious limitation of the analysis, in the author's view, is that we have been looking only at the effect of *permanent* changes in the domestic nominal rate of interest. A temporary rise in the interest rate, subsequently undone, should leave no enduring legacy. The fall in capital and rise in debt will eventually be reversed. So will the effects it may have on the rate of inflation.

There are other respects in which the story is incomplete. No mention is made of fiscal policy, for example. The private and public sectors have been fused. Nothing has been said about financial intermediation (an increase in interest rates should push up broad money aggregates by inducing households to substitute out of narrow money). The way in which the forward premium on foreign exchange is related to net overseas debts is *ad hoc*. Real interest rates have not been linked to the real forces of technology, demography and thrift. The precise character of the sluggish adjustment postulated in money and factor markets has been assumed, not derived from analysis of information and optimisation that ought to precede it. Some of these shortcomings the author hopes to surmount in later work.

What this paper has aimed to do, however, is to enlarge the standard approach to open economy macroeconomic and exchange rate modelling by taking explicit account of several issues of both theoretical and practical importance. These include the need to move away from treating the money stock, or its growth rate, as a policy parameter, and instead to regard nominal interest rates as policy instruments; the need to endogenise "natural output" by incorporating explicit factor markets and a mechanism to drive the dynamics of the capital stock; the need to bring hysteresis and indexation into the behaviour of wages; and the need to allow for the possibilities of less than perfect international capital mobility and imperfect foresight in forward foreign exchange markets. We have seen that these various factors can be combined in a formal setting, and that the resulting model's implications differ considerably from those of standard models.

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