On the (Non)Equivalence of Money- and Exchange-Rate-Based Disinflation

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Abstract

An analytical dynamic general equilibrium model of a small open economy with tradeable and nontradeable sectors is constructed. Workers have monopoly power and wage setting is staggered. Initially, the economy is in an inflationary steady state with a floating exchange rate. We consider policies of disinflation by exchange rate stabilisation; such policies are parameterised by a parameter that relates the exchange rate chosen for stabilisation to the exchange rate obtaining immediately before the implementation of the policy. We consider the circumstances under which such policies are expansionary or contractionary, and also the question of whether there is equivalence between exchange-rate-based and money-based disinflation.

Keywords: Money-based disinflation, exchange-rate-based disinflation, staggered wage setting, intertemporal optimisation.

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1. Introduction

In this paper we explore the extent to which the so-called New Open Economy Macroeconomics can explain disinflation in open economies. This is the approach initiated by Obstfeld and Rogoff (1995), henceforth referred to as the 'Redux' paper, which combined intertemporal optimisation, imperfect competition and nominal rigidities in an open economy framework. (Lane, 2001, reviews the literature.) It can be argued that these elements are vital in explaining many macroeconomic phenomena. However, the Redux model can be criticised in assuming that price setting is synchronised, so that prices, which are fixed in the short run, adjust fully to their new steady-state levels in the period following a shock. A preferable approach recognises that prices are set by economic agents but also that not all prices are changed simultaneously. This leads to the idea of staggered price (or wage) setting, which we adopt here.

There have been some recent papers that introduce staggered price setting into Redux-type models, but there are, to our knowledge, no such published papers on disinflation policies.[1] However, the Redux approach with staggered price setting seems appropriate for analysing these effects, since it can explain changes in inflation in terms of agents' price setting decisions, and changes in economic activity as a result of changes in aggregate demand or supply (these being generated by agents' optimising behaviour). So our intention in this paper is to explore the effects of disinflation policies in a Redux model with staggered price setting.

The model we develop locates imperfect competition in the labour market, and the 'price' that is staggered is hence a wage rate. The economy is populated by a large number of agents who both supply labour to firms and consume, but since each agent provides a differentiated type of labour, it has monopoly power in its supply thereof. (Each type of labour can be thought of as provided by a trade union consisting of identical agents, but formally we assume that just one agent supplies each type.) There is staggered wage setting, as in Taylor (1979), modelled by assuming agents are divided into two groups, characterised by the time at which they change their wages. Consumption, real money holdings and wages are chosen to maximise an intertemporal utility function. There are two goods, tradeables and nontradeables, both of which are produced domestically using labour. Tradeables are bought and sold on the world market at a given world currency price, whereas a domestic goods market equilibrium condition determines the price and output of nontradeables.[2]

We assume that, initially, the economy is in a steady state with constant money growth and inflation and that, suddenly and unexpectedly, a permanent and credible disinflation policy is introduced. We confine our analysis to policies that are both permanent and credible. Although disinflation policies are sometimes not entirely credible and may be reversed, it is important, at least as a first step, to understand the effects a policy would have were it permanent and credible. Indeed, disinflation policies may sometimes be introduced when institutional reforms have made it possible to introduce such a policy credibly, and we consider it desirable to see how far the stylised facts can be explained without invoking imperfect credibility.

An ERB stabilisation policy pegs the exchange rate permanently.

In the theoretical literature on disinflation in open economies, Calvo and Végh (1993, 1994) have been particularly influential. Our model includes many of the same elements: intertemporal optimisation, staggered price setting, and a tradeables-nontradeables structure.

The rest of the paper is as follows: Section 2 presents the elements of the model, Section 3 discusses its solution, and Section 4 uses it to characterise the initial steady state before the stabilisation policy is adopted.

2. Structure of the Model

There are two output sectors: tradeables and nontradeables. Output of the nontradeable (tradeable) sector at time t is Y_{Nt} (Y_{Tt}). Subscripts N and T denote the nontradeable and tradeable sectors, respectively. Labour is the one variable factor of production, and both sectors draw on a common labour market. The production functions are:

$$Y_{Nt} = N_{Nt}^{\sigma}, \quad Y_{Tt} = N_{Tt}^{\rho}, \qquad 0 \le \sigma, \rho \le 1. \tag{1}$$

where N_{Nt}, N_{Tt} are composite labour inputs (defined below). In the remainder of the paper we focus on the special case where $\rho = 0$. In this case tradeable output is exogenous, and normalised to unity. Later we show that this assumption, together with others to be presented, implies the trade balance is always zero. This provides a benchmark version of the model that is relatively easy to analyse, and avoids the considerable complications caused by having to keep track of, and consider the implications of, a changing supply of foreign assets.

We assume two perfectly competitive goods markets, with flexible prices. In the tradeable sector, the law of one price holds, i.e. $P_{Tt} = E_t$, where P_{Tt} is the domestic currency price of tradeables and E_t is the nominal exchange rate, the domestic currency price of foreign exchange (we normalise the foreign currency price of tradeables to unity). In the nontradeables market, the price (P_{Nt}) adjusts to equate demand for, and supply of, such goods. In the labour market, there is a continuum of labour skills, indexed by $j \in [0,1]$. A household controls the supply of each type of labour and sets its money wage for two periods, subject to a demand function presented below. Each sector uses the full range of labour skills, and the aggregate demand for labour skill j is the sum of the demands of the two sectors.

As regards financial markets, there are two currencies, home and foreign, held only by the residents of the countries concerned. Money is demanded because of the liquidity services it provides. International borrowing and lending may take place between home and foreign private agents, by issuance or purchase of bonds. Since the initial outstanding stock of bonds is assumed to be zero, and there is no uncertainty after the policy change at time 0, their currency of denomination is immaterial. Perfect capital mobility means that domestic and foreign (gross) interest rates are linked by the usual interest parity condition, $I_t = I_t^*(E_{t+1}/E_t)$, where I_t (I_t^*) is the domestic (foreign) gross interest rate (asterisks denote foreign variables).

We turn now to the optimisation problem of individual agents. A typical firm in sector k ($k = N,T$) allocates its spending across labour types, where the wage of type j is W_{jt}, and the quantity of labour each household supplies to the typical firm is L_{kjt}, so as to minimise the cost of achieving a certain amount of a composite labour input given by:

$$N_{kt} = \left[\int_0^1 L_{kjt}^{(\varepsilon-1)/\varepsilon} dj \right]^{\varepsilon/(\varepsilon-1)}, \qquad \varepsilon > 1 \tag{2}$$

where the elasticity of technical substitution across labour types, ε, is the same in both sectors. Solving the problem gives a standard conditional demand function for labour type j:

$$L_{kjt} = N_{kt}(W_t / W_{jt})^{\varepsilon}, \tag{3}$$

where $W_t \equiv [\int_0^1 W_{jt}^{1-\varepsilon} dj]^{1/(1-\varepsilon)}$ is the wage index. Combined with (1), this then implies the following supply functions for nontradeable output:

$$Y_{Nt} = (W_t / \sigma P_{Nt})^{\sigma/(\sigma-1)}, \tag{4}$$

To write the aggregate demand function for labour of type j, we replace N_{kt} in (3) by:

$$N_t = N_{Nt} \tag{5}$$

In the limit as $\rho \to 0$, the function for Y_{Tt} in (4) reduces to $Y_{Tt} = 1$, while N_{Tt} as a function of W_t/P_{Tt} reduces to $N_{Tt} = 0$. Thus the benchmark version of the model, with tradeable output exogenous and tradeable employment zero, is nested within the general version.

Household j is representative of all households supplying labour skill j, obtaining utility from consumption of both types of goods, and from real balances; and disutility from supplying labour. As the sole supplier of type-j labour, it is a monopoly seller of labour. But since there is a continuum of households over $j \in [0,1]$, household j is 'small', and thus a price-taker, in every other market. Households' preferences over goods are represented by a Cobb-Douglas sub-utility function:

$$C_{jt} = C_{Njt}^{\alpha} C_{Tjt}^{1-\alpha}. \qquad (0 < \alpha < 1) \tag{6}$$

This is maximised subject to a given aggregate nominal expenditure, Ω_{jt}, defined by $\Omega_{jt} = P_{Nt}C_{Njt} + P_{Tt}C_{Tjt}$. The resulting demand functions are then:

$$C_{Njt} = \alpha\Omega_{jt} / P_{Nt} \qquad C_{Tjt} = (1-\alpha)\Omega_{jt} / P_{Tt} . \tag{7}$$

The indirect utility function for this problem can be written as $C_{jt} = \Omega_{jt}/P_t$, where P_t is the consumer price index:

$$P_t = P_{Nt}^{\alpha} P_{Tt}^{1-\alpha} / \alpha^{\alpha}(1-\alpha)^{1-\alpha} . \tag{8}$$

This spending allocation problem may now be embedded in household j's higher-level optimisation problem. Wage staggering is introduced, as in Taylor (1979), by assuming that households are divided into two sectors: A, comprising labour types $j \in [0,½)$; and B, with types $j \in [½,1]$. The money wage must be set for two successive periods at the same level. Households in sector A choose their wage in even periods, and solve the following problem:

$$\text{maximise} \quad U_j \;=\; \Sigma_{t=0}^{\infty}\beta^t \left[\delta \ln C_{jt} \;+\; (1-\delta)\ln(M_{jt} / P_t) \;-\; \eta L_{jt}^{\zeta}\right] \qquad (\beta < 1,\ \zeta \geq 1) \tag{9}$$

$$\text{s.t.} \qquad M_{jt-1} + I_{t-1}B_{jt-1} + W_{jt}L_{jt} + \Pi_t + S_t \;=\; P_tC_{jt} + M_{jt} + B_{jt} , \tag{10}$$

$$L_{jt} = (W_t / W_{jt})^{\varepsilon} N_t , \quad \text{for } t = 0,1,...,\infty; \tag{11}$$

$$W_{jt} = W_{jt+1} \equiv X_t , \quad \text{for } t = 0,2,...,\infty. \tag{12}$$

The problem of a sector-B household is the same, except that its wage is given at time 0 and is chosen in odd periods. The utility function in (9) shows that a household derives positive utility from consumption and from real money balances, but derives disutility from working; ζ is the elasticity of this disutility with respect to labour supplied. The LHS of (10) states that the household's resources in period t consist of its stocks of money (M_{jt-1}) and bonds ($I_{t-1}B_{jt-1}$) brought forward from the previous period, labour income earned in the period ($W_{jt}L_{jt}$), an equal share in firms' profits (Π_t), and a lump-sum subsidy from the government (S_t). These resources are allocated between consumption, money balances and bond holdings, as shown on the RHS. Equation (11) is the demand function for labour of type j, derived above, and equation (12) the wage-setting constraint, implying newly set wages obtain for two periods; we denote the ‘new’ wage by X_t.[3] Agents are assumed to have rational expectations.

We derive the following first-order conditions for the above optimisation problem:

$$C_{jt+1} = \beta[I_t P_t / P_{t+1}]C_{jt}\,, \tag{13}$$

$$M_{jt} / P_t = [(1-\delta)/\delta]C_{jt}I_t /(I_t - 1)\,, \tag{14}$$

$$X_t = \frac{\varepsilon}{\varepsilon - 1}\frac{\eta\zeta}{\delta}\frac{L_{jt}^{\zeta} + \beta L_{jt+1}^{\zeta}}{L_{jt} / P_t C_{jt} + \beta L_{jt+1} / P_{t+1} C_{jt+1}}\,. \tag{15}$$

The first two equations are the optimality conditions for intertemporal consumption choice and money holding, respectively. The third gives the new wage as a mark-up ($\varepsilon/(\varepsilon\text{-}1) > 1$) over a weighted average of the two wages which would apply within each period were the labour market competitive and not subject to the constraint that the wage is fixed for two periods.

The third type of agent in the model is the government, whose role is to determine the growth rate of the money supply, which it does by means of lump-sum subsidies to households. The government’s budget constraint is hence:

$$S_t = M_t - M_{t-1}\,. \tag{16}$$

We now turn to the market equilibrium conditions. The aggregate demand for money can be found by summing the individual demands, given by (14), across all households j. Denoting aggregate values by dropping the j subscript (i.e., $C = \int_0^1 C_j dj$, $M = \int_0^1 M_j dj$), and treating M_t as the government-determined supply, the equilibrium condition is then:

$$M_t / P_t = [(1-\delta)/\delta]C_t I_t /(I_t - 1)\,. \tag{17}$$

Market clearing for nontradeables requires that supply as determined by (4) should equal demand as determined by the aggregate version of (7):

$$(W_t / \sigma P_{Nt})^{\sigma/(\sigma-1)} \;=\; \alpha\Omega_t / P_{Nt}\,. \tag{18}$$

This determines P_{Nt} as an implicit function of (W_t,Ω_t). Domestic supply of tradeables is given by (4) with $P_{Tt} = E_t$ (as already noted) and may differ from domestic demand as determined by the aggregate version of (7), resulting in a trade surplus or deficit. We denote this by:

$$T_t = Y_{Tt} - C_{Tt}\,. \tag{19}$$

Over time, deficits must be balanced by surpluses (appropriately discounted) plus any initial net foreign assets. The national intertemporal budget constraint states this:

$$-I_{-1}B_{-1} = \Sigma_{t=0}^{\infty}[I_0 I_1 ... I_{t-1}]^{-1} P_{Tt} T_t\,. \tag{20}$$

B_{-1} (with no j subscript) denotes total initial private bond holdings. The home government issues no bonds, so B_{-1} is also the home country's initial net foreign assets. Equation (20) is derived from a No Ponzi Game condition, ensuring that indebtedness does not go to infinity. We start with this general formulation, although later we show that with exogenous tradeable output, the balance of trade is zero in every period.

In the labour market, each union chooses the wage that maximises its utility, taking into account the consequences of its decision for the amount of labour it can sell. The household's wage-setting condition, (15), does not make the dependence of labour demanded on the wage explicit. We can remedy this by substituting out L_{jt} and L_{jt+1} using (11) to obtain:

$$X_t = \left[\frac{\varepsilon}{\varepsilon - 1} \frac{\eta\zeta}{\delta} \frac{W_t^{\varepsilon\zeta} N_t^{\zeta} \; + \; \beta W_{t+1}^{\varepsilon\zeta} N_{t+1}^{\zeta}}{W_t^{\varepsilon} N_t / P_t C_{jt} \; + \; \beta W_{t+1}^{\varepsilon} N_{t+1} / P_{t+1} C_{jt+1}} \right]^{\frac{1}{1+\varepsilon(\zeta-1)}}. \tag{21}$$

Note that W_t, which appears in this, can be expressed as:

$$W_t = [\tfrac{1}{2} X_t^{1-\varepsilon} + \tfrac{1}{2} X_{t-1}^{1-\varepsilon}]^{1/(1-\varepsilon)}\,. \tag{22}$$

This follows from the formula for the wage index and the facts (see below) that $W_{jt} = X_t$ for all j in sector A, $W_{jt} = X_{t-1}$ for all j in sector B (when t is even; the sectors are reversed when t is odd). A necessary last step in elaborating the expression for X_t is to relate C_{jt} to aggregate C_t. Since there is symmetry amongst the preferences and constraints of households, and since we henceforth assume that all households start with common asset stocks, it is clear that $C_{jt} = C_{kt}$, $W_{jt} = W_{kt}$ for any j,k in the same sector. We now in addition assume that $C_{jt} = C_{kt}$ for any j,k in *different* sectors. This can be justified by assuming complete domestic asset markets, allowing agents to insure against shocks that would affect agents in different sectors differently because of the staggering structure. Under these conditions P_tC_{jt}, which appears in (20), can be equated to Ω_t, the average (and aggregate) nominal consumption level.

3. General Equilibrium

To study the model's properties, we take a log-linear approximation of its equations around the zero-inflation steady state (ZISS). This is a standard procedure (see, for example, Woodford, 2003, p.79) and is acceptable provided the rate of inflation is not too large. Note that the reference steady state (whose values we denote by an R subscript) is not the same as the initial steady state. As we are studying disinflation policies, we assume that the economy is initially in a constant-inflation steady state (CISS). Also, we assume that net foreign assets are zero both initially and in the reference steady state (i.e., $B_{-1} = B_R = 0$), so the trade balance is also zero (since there are then no net international interest receipts or payments which could sustain a permanent non-zero trade balance).

The log-linearised equations are given below. The derivation of these equations (where it is at all complex), as well as some other technical material, is given in a Technical Appendix.[4] Notationally, with one or two exceptions to be noted, lower-case symbols represent log-deviations of variables from their reference steady-state values, so $v_t \equiv \ln(V_t/V_R)$, where V_t denotes any variable, and V_R its value in the reference steady state.

$$\mu_{t+1} \equiv m_{t+1} - m_t \tag{23}$$

$$\omega_t \equiv p_t + c_t \tag{24}$$

$$z_t \equiv m_t - \omega_t \tag{25}$$

$$z_t = -[\beta/(1-\beta)]i_t \tag{26}$$

$$z_{t+1} = (1/\beta)z_t + \mu_{t+1} \tag{27}$$

$$e_{t+1} - e_t = i_t \tag{28}$$

$$y_{Nt} = [\sigma/(1-\sigma)](p_{Nt} - w_t) \qquad y_{Tt} = 1 \tag{29}$$

$$c_{Nt} = \omega_t - p_{Nt} = y_{Nt} \qquad c_{Tt} = \omega_t - e_t \tag{30}$$

$$p_t = \alpha p_{Nt} + (1-\alpha)e_t \tag{31}$$

$$y_t = \alpha y_{Nt} + (1-\alpha)y_{Tt} \tag{32}$$

$$\tau_t = y_{Tt} - c_{Tt} \tag{33}$$

$$0 = \Sigma_{t=0}^{\infty}\beta^t \tau_t \tag{34}$$

$$x_t = \frac{1}{1+\varepsilon(\zeta-1)}\left\{\frac{1}{1+\beta}\left[\omega_t + \varepsilon(\zeta-1)w_t + (\zeta-1)n_t\right] + \frac{\beta}{1+\beta}\left[\omega_{t+1} + \varepsilon(\zeta-1)w_{t+1} + (\zeta-1)n_{t+1}\right]\right\} \tag{35}$$

$$w_t = \tfrac{1}{2}x_t + \tfrac{1}{2}x_{t-1} \tag{36}$$

$$n_t = (1/\sigma)y_{Nt} \tag{37}$$

$$v_t \equiv x_t - m_t \tag{38}$$

$$q_t \equiv e_t - m_t. \tag{39}$$

Equations (23)–(25) define the monetary expansion rate (μ_t), nominal consumption (ω_τ) and money demand per unit of consumption (z_t), respectively. The negative relationship of z_t to the nominal interest rate, shown in (26), comes from the aggregate version of the first-order condition, (14). Equation (27) shows how z_t evolves over time and is obtained by combining the aggregate versions of first-order conditions (13) and (14); equation (28) is the uncovered interest parity condition under the assumption (which we make henceforth) that the log-deviation of the foreign interest rate is zero. Turning to goods markets, the sectoral supply functions (29) are logged versions of those in (4) above. Likewise, (30) gives the two sectoral demand functions, which depend on nominal consumption and the relevant price; the nontradeable goods market equilibrium condition is also included. The consumer price index, (31), is obtained by taking logs of (8). Real gross domestic product is defined in levels as $Y_t \equiv (P_{Nt}Y_{Nt} + P_{Tt}Y_{Tt})/P_t$. When loglinearised with coefficients evaluated in a balanced-trade steady state, we obtain (32). We cannot derive a *loglinear* approximation for the trade balance, as the log-deviation of the trade balance from zero is undefined. Instead we define τ_t as T_t/Y_{TR}, the 'levels' trade balance scaled by tradeables output in the reference steady state. It is then related to the log-deviations of tradeables production and consumption by (33). On the assumptions that both initial net foreign assets and the trade balance are zero in the reference steady state, (34) can be derived as a log-linearised version of (20). Turning to the labour market, the wage-setting equation (21) becomes (35) upon loglinearisation, and the wage index formula (22) becomes (36). Aggregate employment, n_t, is written as a weighted average of the two sectors' outputs, as in (37). We also define two new variables, v_t and q_t; these are the new wage, x_t, and the exchange rate, e_t, respectively, both normalised by m_t (see (38) and (39)); these variables are constant in a CISS, and this facilitates some of the analysis.

There is no assumption in the above set of equations about the exchange rate regime. If we assume that the monetary growth rate is constant, then we would be in a flexible rate world. On the other hand, an assumption of a constant exchange rate would give us a fixed exchange rate economy. The money supply would then be determined endogenously.

It is useful to reduce the wage setting equation to a version that is easier to manipulate. This gives rise to

$$\frac{(1-\gamma)}{(1+\beta)(1+\gamma)}x_{t-1} + \frac{\beta(1-\gamma)}{(1+\beta)(1+\gamma)}x_{t+1} + \frac{2\gamma}{(1+\gamma)}\omega = x_t \tag{40}$$

The solution is given by

$$x_t = x + (x_{-1} - x)\lambda^{t+1}. \tag{41}$$

Here x is the steady-state level of the new wage, x_{-1} is the value of the new wage in period -1 and λ is the stable eigenvalue of the characteristic equation, given by

$$\lambda = \frac{(1+\beta)(1+\gamma) - \sqrt{(1+\beta)^2(1+\gamma)^2 - 4\beta(1-\gamma)^2}}{2\beta(1-\gamma)}, \tag{42}$$

where $\gamma = \zeta / \{1 + \varepsilon(\zeta - 1)\}$. We are considering a policy change that is implemented at time t = 0; this accounts for the presence of x_{-1} in equation (41); this is the equation that governs the movement of x_t from the time the policy is implemented at time 0.

4. The Constant Inflation Steady State with Zero Initial Net Foreign Assets

Suppose we are in an initial steady state with monetary expansion rate (and hence inflation rate) μ. Then this steady state is characterised by the following equations (we omit the derivations):

$$q_I = (\beta/(1-\beta))\mu \tag{43}$$

$$v_I = \left[\frac{1}{2} + \frac{\beta}{1-\beta} - \frac{1}{2}\frac{(1-\beta)}{(1+\beta)\gamma}\right]\mu \tag{44}$$

$$y_{NI} = \frac{\sigma(1-\beta)}{2(1+\beta)\gamma}\mu \tag{45}$$

$$(e - p_N)_I = \frac{\sigma(1-\beta)}{2(1+\beta)\gamma}\mu \tag{46}$$

$$z_I = \left(\beta/(\beta-1)\right)\mu \tag{47}$$

$$i_I = \mu \tag{48}$$

A subscript I denotes the value of variables in the initial steady state. The equations give the values of the variables that are constant in the CISS. Nominal variables such as the exchange rate, price of nontradeable goods and the money supply will of course increase at the rate of growth of the money supply in this steady state. So the exchange rate deflated by the money supply ($q_t = e_t - m_t$) and the reset wage deflated by the money supply ($v_t \equiv x_t - m_t$) are both constant in this steady state.

One noteworthy feature of this steady state is the positive relationship between output and inflation. Higher monetary growth means a higher rate of inflation, and higher output of nontradeables (and hence of total output) as can be seen from equation (45). This is an effect that has featured in a number of papers. With wage staggering and inflation, a wage setter sets a wage for two periods as a weighted average of the wages he would have set in each of the two periods were he not constrained to set the same wage in both periods (call these the optimal wages for each period). The more the future is discounted, the greater the weight he will put on the first-period optimal wage and hence the lower the wage will be. Also, the faster the rate of inflation, the more the optimal wage increases between periods, so higher inflation tends to lower the average wage in the economy, and this tends to raise output and employment. The effect disappears as β, the discount term, tends to unity, as we would expect. Also, from (43), inflation tends to raise the relative price of tradeable goods. Since inflation tends to raise the output of nontradeable goods, and the output of tradeables is constant, market clearing requires a lower relative price of nontradeables.

5. Exchange-Rate-Based Disinflation

We suppose that at time $t = 0$, the exchange rate is pegged credibly and permanently at a level $\bar{e}$. We note that, since the exchange rate is credibly fixed, the interest parity condition implies that $i_t = 0$ for all $t \geq 0$. So, from (26), z_t is zero from $t = 0$ onwards, and, from (27), monetary expansion μ_t (now endogenous) is also zero from $t = 1$ onwards and m_t hence jumps to its new level at time 0 and stays there. Since $z_t = 0$, $\omega_t = m_t = m$ for all t greater than or equal to zero (variables without subscripts denote steady-state values). Also, simple calculations show that the trade balance in any period is given by $\tau_t = \bar{e} - m$. So the trade balance is time invariant; since initial foreign indebtedness is zero, the condition that the trade is balanced intertemporally (equation (34)) implies that the trade balance is zero for all $t \geq 0$. This also implies that $m = \bar{e}$. So there are a number of variables that jump immediately to their steady-state levels and stay there. So we have

$$i_t = i = z_t = z = \tau_t = \tau = 0 \text{ and } \omega_t = \omega = m_t = m = \bar{e}. \quad (49)$$

So the model possesses a kind of neutrality. A one percentage increase in the exchange rate peg increases the money supply by the same amount. However, a number of variables, notably the new wage and some other variables linked to it, do not adjust immediately to the new steady state, but instead follow a period of adjustment. It is useful, first of all, to calculate the steady-state values of these variables. From the wage setting equation, we derive $x = \bar{e}$; we also have $w = p_N = \bar{e}$ and $y_N = e - p_N = 0$.

Impact Effect on Nontradeable Output.

However, the main variable we are interested in, y_{Nt} does not jump immediately to its steady state value. To work out what happens to it, we first of all combine (29) and (30) to derive:

$$y_{Nt} = \sigma(\omega_t - w_t) \quad (50)$$

What happens to nontradeable output depends on what happens to nominal consumption and to the wage. If the increase in the former exceeds that of the latter, the effect on demand for nontradeables exceeds the effect on supply (speaking loosely) and output rises. We are interested in the effect of the policy on output at time zero compared with the initial level of output (that in the inflationary steady state, which can be written:

$$y_{N0} - y_{NI} = \sigma\left[(\omega_0 - \omega_{-1}) - (w_0 - w_{-1})\right] \quad (51)$$

This equation states that output growth depends on the difference between nominal consumption growth and the increase in wages. To sign this expression, we first of all note that ω_{-1} can be written (using (25) and (47)) as $m_{-1} + (\beta/(1-\beta))\mu$. It follows that

$$\omega_0 - \omega_{-1} = \bar{e} - m_{-1} - (\beta/(1-\beta))\mu \quad (52)$$

We also have (from (39) and (43)):

$$m_{-1} = e_{-1} - (\beta/(1-\beta))\mu \tag{53}$$

So combining (52) and (53) we have

$$\omega_0 - \omega_{-1} = \overline{e} - e_{-1}. \tag{54}$$

We also note that

$$w_0 - w_{-1} = (x_0 + x_{-1})/2 - (x_{-1} + x_{-2})/2 = (x_0 - x_{-1})/2 + \mu/2. \tag{55}$$

This uses the fact that $x_{-2} = x_{-1} + \mu$ in the initial steady state. We now need to substitute out $x_0 - x_{-1}$. We do this, we use (41):

$$x_0 - x_{-1} = (1-\lambda)(x - x_{-1}). \tag{56}$$

A certain amount of further manipulation establishes that

$$x_0 - x_{-1} = (1-\lambda)\left(\overline{e} - e_{-1} - \left[1 - \frac{(1-\beta)}{(1+\beta)\gamma}\right]\mu/2\right) \tag{57}$$

Using this in (55), we thus derive

$$w_0 - w_{-1} = \frac{1}{2}\left[(1-\lambda)\left(\overline{e} - e_{-1} + \frac{1-\beta}{2(1+\beta)\gamma}\mu\right) + \left(1 - [1-\lambda]/2\right)\right]\mu. \tag{58}$$

We can substitute this into (51), using (54), to derive an expression for the initial change in output due to the policy:

$$y_{N0} - y_{NI} = \sigma\left\{[1-(1-\lambda)/2](\overline{e} - e_{-1} - \mu/2) - \frac{(1-\lambda)(1-\beta)}{4(1+\beta)\gamma}\mu\right\}. \tag{59}$$

It seems, then, that the choice of the fixed exchange rate, or, more precisely, the extent to which the fixed exchange rate is a depreciation from the previous period's exchange rate, is crucial in determining whether, and the extent to which, the policy results in an expansion. Suppose the policy is chosen as follows:

$$\overline{e} = e_{-1} + \chi\mu. \tag{60}$$

χ therefore parameterises the extent of (initial) exchange rate depreciation embodied in the policy. If $\chi = 0$, then the peg fixes the exchange rate at its level the previous period. If $\chi = 1$, then the policy fixed the exchange rate at the level it would have reached in any case in the period when it is introduced; any effects of the policy must, therefore, be because it changes expectation of the future level of the exchange rate. Substituting (60) into (59), we obtain:

$$y_{N0} - y_{NI} = \sigma\left\{\left[1-(1-\lambda)/2\right](\chi - 1/2) - \frac{(1-\beta)(1-\lambda)}{4(1+\beta)\gamma}\right\}\mu \tag{61}$$

It is clear that if $\chi \leq$ ½, then output falls on impact. It is possible to show that if $\chi = 1$, then output increases. An explanation behind the positive connection between χ and output growth is that as the depreciation of the exchange rate increases, nominal consumption growth increases proportionately (see (54)), but nominal wage inflation increases less than proportionately. The explanation behind the less than proportionate adjustment of wage inflation is that expectations of lower inflation in the future due to the exchange rate policy induce wage setters to moderate wage claims. By setting (61) to zero we can derive a critical value of χ (χ_A) at which output growth will be zero:

$$\chi_A = \frac{1}{2} + \frac{(1-\lambda)(1-\beta)}{4\left[1-(1-\lambda)/2\right](1+\beta)\gamma}. \tag{62}$$

It is clear that as β tends to unity (the discount rate tends to zero), the value of χ for which the effect on output is zero tends to ½ from above.

Impact Effect on the Real Exchange Rate

We are also interested in the impact effect of the policy on the real exchange rate; this is given by

$$(e-p)_0 - (e-p_N)_{-1} = \left(\overline{e} - e_{-1}\right) - (p_{N0} - p_{N(-1)}) \tag{63}$$

From (29) and (30) we have

$$p_{Nt} = (1-\sigma)\omega_t + \sigma w_t \tag{64}$$

So

$$p_{N0} - p_{N(-1)} = (1-\sigma)(\omega_0 - \omega_{-1}) + \sigma(w_0 - w_{-1}) \tag{65}$$

Using (54), we derive

$$(e - p_N)_0 - (e - p_N)_I = \sigma\left[\left(\omega - \omega_{-1}\right) - \left(w_0 - w_{-1}\right)\right] \tag{66}$$

But this is exactly the same as (51). So the real exchange rate depreciates on impact if and only if the effect of the ERB stabilisation policy is expansionary. It follows that a real appreciation combined with an initial boom is impossible in our model.

<u>Impact Effect on Inflation</u>

Suppose we want the policy to halt inflation, the question arises when, precisely, does inflation cease. There are two possibilities that come to mind. One is between periods -1 and 0; the second is between period 0 and 1. A second question is how to measure inflation. Let us start by considering wage inflation. We first of all note from equation (55) that

$$w_0 - w_{-1} = (1/2)\{x_0 - x_{-1} + \mu\} \tag{67}$$

It follows that a policy that sets this to zero (i.e., one that sets wage inflation to zero immediately) needs to set x_0 to x_{-1} - μ.. This means a reduction in the new wage at time zero (compared with the previous period's new wage). Further calculations reveal that keeping wage inflation to zero indefinitely (i.e., setting $w_t = w_{t-1}$ for all $t \geq 0$) requires that the new wage in odd periods be set equal to x_{-1} and the new wage in even periods to x_{-1} - μ.. This means that real wages between the two sectors will fluctuate permanently, even in the zero inflationary steady state; it also means that the group that sets its wage in even periods will be permanently worse off compared with the other group. It seems that this may not be a sensible way of disinflating. It is also impossible to implement in our model. So let us consider instead a policy that sets $w_1 - w_0$ to zero. From (36) we have

$$w_1 - w_0 = \left(x_1 - x_0\right)/2 + (x_0 - x_{-1})/2. \tag{68}$$

Using (41) for both x_1 and x_0 , we obtain

$$x_1 - x_0 = \lambda(1-\lambda)(x - x_{-1}) \tag{69}$$

It follows that

$$w_1 - w_0 = (1+\lambda)(1-\lambda)(x - x_{-1})/2. \tag{70}$$

So setting wage inflation to zero in the first period, we need to choose an exchange rate policy that sets $x = x_{-1}$. From (56) and (57) we have

$$x - x_{-1} = \overline{e} - e_{-1} - \left[1-(1-\beta)/(1+\beta)\gamma\right]\mu/2. \tag{71}$$

Using (60), the value of χ that sets (71) to zero is hence

$$\chi_C = \frac{1}{2} - \frac{(1-\beta)}{2(1+\beta)\gamma} \tag{72}$$

This may be compared with (62). It is apparent that, provided that $\beta < 1$, that $\chi_A > \chi_C$. There are hence three possibilities. If $\chi > \chi_A$, then the exchange rate disinflation brings an expansion of output and inflation persistence. If $\chi_A > \chi > \chi_C$, then the policy results in a fall in output, yet inflation is still persistent. For $\chi < \chi_C$, then output contracts, but inflation overshoots – that is, it initially becomes negative before approaching its new steady state level of 0 from below. We would also note that as β tends to unity (i.e., the discount rate tends to zero), χ_A tends to χ_C; so the possibility of a slump coinciding with inflation persistence is due to the fact that agents discount the future.

6. Money-based Disinflation

It is straightforward to show (see below) that exchange-rate-based disinflation is typically accompanied by an increase in the money supply – the transition to a lower rate of inflation increases the demand for money, and this is accommodated by the central bank in a fixed exchange rate regime. We might ask whether there is a value of χ for which monetary growth ceases. From (43) we have $q_1 = e_{-1} - m_{-1} = \left(\beta/(1-\beta)\right)\mu$; also, from (49) $m = \bar{e}$, so

$$m_0 - m_{-1} = \bar{e} - e_{-1} + \beta\mu/(1-\beta) = \left(\chi + \frac{\beta}{1-\beta}\right)\mu\,. \tag{73}$$

So any nonnegative value of χ is associated with an increase in the money supply; this explains the 'remonetisation' that is characteristic of exchange-rate based disinflations.

If the critical value of χ at which monetary growth ceases ($m_0 - m_{-1} = 0$) is denoted χ_E, then we have

$$\chi_E = \frac{-\beta}{1-\beta}\,. \tag{74}$$

This is negative, and may be large in absolute value. This illustrates an equivalence, of sorts, between money and exchange rate based disinflation.

7. Conclusions

We have sought to extend the 'New Open Economy Macroeconomics' approach to the explanation of disinflation experiences of small open economies, especially with the case of developing countries in mind.

There are a number of extensions of the analysis that might be suggested:

(1) Gradual disinflation. Such a policy would appear more realistic; we would expect it to strengthen the initial boom under ERB disinflation, by increasing the scope for the wage slowdown to precede the demand slowdown.

(2) Policy reversal. Expectations of eventual abandonment of the policy play a central role in some analyses of disinflation, particularly Calvo and Végh (1993, 1994). Including this might explain an initial expansion of demand under ERB disinflation.

(3) Learning. We have assumed that agents have full information about the new policy. However, in reality there is more commonly imperfect information and a need to learn about the new policy. Extending the model in this way might, in particular, generate more sluggish adjustment of inflation in response to MB disinflation.

(4) Investment and durable goods. There are no such goods in our model. Changes in durable purchases have been argued to be important in explaining the initial boost to demand and the trade deficit in ERB disinflations (De Gregorio et al., 1998).

(5) Utility. Our assumption that the intertemporal utility function is logarithmic has played a helpful part in enabling us to solve the model analytically, ensuring that nominal consumption immediately jumps to its new level when the reform is introduced, and stays there. A different utility function, however, might enable the model to generate some consumption dynamics post-reform, and this might be useful in explaining, for example, the boom-bust cycle under ERB disinflation.

Although pursuing these extensions would be worthwhile, this must be done elsewhere; we believe that the model as it is gives a considerable number of insights, and illustrates the strengths of the New Open Economy Macroeconomics approach.

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ENDNOTES

1. For example, Bergin and Feenstra (2001), Kollmann (2001), Chari, Kehoe and McGrattan (2002), Clarida et al. (2002) and Andersen and Beier (2003) introduce staggered pricing into Redux-type models. In an unpublished paper Senay (2000) looks at disinflation in such a model but does not explain the initial boom under ERB disinflation.

2. A related small open economy model, but with an importables-exportables structure, is constructed in Fender and Rankin (2003). In that paper changes in the level of the money supply are the main concern, whereas here the focus is on changes in its rate of growth.

3. The lack of the *j* subscript anticipates the point that all households in sector *A*, though acting independently, will choose the same new wage, as will be seen below.

4. Available at:

http://www2.warwick.ac.uk/fac/soc/economics/staff/faculty/rankin/wp/disinf.techappxii.pdf