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International Monetary Policy to Promote Economic Recovery

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I. Introduction

The purpose of monetary policy is to ensure that money doesn't matter. There are three reasons why money may matter for real economic performance. First, to the extent that monetary growth is causally connected with inflation, insufficient or excessive money growth (even if fully predictable) will cause the actual inflation rate to differ from the optimal one. The optimal inflation rate is the one that produces satiation with costlessly produced non-interest-bearing money balances. It is associated with a zero nominal interest rate. If the real interest rate is positive, the optimal inflation rate will be negative. This result is both well-known and pratically uninteresting. Equally obvious is the second reason why money may matter. Monetary policy should not introduce extraneous, unnecessary noise into the economic system. Even in an idealized flexible price economy, randomization of monetary policy will be costly if the realization of the stochastic money supply process are not immediately and fully observable by private agents. Adopting non-stochastic policy rules is of course quite consistent with the specification of the monetary policy rule as a known, contingent (conditional or flexible) function of current or past observables.

The third reason why money may matter hinges on the presence of nominal inertia or stickiness in the behaviour of wages and/or prices. Given such "Keynesian" features, tight monetary policy will not result in a transition to a lower price level or inflation rate at full employment. Even if in the long run, reductions in money growth are associated with equal reductions in the rate of inflation, the real-time transition or traverse may involve persistent and significant periods of excess capacity and involuntary unemployment. Well-designed monetary policy minimizes these output or unemployment costs of achieving a sustained and sustainable reduction in the rate of inflation. To minimize the "sacrifice ratio,"[1] it will often be beneficial to use the instruments of fiscal policy in conjunction with monetary policy. The two are of course linked through the government's budget identity, but there are infinitely many combinations of changes in taxes, spending, borrowing and external financing that are consistent with a given sustained change in the rate of monetary growth. Alternative complementary fiscal packages may have greatly different implications both for the adjustment process and for the nature of the ultimate equilibrium.

In an open economy, external policies and events will alter the current and anticipated future constraints faced by the domestic policy maker. Thus, under a credible fixed exchange rate regime, the domestic rate of inflation cannot be systematically higher or lower than the world rate of inflation. Foreign monetary and fiscal policy actions affect the domestic economy through goods markets (e.g., by altering world demand for home country traded output), through interest rate linkages and, in the case of an endogenous exchange rate regime, through spot and forward exchange markets. Freely floating exchange rates do not, except in a very special and practically unimportant cases, insulate a country from external real and financial shocks, nor do they prevent the spillover of domestic disturbances into the rest of the world. Only the most naive zero-capital mobility, trade balance view of exchange rate determination could lead one to believe that "decoupling" through exchange rate flexibility is an option.

[1] The sacrifice ratio is the cumulative undiscounted net output or unemployment cost of achieving a one percent steady-state reduction in the inflation rate.

The existence of mutual spillovers is not by itself sufficient for policy coordination. It could be the case that policy actions are properly "priced" so that even decentralized, non-cooperative policy design leads to Pareto-efficient outcomes. Merely to state this possibility is almost sufficient to refute it. The two main reasons are that market prices are not sufficient indices of marginal social value and that national policy makers are not sub-atomistic, competitive agents. Even in highly abstract, idealized representations of competitive, market-clearing economies such as the overlapping generations model, the incompleteness of the set of markets (reflecting, e.g., the difficulties one is likely to encounter when attempting to make binding private contracts with the dead and the unborn) may prevent prices in the markets that do exist from being accurate social shadow prices. Other reasons for the non-existence of a complete set of Arrow-Debreu markets are adverse selection and moral hazard. The insufficiency of market prices for harmonizing non-cooperative policy actions is especially serious when labor, goods or credit markets are in disequilibrium (or in non-Walrasian equilibrium) and non-price rationing occurs. In addition, the non-atomistic nature of national policy makers means that they do not necessarily treat market prices or other policy makers' actions as parametric when designing policies that are optimal from a national perspective. Government behavior in countries other than Andorra, Lichtenstein, Luxembourg, etc., is more properly viewed as a non-cooperative dynamic game against other governments and against markets with anticipating (even if competitive) private agents. In these markets some governments will be large participants.

To assert that, given externalities and non-competitive behavior by governments, there exists scope for global welfare improving policy coordination schemes that move the world economy closer to the contract curve, is not to argue that there may not also be many "cooperative" schemes that will result (or in the past have resulted) in reduced global welfare. Nor does the merely qualitative proposition that there exist welfare improving arrangements for international cooperation and coordination deny the possibility that the quantitative significance of the improvement could be slight and/or highly uncertain. The task of quantifying the fruits of international policy coordination is an important one but lies beyond the scope of this paper. In what follows I propose to study the design of efficient disinflationary policies in an interdependent economic system. The formal vehicle for this analysis is a small and simple analytical two-country macroeconomic rational expectations model.[2] I will start with the case of the flex-price New Classical wonderland in which credibility of monetary policy is necessary and sufficient for costless disinflation. The consequences of successive concessions to realism can then be traced in a relatively straightforward manner. The consequences of unilateral and coordinated policy design and implementation are emphasized throughout.

In what follows, "first-best" policies which eliminate inflation at a stroke without output or unemployment costs will almost always exist, and can be derived by inspection. It will therefore not be necessary formally to specify an objective functional penalizing deviations from zero inflation and from full employment or capacity output. The paper does not deal at all with the "incentive-compatibility" of the first-best policies, i.e., with whether these policies are time-consistent.

[2]The analysis relies heavily on the single-country analysis of efficient disinflationary policy in Buiter and Miller [1983b]. The two-country model is a slight extension of the model used in Miller [1982].

II. A Model in Which Credibility of Monetary Policy Is Necessary and Sufficient for a Costless Sustained Reduction in Inflation

The various models to be considered in this paper will differ from each other only as regards the specification of the inflation process. They will have a common set of portfolio balance equations and output market equilibrium equations. These are given in equations (1)-(7). Starred variables relate to the foreign country, unstarred variables to the home country. All variables except for interest rates, measures of fiscal stance and tax rates are in logarithms. The notation is as follows. m is the nominal stock of money, p the consumer price index, y real output, r the short nominal interest rate, e the nominal exchange rate, measured as the number of units of home currency per unit of foreign currency, f is an index of fiscal stance, v the value added deflator at factor cost, τ_i the indirect tax rate, ℓ a measure of real money balances, c international competitiveness or the real exchange rate and μ the instantaneous proportional rate of growth of the nominal money stock.

All parameters are non-negative. $\dot{x}$ denotes the right-hand side time derivative of x. Expectations are formed rationally. E_t denotes the conditional rational expectation operator at time t.

(1a) $$m - p = ky - \lambda r$$

(1b) $$m^* - p^* = k^*y^* - \lambda^*r^*$$

(2a) $$y = -\gamma(r - E_t\dot{p}) + \delta c + \varepsilon(m-p) + \beta f + \eta y^*$$

(2b) $$y^* = -\gamma^*(r^* - E_t\dot{p}^*) - \delta^*c + \varepsilon^*(m^* - p^*) + \beta^*f^* + \eta^*y$$

(3) $$E_t\dot{e} = r - r^*$$

(4a) $p = \alpha v + (1-\alpha)(e + v^*) + \tau_i , \quad 0 < \alpha < 1$

(4b) $p^* = \alpha^* v^* + (1-\alpha^*)(v-e) + \tau_i^* , \quad 0 < \alpha^* < 1$

(5a) $\ell \equiv m - v$

(5b) $\ell^* \equiv m^* - v^*$

(6) $c \equiv e + v^* - v$

(7a) $\mu \equiv \dot{m}$

(7b) $\mu^* \equiv \dot{m}^*.$

Equations (1a) and (1b) are standard domestic and foreign money demand functions. Demand for domestic output, in (2a) is a decreasing function of the real interest rate and an increasing function of competitiveness, of real money balances, of the degree to which fiscal policy is expansionary, as measured by f, and of the foreign level of economic activity. The demand for foreign output is specified analogously in (2b).

The money stock is to be interpreted as narrow money, say the monetary base. Domestic money is held only by domestic residents, for domestic transactions purposes. There is no direct currency substitution. This seems reasonable as domestic money is dominated as a store of value by short domestic bonds and foreign money by short foreign bonds. Between these two interest-bearing assets there is perfect substitutability. Equation (3) represents uncovered interest parity, the outcome of perfect markets and risk-neutral speculative behavior. The consumer price index is a weighted average of the two national value added deflators as shown in (4a) and (4b). Indirect taxes can drive a wedge between factor costs and market prices.[3]

[3] The absence of explicit consideration of the government budget identity is justified as follows. In natural units (using upper case letters) the domestic output market equilibrium condition and public sector budget identity (under a freely floating exchange rate regime) can be written as follows:

In the New Classical wonderland of this section, output is always equal to its exogenous capacity or full employment level, i.e.,

(8a) $$y = \bar{y}$$

(8b) $$y^* = \bar{y}^* .$$

What permits this is the perfect flexibility of the domestic and foreign price levels and (in the background) of domestic and foreign money wages. GDP deflators have the flexibility normally associated with the exchange rate and other financial asset prices. The domestic and foreign rates of inflation can be expressed as in (9a,b)

$$Y = F\left(r - E_t \frac{\dot{P}}{P}, \frac{EP^*}{P}, \frac{M}{P}, G, T, Y^*\right)$$

$$F_r < 0 ; F_C > 0 ; F_{M/P} \geq 0 ; F_G > 0 ; F_T < 0 , F_{Y^*} > 0$$

$$\frac{\dot{M}+\dot{B}}{P} \equiv G + \frac{rB}{P} - T .$$

G denotes exhaustive public spending on goods and services, T total taxes net of transfers. B is the nominal stock of government bonds. βf, the effect of fiscal policy on demand in equation (2a) is given by

$\frac{\partial \ln Y}{\partial G} dG + \frac{\partial \ln Y}{\partial T} dT$. Note that, if the balanced-budget multiplier is positive, then $F_G > |F_T|$.

I assume that as regards bond financing the domestic authorities throughout follow a "constant financial crowding out pressure" policy which consists in keeping constant the real stock of government debt B/P. The foreign authorities similarly keep B^*/P^* constant. Thus $\dot{B} = B(\dot{P}/P)$ and $\dot{B}^* = B^*(\dot{P}^*/P^*)$. Whether or not B/P and B^*/P^* are arguments in the money demand functions and/or the output demand functions, their constancy makes it unnecessary to consider them further. I am ignoring as of second-order importance the fact that domestic bonds may be held abroad and foreign bonds domestically. Let B^d denote domestic holdings of domestic government debt and B^f foreign holdings of domestic government debt. Then $B \equiv B^d + B^f$ and, by analogy, $B^* \equiv B^{*d} + B^{*f}$. The proper argument is domestic behavioral relationships is $b^d \equiv \frac{B^d}{P} + \frac{EB^{*d}}{P}$; for foreign behavioral the proper argument is $b^{*f} \equiv \frac{B^f}{EP^*} + \frac{B^{*f}}{P^*}$. Even if $\frac{B}{P}$ and $\frac{B^*}{P^*}$ are constant over time, b^d and b^{*f} could vary. If purchasing power parity (p.p.p.) held, then

(9a) $$\dot{p} = -\dot{\ell} + (1-\alpha)\dot{c} + \mu + \dot{\tau}_i$$

(9b) $$\dot{p}^* = -\dot{\ell}^* - (1-\alpha^*)\dot{c} + \mu^* + \dot{\tau}_i^* .$$

Equivalently (except at those instants at which "news" arrives), we can look at the expected rates of inflation given in (9'a) and (9'b):

(9'a) $$E_t\dot{p} = -[\lambda^{-1} + \gamma^{-1}\varepsilon]\ell + [(\lambda^{-1} + \gamma^{-1}\varepsilon)(1-\alpha) - \gamma^{-1}\delta]c + [\lambda^{-1} + \gamma^{-1}\varepsilon]\tau_i - \gamma^{-1}\beta f + (\lambda^{-1}k + \gamma^{-1})\bar{y} - \gamma^{-1}\eta\bar{y}^*$$

$\dot{b}^d + \dot{b}^{*f} = 0$. Without p.p.p., $\dot{b}^d + \frac{EP^*}{P}\dot{b}^{*f} = \left(\frac{\dot{E}}{E} - \frac{\dot{P}}{P} + \frac{\dot{P}^*}{P^*}\right)\left(\frac{EB^{*d} - B^f}{P}\right)$.
Even if total (global) real bond wealth doesn't change, a redistribution of a given total through current account deficits and surpluses (or through capital gains and losses) may change total demand for a country's output if the marginal propensity to spend out of bond wealth on that country's output differs between the two countries. I rule out any such "transfer effects" either on total spending or on spending on the individual countries' outputs.

Given our bond financing assumption, we can write

$$\mu \equiv \frac{\dot{M}}{M} = \frac{P}{M}\left[G + \left(r - \frac{\dot{P}}{P}\right)\frac{B}{P} - T\right].$$

Given M/P , G and $\left(r - \frac{\dot{P}}{P}\right)\frac{B}{P}$, the authorities can use total taxes net of transfers to choose the rate of monetary growth, μ . This still leaves them real spending, G, to set the current fiscal stimulus f at its desired value. Note, however, that since total tax receipts T (and G) are "assigned" to μ and βf , the indirect tax rate τ_i cannot be varied independently. Higher values of τ_i must be matched by a lower direct tax rate τ_d . For simplicity I will represent this requirement as $\tau_i + \tau_d = \bar{\tau}$.

(9'b) $$E_t\dot{p}^* = -[\lambda^{*-1} + \gamma^{*-1}\varepsilon^*]\ell^* - [(\lambda^{*-1} + \gamma^{*-1}\varepsilon^*)(1-\alpha^*) - \gamma^{*-1}\delta^*]c$$
$$+ (\lambda^{*-1} + \gamma^{*-1}\varepsilon^*)\tau_i^* - \gamma^{*-1}\beta^* f^* - \gamma^{*-1}\eta^*\overline{y} + (\lambda^{*-1}k^* + \gamma^{*-1})\overline{y^*} \; .$$

ℓ , ℓ^* and c form a minimal set of state variables for our model. The state equations can be written as:

(10) $$\begin{bmatrix} E_t\dot{\ell} \\ E_t\dot{\ell}^* \\ E_t\dot{c} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} \ell \\ \ell^* \\ c \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} & b_{16} & b_{17} & b_{18} & b_{19} & b_{1,10} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} & b_{26} & b_{27} & b_{28} & b_{29} & b_{2,10} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} & b_{36} & b_{37} & b_{38} & b_{39} & b_{3,10} \end{bmatrix} \begin{bmatrix} \mu \\ \mu^* \\ \tau_i \\ \tau_i^* \\ f \\ f^* \\ \overline{y} \\ \overline{y^*} \\ \dot{\tau}_i \\ \dot{\tau}_i^* \end{bmatrix}$$

where the a_{ij} and b_{ij} coefficients are given in Appendix 1.

The system given in (9) has three non-predetermined, forward-looking or 'jump' state variables. The domestic and foreign value added deflators, v and v^* are flexible, market-clearing prices, as is the nominal exchange rate e. The boundary conditions for $\ell \equiv m-v$, $\ell^* \equiv m^* - v^*$ and $c \equiv e + v^* - v$ take therefore the form not of given initial conditions but of the terminal or transversality condition that the solution to (10) should lie on the stable manifold (if this exists). For this terminal condition to generate a unique, convergent solution trajectory for ℓ, ℓ^* and c, given the actual and anticipated future values of the ten forcing variables, the characteristic equation of (10) should have three unstable roots, i.e., roots with positive real parts. It is easily seen that if there are no real balance effects in the two countries' IS curves $(\varepsilon = \varepsilon^* = 0)$ the three characteristic roots are $\rho_1 = \lambda^{-1}$, $\rho_2 = \lambda^{*-1}$ and $\rho_3 = [\gamma^{-1}\delta + \gamma^{*-1}\delta^*]/[\alpha + \alpha^* - 1]$. The first two are always positive, the third will be positive if $\alpha + \alpha^* > 1$, i.e., if on average the residents of each of the two countries have a preference, at the margin, for spending on own output. If both α and α^* exceed one half, this condition will be satisfied.[4] The characteristic roots are continuous functions of the a_{ij} in equation (10). A sufficient condition for (10) to have 3 unstable characteristic roots is therefore $\alpha + \alpha^* > 1$ and small real balance effects.

The steady state conditions of the model have the familiar long-run classical or monetarist properties. The same set of steady-state conditions, given in (11) below, will also characterize the other variants of the model analyzed in this paper, although the latter exhibit "Keynesian" behavior outside the steady state.

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[4]If $\alpha + \alpha^* = 1$, the exchange rate is constant, $e \equiv 0$ and $p = p^* + \tau_i - \tau_i^*$.

(11a) $\dot{p} = \dot{v} = \mu$

(11b) $\dot{p}^* = \dot{v}^* = \mu^*$

(11c) $\dot{e} = \mu - \mu^*$

(11d) $r = r^* + \mu - \mu^*$

(11e) $y = \bar{y}$

(11f) $y^* = \bar{y}^*$

(11g) $$r = \frac{(\delta^*\gamma+\delta\gamma^*)\mu+\delta\varepsilon^*\lambda^*(\mu-\mu^*)+\delta^*\beta f+\delta\beta^* f^*-[\delta^*(1-\varepsilon k)-\delta\eta^*]\bar{y}-[\delta(1-\varepsilon^* k^*)-\delta^*\eta]\bar{y}^*}{(\gamma+\varepsilon\lambda)\delta^*+(\gamma^*+\varepsilon^*\lambda^*)\delta}$$

(11h) $$c = \frac{(\gamma^*+\varepsilon^*\lambda^*)\varepsilon\lambda\mu - (\gamma+\varepsilon\lambda)\varepsilon^*\lambda^*\mu^* - (\gamma^*+\varepsilon^*\lambda^*)\beta f + (\gamma+\varepsilon\lambda)\beta^* f^*}{(\gamma+\varepsilon\lambda)\delta^* + (\gamma^*+\varepsilon^*\lambda^*)\delta}$$
$$+ \frac{[(\gamma^*+\varepsilon^*\lambda^*)(1-\varepsilon k)+(\gamma+\varepsilon\lambda)\eta^*]\bar{y} - [(\gamma+\varepsilon\lambda)(1-\varepsilon^* k^*)+(\gamma^*+\varepsilon^*\lambda^*)\eta]\bar{y}^*}{(\gamma+\varepsilon\lambda)\delta^* + (\gamma^*+\varepsilon^*\lambda^*)\delta}$$

(11i) $\ell = k\bar{y} - \lambda r + (1-\alpha)c + \tau_i$

(11j) $\ell^* = k^*\bar{y}^* - \lambda^*(r - \mu + \mu^*) - (1 - \alpha^*)c + \tau_i^*$.

In the long run, real interest rates are equalized and the real exchange rate is constant. Differences in monetary growth are reflected in the rate of depreciation of the exchange rate. The world real interest rate rises with fiscal expansion at home and abroad. An increase in capacity output at home or abroad lowers the long-run real interest rate if $\delta^*(1 - \varepsilon k) - \delta\eta^* > 0$ and $\delta(1 - \varepsilon^* k^*) - \delta^*\eta > 0$ respectively. If there is no real balance effect at home or abroad, a change in the rate of growth of the nominal money stock at home (abroad) raises the domestic (foreign) nominal interest rate one-for-one and leaves the long-run real interest rate unaffected. If there is a real balance effect at home $(\varepsilon > 0)$ an increase in monetary growth at home raises the nominal interest rate at home less than one-for-one. The real interest rate (at home and abroad) is reduced.

Absent real balance effects, changes in money growth rates leave the long-run real exchange rate unaffected. With a real balance effect at home, higher money growth at home means a long-run depreciation of the real exchange rate. The mechanism is that, if $\lambda > 0$, higher money growth and domestic inflation lowers the real stock of money balances and thus the demand for output. An improvement in competitiveness is required to rebalance the output market. Fiscal expansion at home causes long-run real appreciation while fiscal expansion abroad has the opposite effect. It should be clear that a proportional shift in the levels of the domestic or foreign money stock paths will not affect the nominal or real interest rate or the real exchange rate but will be associated with equal proportional shifts in the levels of the paths of p, p^* and e.

Linear dynamic rational expectations models in continuous time can in general be represented as in equation (12)

$$(12) \qquad \begin{bmatrix} \dot{x}(t) \\ E_t\dot{y}(t) \end{bmatrix} = A\begin{bmatrix} x(t) \\ y(t) \end{bmatrix} + bz(t)$$

where x is an n_1 vector of predetermined state variables, y is an $n - n_1$ vector of non-predetermined state variables, and $z(t)$ is a vector of exogenous or forcing variables. We assume that A is diagonalizable and has n_1 stable and $n - n_1$ unstable characteristic roots. The boundary conditions for (12) are given by:

(13a) $x(t_0) = \overline{x}(t_0)$ (n_1 initial conditions)

(13b) The solution should lie on the stable manifold ($n - n_1$ terminal conditions).

Let Λ be a diagonal matrix whose diagonal elements are the characteristic roots of A. We partition Λ as follows: $\Lambda = \begin{bmatrix} \Lambda_1 & 0 \\ 0 & \Lambda_2 \end{bmatrix}$. Λ_1 is the $n_1 \times n_1$ matrix whose diagonal elements are the stable roots of A while Λ_2 contains the unstable roots. Let V be an $n \times n$ matrix whose rows are linearly independent left-eigenvectors of A. We partition A, B, V and $V^{-1} \equiv W$ conformably with x and y as follows:

$$A = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} ; \quad B = \begin{bmatrix} B_1 \\ B_2 \end{bmatrix} ; \quad V = \begin{bmatrix} V_{11} & V_{12} \\ V_{21} & V_{22} \end{bmatrix} ; \quad V^{-1} = \begin{bmatrix} W_{11} & W_{12} \\ W_{21} & W_{22} \end{bmatrix} .$$

We also define $D \equiv V_{21}B_1 + V_{22}B_2$.

The solution to the two-point boundary value problems (12), (13a) and (13b) is given by:

(14a) $$y(t) = -V_{22}^{-1}V_{21}x(t) - V_{22}^{-1}\int_t^\infty e^{\Lambda_2(t-\tau)} DE_t z(\tau)d\tau$$

(14b) $$x(t) = W_{11}e^{\Lambda_1(t-t_0)}W_{11}^{-1}\overline{x}(t_0) + \int_{t_0}^t W_{11}e^{\Lambda_1(t-s)}W_{11}^{-1}B_1 z(s)ds$$

$$- \int_{t_0}^t W_{11}e^{\Lambda_1(t-s)}W_{11}^{-1}A_{12}V_{22}^{-1}\int_s^\infty e^{\Lambda_2(s-\tau)}DE_s z(\tau)d\tau ds .$$ [5]

[5] See Buiter [1984a].

In the classical model of equation (10) the x-vector of predetermined variables vanishes, $y^T(t) \equiv [\ell(t), \ell^*(t), c(t)]$,[6] and $z^T(t) \equiv [\mu, \mu^*, \tau_i, \tau_i^*, f, f^*, \bar{y}, \bar{y}^*, \dot{\tau}_i, \dot{\tau}_i^*]$. Thus:

$$(15) \quad \begin{bmatrix} \ell(t) \\ \ell^*(t) \\ c(t) \end{bmatrix} = -V_{22}^{-1} \int_t^\infty \begin{bmatrix} e^{\rho_1(t-\tau)} & & 0 \\ 0 & e^{\rho_2(t-\tau)} & 0 \\ 0 & & e^{\rho_3(t-\tau)} \end{bmatrix} DE_t \begin{bmatrix} \mu(s) \\ \mu^*(s) \\ \tau_i(s) \\ \tau_i^*(s) \\ f(s) \\ f^*(s) \\ \bar{y}(s) \\ \bar{y}^*(s) \\ \dot{\tau}_i(s) \\ \dot{\tau}_i^*(s) \end{bmatrix} ds$$

The crucial aspect of equation (15) is that the state variables depend only on current anticipations of future values of the forcing variables. Current and past behavior of the exogenous variables and the policy instruments matters only to the extent that it influences expectations of the future.

From the general dynamic specification of the model in equations (1)-(8) and from the steady state conditions in equation (11), or from equations (9a), (9b) or (9'a), (9'b) and (10) the following result can be obtained by inspection. The initial situation is one of constant values of all forcing variables (i.e., $\dot{\tau}_i = \dot{\tau}_i^* = 0$).

<u>Proposition 1</u>: In the flexible price model, the credible announcement of an immediate, permanent reduction in current and future monetary growth by $\Delta\mu$ in the home country is necessary and sufficient for an immediate, sustained reduction in domestic inflation by $\Delta\mu$.

[6] y^T denotes the transpose of y .

It will be obvious that in this model with its instantaneous market-clearing features there will never be any output costs of bringing down inflation. Lack of credibility about future monetary growth may, however, prevent a desired reduction in inflation, no matter how faithfully the authorities restrict the current monetary growth rate. E.g., the possibility of the election at some future date of an inflation-prone government may prevent even a very conservative government from translating monetary deceleration during its term of office into corresponding reductions in current inflation. It is not sufficient to commit oneself, one must also be able to commit one's successors. The recognition of this dilemma is behind some of the calls for embedding monetary policy in a constitutional framework (or tying it into a constitutional straightjacket, depending on one's point of view) in order to safeguard it against political manipulation.

The response of the system to the immediate credible permanent reduction in domestic monetary growth is especially transparent when there are no real balance effects ($\varepsilon = \varepsilon^* = 0$). The transition to the new steady state with the lower rate of inflation is instantaneous. All real variables other than the domestic rate of inflation and the domestic stock of real money balances remain unchanged. The domestic nominal interest rate declines by the same amount as the reduction in domestic monetary growth and domestic inflation. Foreign inflation remains unchanged. The rate of depreciation of the domestic currency ($\dot{e}$) also declines by the amount of the reduction in μ and $\dot{p}$. Real competitiveness remains constant. Note however, that both the domestic value added deflator v and the nominal exchange rate undergo an immediate discontinuous or discrete drop at the time of the policy announcement with $\Delta v = \Delta e = \lambda \Delta \mu$. The reason for this is apparent in the domestic money demand function (1a). Lower money growth and lower inflation imply a correspondingly lower nominal rate of interest. This raises the demand for real money balances. With the level of the nominal money stock given (only its instantaneous rate of change has declined by a finite amount) and output exogenous, the required jump increase in $m-p$ must be effected through a discrete decline in p. With real competitiveness constant, the decline in p is made up of equal discrete reductions in v and e. The picture is drawn in Figure 1. Note that there are no externalities or indeed any real external effects of the domestic anti-inflation program. Coordination is redundant.

When there are non-zero real balance effects, immediate credible permanent reductions in domestic money growth again result in an immediate transition to the new steady state equilibrium with domestic inflation reduced by the amount of the reduction in money growth and with foreign inflation unchanged. This time, however, the real interest rate at home and abroad and the real exchange rate will be affected.

Since $\frac{\partial r}{\partial \mu} = \frac{\delta^*\gamma + \delta(\gamma^* + \varepsilon^*\lambda^*)}{\delta^*(\gamma+\varepsilon\lambda) + \delta(\gamma^* + \varepsilon^*\lambda^*)}$ (across steady states), the domestic (and foreign) real interest rate rises when the domestic money growth rate is cut if $\varepsilon > 0$. The domestic nominal interest rate declines less than one-for-one when μ is lowered, while the foreign nominal interest rate $r + \mu^* - \mu$ rises. Since $\frac{\partial c}{\partial \mu} = \frac{(\gamma^* + \varepsilon^*\lambda^*)\varepsilon\lambda}{(\gamma+\varepsilon\lambda)\delta^* + (\gamma^* + \varepsilon^*\lambda^*)\delta}$ (across steady states), a reduction in domestic money growth worsens domestic competiveness if $\varepsilon > 0$. The reason is that a lower value of μ raises the real interest rate equally at home and abroad. The domestic nominal interest falls, however, while the foreign nominal interest rate rises. The domestic stock of real balances thus goes up while the foreign real money stock declines. To equilibrate the domestic and foreign output markets domestic

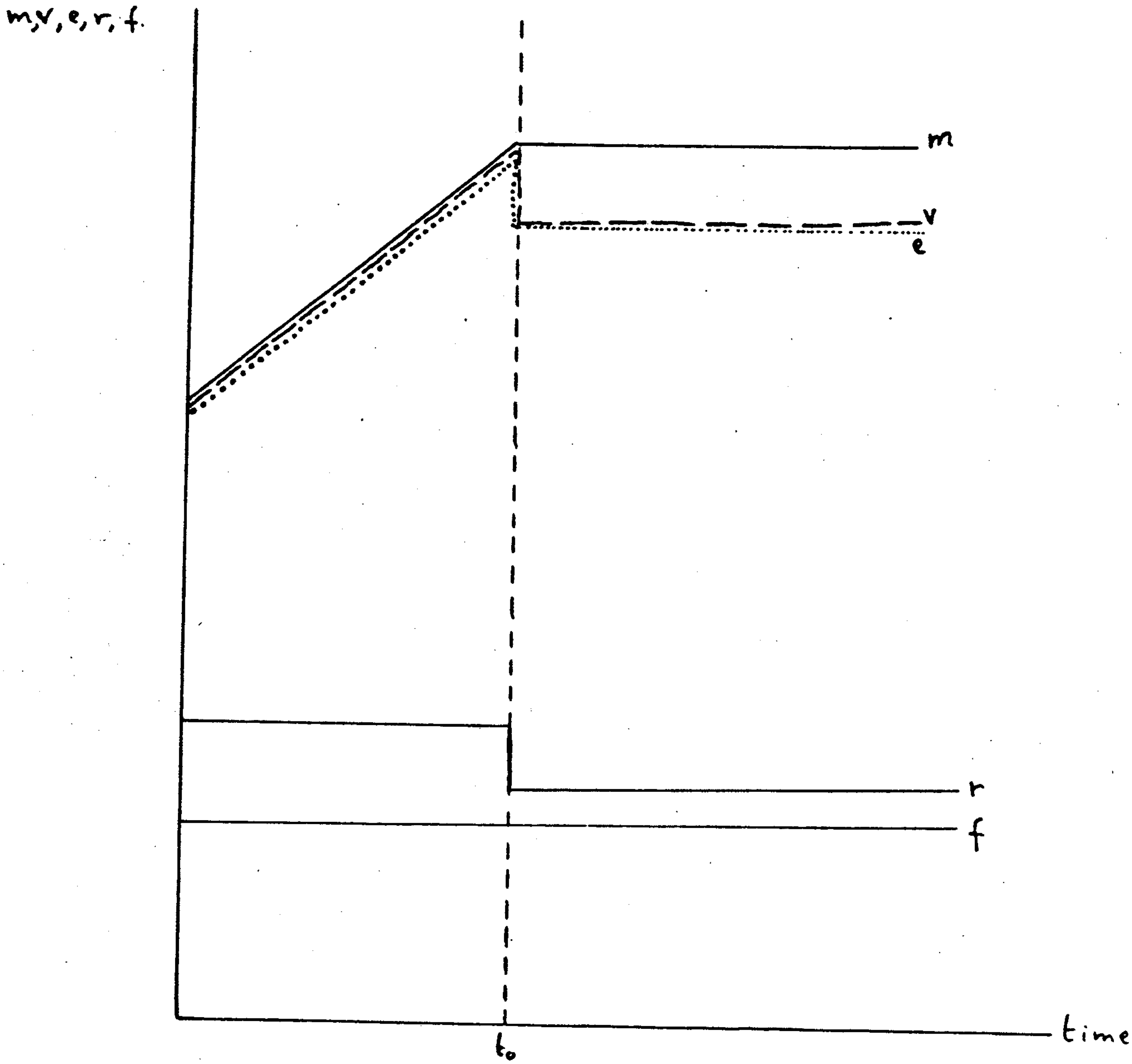

FIGURE 1

An unexpected permanent reduction in money growth at $t=t_0$.

competitiveness must decline (foreign competitiveness must improve). In this case the credible announcement of the immediate, permanent reduction in μ is accompanied by a discrete drop in v and a discrete increase in v^*. While c falls, the impact effect on e is ambiguous.

There are several ways of avoiding these spillovers from domestic monetary growth reductions on real variables that concern foreigners. The home country could stop its real interest rate (and thus the world real interest rate) from rising by contractionary fiscal policy with $\Delta f = \frac{\varepsilon\lambda}{\beta}\Delta\mu$. This would also stabilize the real exchange rate and stop the foreign nominal interest rate from rising. The foreign country cannot use fiscal policy alone to stabilize both its real interest rate and its real exchange rate. To prevent the real interest rate from rising, contractionary fiscal policy abroad is called for (with $\Delta f^* = \frac{\varepsilon\lambda\delta^*}{\beta^*\delta}\Delta\mu$) while to stop foreign competitiveness from improving, expansionary fiscal policy abroad is called for with $\Delta f^* = \frac{-(\gamma^* + \varepsilon^*\lambda^*)\varepsilon\lambda}{(\gamma+\varepsilon\lambda)\beta}\Delta\mu$. It is clear from equations (11g) and (11h) that the foreign money growth rate μ^* and the foreign fiscal stance, f^* can be used jointly to stabilize the real interest rate and the real exchange rate. This does mean, of course, that the foreign country cannot choose to stabilize its real exchange rate and its real interest rate while maintaining its previous rate of inflation.

It is possible for the two countries jointly to choose any pair of inflation rates $\dot{p}$ and $\dot{p}^*$ while maintaining the old real interest rate and competitiveness by using both money growth rates and fiscal instruments appropriately.

III. Models in Which Smart Demand Management Is Necessary and Sufficient for a Costless, Sustained Reduction in Inflation

The main reason for spending time with the classical model in which, given credibility, nothing can go wrong, is that it provides good insight into what can go wrong in more realistic and useful models.

It is generally accepted that the level of money wages and the GDP deflator are not like the foreign exchange rate or the stock market index. A common alternative view is that the value added deflator (or the wage) changes only gradually over time in response to excess demand or supply pressure, e.g., through an augmented Phillips curve:

$$(16) \qquad \frac{d}{dt}(v - \theta\tau_d) = \psi(y-\bar{y}) + \pi \ , \quad \psi > 0 \ ; \quad 0 \leq \theta \leq 1$$

$$(16') \qquad \frac{d}{dt}(v^* - \theta^*\tau_d^*) = \psi^*(y^* - \bar{y}^*) + \pi^* \ , \quad \psi^* > 0 \ ; \quad 0 \leq \theta^* < 1.$$

In (16) it is recognized that the direct tax rate may influence the behavior of before-tax wages and other factor payments. The two extreme possibilities are that it is the rate of change of after-tax factor rentals ($v - \tau_d$ and $v^* - \tau_d^*$ with $\theta = \theta^* = 1$) or the rate of change of before-tax factor rentals (v and v^* with $\theta = \theta^* = 0$) that is determined through the Phillips curve mechanism. $v - \theta\tau_d$ and $v^* - \theta^*\tau^*_d$ are treated as sluggish or predetermined (i.e., incapable of making a discontinuous jump at a point in time). The sacrifice ratio depends crucially on the specification of the process governing π , the augmentation term in the Phillips curve or "core inflation." Note that the old-fashioned non-augmented Phillips curve, $\dot{v} = \psi(y-\bar{y}) + \bar{\pi}$ where $\bar{\pi}$ is exogenous (e.g., zero) implies an infinite sacrifice ratio. To keep inflation at a lower level forever, the output or unemployment gap $y-\bar{y}$ has to be increased and kept at this higher level forever.

There are at least three well-known models of the inflation process which combine the view that $v - \theta\tau_d$ (the prive level) moves sluggishly with the view that π (core inflation) moves flexibly. Two are represented in (16) plus (17) or (18) below, the third in (19a), (19b), (19c):

(17) $$\pi = \mu \; ; \quad \pi^* = \mu^*$$

(18) $$\pi = \dot{\tilde{p}} \; ; \quad \pi^* = \dot{\tilde{p}}^*$$

(19a) $$\dot{\tilde{v}} = \Omega(w - \tilde{v}) \; ; \quad \dot{\tilde{v}}^* = \Omega^*(w^* - \tilde{v}^*)$$

(19b) $$E_t\dot{w} = \Omega(w - \tilde{v} - \psi(y - \bar{y})) \; ; \quad E_t\dot{w}^* = \Omega^*(w^* - \tilde{v}^* - \psi^*(y^* - \bar{y}^*))$$

(19c) $$v = \tilde{v} + \theta\tau_d \; ; \quad v^* = \tilde{v}^* + \theta^*\tau_d^* \; .$$

The first model (17) has core inflation equal to the current money growth rate (Dornbusch [1980], Buiter and Miller [1981]. The second (18) has core inflation given by $\dot{\tilde{p}}$ or $\dot{\tilde{p}}^*$, the right-side derivative of the price level path of the classical, flex-price model of the previous section. This means that core inflation equals the rate of change of the price level in the classical equilibrium model except at those points where that rate of change becomes infinite because the classical equilibrium price level makes a discrete jump. Price equations such as (16) and (18) have been used by Mussa [1981] and Barro and Grossman [1976].

Equations (19a), (19b), and (19c) represent a contract model in which the level of the current contract wage, w, depends on current expectations of future values of $\tilde{v}$ and excess demands and the current value added deflator depends on past contract wages. This model is due to Calvo [1982a, b, c] and can be viewed as a continuous time version of Taylor's model of overlapping, staggered 2-period nominal wage contracts (Taylor [1980]). The interpretation of (19a), (19b) and (19c) is clear when we solve for v and w explicitly as follows:

$$\text{(20a)} \quad \tilde{v}(t) = e^{-\Omega(t-t_0)}\tilde{v}(t_0) + \Omega\int_{t_0}^{t} w(s)e^{-\Omega(t-s)}ds$$

and

$$\text{(20b)} \quad w(t) = \Omega\int_{t}^{\infty} E_t[\tilde{v}(s) + \psi(y(s) - \bar{y})]e^{-\Omega(s-t)}ds + e^{\Omega t}E_t \lim_{\tau\to\infty} e^{-\Omega\tau}w(\tau)$$

or

$$\text{(21a)} \quad v(t) = v(t_0) + \theta[\tau_d(t) - \tau_d(t_0)] + K(t - t_0) + \Omega^2\psi\int_{t_0}^{t}\int_{s}^{\infty} E_s(y(z) - \bar{y})dzds$$

and

$$\text{(21b)} \quad w(t) = v(t) - \theta\tau_d(t) + K + \Omega\psi\int_{t}^{\infty} E_t(y(s) - \bar{y})ds .$$

K in (20a) and (20b) is an arbitrary constant of integration, to be determined by a terminal boundary condition. It is easily seen that in models with a well-defined steady state rate of inflation and monetary growth μ^{∞}, the arbitrary constant K is equal to μ^{∞}/Ω. Note that while $\tilde{v}$ is predetermined in (20a), the current contract wage w is, among other things, an increasing function of current expectations of future excess demand and of the transversality condition determining steady-state inflation through K. Since w is flexible, the rate of change of the value added deflator, $\dot{\tilde{v}}$, is flexible (see equation (19a)). The effect of direct taxes on v if $\theta > 0$ also introduces an element of domestic cost flexibility. All three models in equations (16)-(19) thus have flexible core inflation. It may therefore appear that the credible announcement of an immediate, permanent reduction in money growth would again be sufficient ments of future money growth and given a policy for mimicking or avoiding the need for, the price level drop shown in Figure 1.

We can write the domestic monetary equilibrium condition as

$$(22) \quad m - \tilde{v} - \partial\tau_d = k\bar{y} - \lambda r + (1-\alpha)c + \tau_i$$

Note that $\tilde{v} \equiv v - \theta\tau_d$ is predetermined.

To achieve an instantaneous transition to a new low-inflation steady state, if the foreign country does not change any of its policy instruments, the home country's policy instruments should satisfy:

$$(23) \quad \Delta m - \theta\Delta\tau_d - \Delta\tau_i + \frac{\beta(\lambda\delta^* + (1-\alpha)(\gamma^* + \varepsilon^*\lambda^*))}{\Lambda}\Delta f$$

$$= -\frac{\lambda[\delta^*\gamma + \delta\gamma^* + \delta\varepsilon^*\lambda^* + (\alpha-1)(\gamma^* + \varepsilon^*\lambda^*)\varepsilon]}{\Lambda}\Delta\mu$$

where $\Lambda = (\gamma+\varepsilon\lambda)\delta^* + (\gamma^* + \varepsilon^*\lambda^*)\delta$.

(and necessary) for reducing domestic inflation without output costs. This is not correct, because an immediate transition to a lower rate of inflation would require, if the interest-elasticity of demand for money balances is negative, that the stock of real money balances is increased. In the classical flex-price model, the price level drop shown in Figure 1 brought about the necessary increase in real money balances. Absent price level flexibility, the authorities must either increase the level of the nominal stock of money balances, or cut direct or indirect taxes so as to reduce the market price level for any given level of after-tax factor income or prevent the fall in nominal interest rates associated with lower steady state inflation by engaging in expansionary fiscal policy. Therefore:

Proposition 2: In the model with a predetermined price level but flexible core inflation, credible, immediate, permanent reduction in money growth in the home country is necessary for an immediate, costless, sustained reduction in domestic inflation by the same amount. In addition, the authorities must either generate an immediate increase in the level of the real money stock (by a 'jump' in the nominal money stock or by direct or indirect tax cuts, with all fiscal variables adjusted in such a way as to keep aggregate demand equal to full employment supply) or engage in a set of fiscal measures (e.g., an increase in f) that prevent a decline in the domestic nominal interest rate. Only the first of these two options avoids international spillover effects (assuming no real balance effects).

In all three of these models one country's inflation can be eliminated costlessly and at a stroke, given credibility of announce-

If there is no real balance effect at home or abroad, the "money jump" policy with $\Delta m = -\lambda\Delta\mu$ would be the simplest way to proceed. The level of the nominal money stock is raised once-and-for-all at the same time that its rate of growth is lowered. While such a policy combination may appear to be prone to credibility problems, it should be noted that it would be implemented automatically if the government announced a credible nominal income target rather than a monetary growth target. A nominal income target is of course a "velocity-corrected" monetary target which would automatically allow for the decline in velocity associated with the transition to a lower rate of inflation. The jump in real money balances can, from (23) also be achieved with an unchanged nominal money stock, through a cut in indirect taxes balanced in terms of revenue by an increase in direct taxes, provided $\theta < 1$, i.e. provided indirect taxes have a larger immediate effect on the price level than direct taxes.[7]

Absent real balance effects, changes in m or τ_i would permit costless and instantaneous domestic disinflation without any real spillovers to the foreign country. The real interest rate, the real exchange rate and the foreign country's nominal interest rate would be unaffected.

Expansionary domestic fiscal policy (an increase in f at the same time that μ is reduced) will not in general be consistent with an immediate, costless transition to a lower inflation steady state, except for a closed economy or a small open economy. Even without real balance effects, an increase in f will be associated with a higher long-run real interest rate and a long-run appreciation of the domestic real exchange rate. The short-run result of such a policy combination would be to start a boom abroad, stimulated by the improvement in foreign competitiveness. The combination of domestic money growth reductions and fiscal stimulus that would satisfy

[7]Remember that, with public spending constant, we must have $\Delta\tau_d + \Delta\tau_i = 0$.

the desired new low inflation domestic steady state conditions, would in all likelihood create a transitional slump at home. With a real balance effect even the money jump and indirect tax cut policies will have repercussions abroad. The domestically correct steady state policy combination is again likely to cause a slump at home and a boom abroad.

If the domestic authorities adopt a money jump or indirect tax cut policy[6] in conjunction with the money growth deceleration when real balance effects are present, the foreign authorities will in general need to change two policy instruments to stay at full employment. They could, e.g., accept a higher real (and nominal) interest rate and an improved level of foreign competitiveness by implementing a discontinuous, once-and-for-all reduction in the level of the foreign nominal money stock (or an increase in foreign indirect taxes if $\theta^* < 1$) and a change in f^*. The same result holds qualitatively whether or not real balance effects are present, if the home country lowers money growth and raises f at the same time.

A combined common reduction in money growth rates at home and abroad will cause a global slump unless both countries undertake simultaneously money jump policies, indirect tax cuts or fiscal stimuli. If there are no real balance effects, money jumps or indirect tax cuts in the two countries permit an immediate, costless global disinflation at a constant real interest rate and real exchange rate. Even if there are real balance effects, an immediate costless global disinflation will be possible, with money jumps or indirect tax cuts in both countries, at a constant real exchange rate but a higher real interest rate, if the two countries have

[6]"Indirect tax cut policy" refers to a constant revenue change from indirect to direct taxes. There are therefore no direct aggregate demand effects of such a policy.

identical structures. Without this restriction, however, the two fiscal instruments f and f* will have to be used jointly with the reductions in money growth and the money jumps or indirect tax cuts to achieve efficient global disinflation.

How important are the costs of badly-designed disinflation policy? Consider as a simple illustrative example the wage-price block of equations (4a), (16) and (17) where core inflation equals the rate of growth of the money stock. A little manipulation yields

$$(24)\qquad -\int_t^{\infty}(y(s)-\bar{y})ds = \frac{1}{\psi}\Big\{[m(\infty)-p(\infty)-(m(t)-p(t))]+\theta[\tau_d(\infty)-\tau_d(t)] + [\tau_i(\infty)-\tau_i(0)]+(1-\alpha)[c(\infty)-c(0)]\Big\}$$

The cumulative net undiscounted output cost given in (24) increases with the amount by which real money balances must be increased in the long run. Without a nominal money stock jump, the long-run change in m-p equals $-\lambda\overset{\infty}{\Delta}r$ where $\overset{\infty}{\Delta}$ means long-run or steady state change. In the simplest case, without real balance effects, $\overset{\infty}{\Delta}r = \overset{\infty}{\Delta}\mu$. The sacrifice ratio is therefore

$$(25)\qquad SR \equiv \frac{\int_t^{\infty}(y(s)-\bar{y})ds}{\overset{\infty}{\Delta}\mu} = \frac{\lambda}{\psi} - \frac{\theta}{\psi\overset{\infty}{\Delta}\mu}\overset{\infty}{\Delta}\tau_d - \frac{1}{\psi\overset{\infty}{\Delta}\mu}\overset{\infty}{\Delta}\tau_i + \frac{(\alpha-1)}{\overset{\infty}{\Delta}\mu}\overset{\infty}{\Delta}c\ .$$

A unilateral reduction in μ has a sacrifice ratio of λ/ψ , increasing in the interest sensitivity of money demand and decreasing in the slope of the Phillips curve. As is clear from (24) or (25) money jumps or tax cuts could reduce the sacrifice ratio to zero. Note, however, that a real appreciation of the currency ($\overset{\infty}{\Delta}c < 0$) also lowers the sacrifice ratio. The problem is that while $\frac{(1-\alpha)}{\psi}\overset{\infty}{\Delta}c$ enters the domestic cost calculation

$\frac{\alpha^* - 1}{\psi^*} \overset{\infty}{\Delta} c$ enters the foreign cost calculation. The anti-inflationary gains of real exchange rate appreciation are strictly beggar-thy-neighbor. In addition, the short-run gains from exchange rate appreciation accruing to a single country may well overstate the long-run gains. Note that without real balance effects $\overset{\infty}{\Delta} c = 0$ after a unilateral reduction in μ. As is shown, e.g., in Buiter and Miller [1983a], any initial anti-inflationary gains due to exchange rate appreciation must be "handed back" as the loss of competitiveness unwinds in the long run, since in their model $\overset{\infty}{\Delta} c = 0$. Of course the timing of the anti-inflationary successes will be different when the exchange rate is permitted to appreciate sharply in the short run, and early reductions in inflation may be worthwhile in themselves, even if the net output cost of fighting inflation is not affected. It should also be pointed out that the model (like all models in this paper) is assumed to be structurally invariant with respect to the class of policy changes under consideration. It may be that the "short sharp shock" of a sudden exchange rate appreciation permits one to "over-write" the existing inflation equations. The sluggishness or inertia of the price-wage mechanism could vanish when the government invests in credibility by engineering a brutal appreciation of the exchange rate. I do not consider that possibility in this paper. In any case, the foreign government would be disinvesting in credibility by suffering a brutal depreciation of the exchange rate.

The moral of this section is that if there is only price level inertia but no inflation inertia, well-designed aggregate demand management policy (changes in μ, m, f, μ^*, m^* and f^*) are sufficient to ensure efficient, i.e., costless and instantaneous unilateral or joint reductions in inflation.[8] When a greater degree of inertia is attributed to the wage-price process, this fairly optimistic conclusion vanishes.

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[8]Of course, indirect tax cuts may be helpful, if $0 \leq \theta < 1$, even if f is kept constant.

IV. Models in Which Genius or Good Luck Are Necessary for a Costless, Sustained Reduction in Inflation

Many economists have a view of the wage-price process that implies considerably more sluggishness and inertia than has been permitted in any of the models considered thus far. Multi-period contract models such as Taylor's [1980] are one well-known example.

Some of the essential features of this entire class of models are represented by the simplest possible "adaptive" core inflation process. It is characterized by a sluggish price level and, subject to some qualifications, a sluggish rate of core inflation. For the home country equations (4a) and (16) are combined with (25). For the foreign country equations (4b) and (16') are joined with (25'):

(25) $$\pi = \xi(\dot{p}-\pi) \ , \quad \xi > 0$$

(25') $$\dot{\pi}^* = \xi^*(\dot{p}^* - \pi^*) \ .$$

It is easily checked that for the home country the sacrifice ratio is now given by:

(26a) $$SR(t) \equiv \frac{\int_t^\infty (y(s) - \bar{y})ds}{\overset{\infty}{\Delta}\pi} = \frac{\int_t^\infty (y(s) - \bar{y})ds}{\overset{\infty}{\Delta}\mu} = \frac{1}{\xi\psi} - \frac{1}{\psi\overset{\infty}{\Delta}\mu}[\theta\overset{\infty}{\Delta}\tau_d + \overset{\infty}{\Delta}\tau_i] + \frac{(\alpha-1)}{\psi\overset{\infty}{\Delta}\mu}\overset{\infty}{\Delta}c \ .$$

Note that a money level jump no longer helps to avoid or even reduce the output costs of bringing down inflation.[9] Barring changes in tax rates or in the real exchange rate, both v and π are predetermined and the sacrifice ratio depends only on the slope of the short-run Phillips curve, ψ, and the speed of adjustment of core inflation, ξ. The foreign sacrifice ratio is given by:

[9] It may still be a useful (or even essential) component of a complete policy package capable of achieving an instantaneous transition to a lower rate of inflation steady state.

$$\text{(26b)} \quad SR^*(t) = \frac{1}{\xi^*\psi^*} - \frac{1}{\psi^*\overset{\infty}{\Delta}\mu^*}[\theta^*\overset{\infty}{\Delta}\tau_d^* + \overset{\infty}{\Delta}\tau_i^*] + \frac{(1-\alpha^*)\overset{\infty}{\Delta}c}{\psi^*\overset{\infty}{\Delta}\mu^*} .$$

Following Okun [1978] we can, as was discussed in the previous section, use direct or indirect tax cuts to break core inflation. Unless $\theta = 1$ and direct tax increases fully offset the price level effect of equal revenue indirect tax cuts, an indirect tax cut financed by a direct tax increase can melt core inflation. Even if $\theta = 1$ a net cut in overall taxes can have the desired effect on core inflation. This exercise is then of course complicated by the fact that tax cuts implemented for their cost-reducing effects will also have aggregate demand effects (i.e., f would increase). Public spending will then have to be lowered in such a way as to maintain aggregate demand at full employment. Note the opposite effect of changes in c on the domestic and foreign sacrifice ratios. If the home country through its policy actions were to achieve a long-run appreciation of its real exchange rate (a decline in c) then the foreign country would, if its inflation objectives are constant, be forced to suffer a cumulative net loss of output. But for this output loss the depreciation of the foreign country's real exchange rate would result in a rise in foreign core inflation.

Note that if some form of incomes policy could shock core inflation, i.e,, jump π, the output cost of bringing down inflation could be reduced or even eliminated altogether without recourse to changes in the tax structure (while keeping the aggregate demand effect of fiscal policy constant) or to beggar-thy-neighbor, zero-sum attempts at "competitive loss of competitiveness."

The rewards from a successful incomes policy would be enormous. The mechanism for achieving it, theoretically and in the light of historical experience, is problematic. With centralized wage bargaining and strong unions capable of delivering on the shop floor wage agreements negotiated centrally, it might be possible to achieve an anti-inflationary breakthrough this way. With decentralized, non-synchronized and non-cooperative wage bargaining someone has to go first while everyone wishes to go last. Proposals for "real wage insurance" through the public purse, floated briefly in the U.S.A. under Carter, may be helpful here. Tax-based income policies are, if anything, primarily a means for lowering the natural rate of unemployment (for raising $\bar{y}$). They may, however, when they are introduced, also serve to break the momentum of on-going core inflation.

Proposition 3: If there is both a predetermined price level and quasi-predetermined, adaptive, core inflation, the policies required if both countries are to achieve an instantaneous and costless disinflation are the following. Both countries have to announce and implement credible reductions in the rate of growth of their nominal money stocks. Tax cuts (or indirect to direct tax changes) have to be implemented to break core inflation. The lower velocities associated with a successful transition to lower inflation rates will have to be accommodated by a once-and-for-all increase in the level of each country's nominal money stock. Public spending in each country is to be adjusted so as to maintain aggregate demand at its full employment level. Credible nominal income targeting could be a substitute for the money growth deceleration and money level increase. Incomes policy, if effective, could be a substitute for tax cuts.

It might be argued that the view of core inflation embodied in equations (25) and (25') is both too "backward-looking" and too optimistic. Modern eclectic views of the wage-price process not only incorporate sluggishness in the level and rate of change of wages but also forward-looking behavior. They also view π as strictly predetermined, i.e., unlike (25) and (25') changes in the price level brought about through changes in the exchange rate or tax rates, cannot move the level of π discontinuously. This view is represented in equations (26), (27) and (26'), (27'):

(26) $\dot{\pi} = \xi_1(q-\pi) \ , \quad \xi_1 > 0$

(26') $\dot{\pi}^* = \xi_1^*(q^* - \pi^*) \ , \quad \xi_1^* > 0$

(27) $E_t\dot{q} = \xi_2(q-\dot{p}) \ , \quad \xi_2 > 0$

(27') $E_t\dot{q}^* = \xi_2^*(q^* - \dot{p}^*) \ , \quad \xi_2^* > 0 \ .$

q is the current rate of wage contract inflation. π, core inflation, has the interpretation of "the going rate." It is a function of past contract inflation. Current contract inflation is a function of current expectations of the future state of excess demand and of what the "going rate" will be in the future.

Solving for q and π we find:

(27) $$q(t) = \pi(t) + \xi_2\int_t^{\infty} e^{(\xi_2-\xi_1)(t-s)} E_t[\psi(y(s)-\bar{y})+\theta\dot{\tau}_d(s)+\dot{\tau}_i(s)+(1-\alpha)\dot{c}(s)]ds$$

(28) $$\pi(t) = \pi(t_0) + \xi_1\xi_2\int_{t_0}^{t}\int_s^{\infty} e^{(\xi_2-\xi_1)(s-z)} E_s[\psi(y(z)-\bar{y})+\theta\dot{\tau}_d(z)+\dot{\tau}_i(z)+(1-\alpha)\dot{c}(z)]dzds$$

This solution makes sense only if $\xi_2 \geq \xi_1$. When $\xi_2 = \xi_1$ (and provided the relevant integrals exist), (27) and (28) simplify to:

$$(27') \quad q(t) = \pi(t) + \xi_2\int_t^{\infty} E_t\psi(y(s)-\overline{y})\,ds + \xi_2 E_t[\theta\overset{\infty}{\Delta}\tau_d + \overset{\infty}{\Delta}\tau_i + (1-\alpha)\overset{\infty}{\Delta}c]$$

$$(28') \quad \pi(t) = \pi(t_0) + \xi_1\xi_2\int_{t_0}^{t}\int_s^{\infty} E_s\psi(y(z)-\overline{y})\,dz\,ds + \xi_1\xi_2\int_{t_0}^{t} E_s[\theta\overset{\infty}{\Delta}\tau_d(s) + \overset{\infty}{\Delta}\tau_i(s) + (1-\alpha)\overset{\infty}{\Delta}c(s)]\,ds$$

In this model the current contract rate of inflation, q , is non-predetermined but core inflation or "the going rate" is strictly predetermined. Barring changes in tax rates and in the real exchange rate, current contract inflation exceeds the going rate if the "present value" of currently expected future excess demand is positive. Current core inflation equals core inflation at some initial date plus an increasing function of the sum between that initial date and the current date of the present value of future excess demand expected at each instant between these two dates. Domestic current contract inflation can be reduced instantaneously by long-run tax cuts or long-run real exchange rate appreciation. Barring these two channels, only credible announcements of (policies causing) future recessions can bring down current contract inflation. Credibility remains central, but is no longer sufficient to avoid costs. Core inflation cannot be brought down instantaneously even when indirect or direct tax cuts or exchange rate appreciation are announced credibly. It is a function of the entire history of past expectations of future excess demands, tax cuts and real exchange rate appreciation. Barring the last two influences, it is (past expectations of) credible future recessions that bring down core inflation. Anticipated current and future reductions in nominal income growth or monetary growth can no longer be translated painlessly into lower inflation. They work if and to the extent that they create expectations of future recessions. Note that this can create some awkward credibility and time-consistency problems. Assume the authorities announce policies that will cause a deep recession at some future date. It is possible that inflation and core inflation are brought down to their desired level before the recession has actually started. What government, having licked inflation with the help of the announcement effects of future recessions, would then create a recession merely to validate these past expectations? These expectations would be bygones and a government reoptimizing after inflation had been brought down would be tempted to cheat on its earlier policy commitments. Such a policy announcement would therefore not be credible.

Both global and single-country attempts to reduce inflation will, in the most realistic of our models, always take time. A single country may achieve its anti-inflationary objectives without unemployment and output costs by using cost-reducing tax cuts and real exchange rate appreciation. The world as a whole can rely only on tax cuts and, where feasible, incomes policy. The transition to the low inflation equilibrium will involve the internal and external coordination of time-varying trajectories for monetary growth (including money stock jumps), tax rates and public spending. If a serious research effort gets underway now, we may be ready with sensible policy packages when there is once again the perceived need to accord high priority to reducing inflation, after the next inflationary outburst.

V. Conclusion

This paper has considered anti-inflationary policy design in an open interdependent economic system. Policy instrument values or rules were treated as though imposed "exogenously." Both for positive analysis (how is policy actually determined?) and for normative analysis (how should policy be designed?) it is essential that policy behavior should be endogenized through the explicit derivation of decision rules that reflect the objectives and the actual and perceived constraints (economic, technical, administrative, political, and informational) of the policy makers.

Finally, it is important not to be misled by the deterministic nature of the models considered in this paper, into believing that credibility and precommitment require inflexible policy design. Credibility requires that preannounced rules are followed faithfully. These rules can, indeed should, be contingent or conditional in nature. Provided the nature of the rules is understood by private agents--and this requires simplicity and transparence but not rigidity--and provided the government's record in sticking to its commitments can be monitored promptly and at little cost, optimal or even merely sensible policy design will always incorporate scope for flexible response to new information about the external environment and about actions of other players.

The widely known result, that in models with rationally anticipating, forward-looking private agents, optimal policy design will not in general be time-consistent, has led to a quite unwarranted resignation to the pursuit of time-consistent but suboptimal policies or even of time-inconsistent and suboptimal policies, such as the adoption of constant money growth rules. The moral is surely quite different. Time-inconsistency of optimal plans calls for institutional innovation and reform aimed at making the optimal policy time-consistent. New rewards, sanctions, threats or promises should be designed to render optimal policy incentive-compatible given the new, purpose-built constraints. Institutional, and indeed constitutional innovation is bound to dominate resignation to the n^{th} best.

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Appendix I

The a_{ij} and b_{ij} coefficients of equation 10 are:

$$a_{11} = \lambda^{-1} - \frac{\alpha^*\gamma^{-1}\varepsilon}{1 - \alpha - \alpha^*} ,$$

$$a_{12} = \frac{(1-\alpha)\gamma^{*-1}\varepsilon^*}{1 - \alpha - \alpha^*}$$

$$a_{13} = (\alpha-1)\left[\lambda^{-1} + \frac{\alpha^*\gamma^{-1}\varepsilon + \gamma^{*-1}(\varepsilon^*(1 - \alpha^*) - \delta^*}{\alpha + \alpha^* - 1}\right] + \frac{\alpha^*\gamma^{-1}\delta}{\alpha + \alpha^* - 1}$$

$$a_{21} = \frac{(1 - \alpha^*)\gamma^{-1}\varepsilon}{1 - \alpha - \alpha^*}$$

$$a_{22} = \lambda^{*-1} - \frac{\alpha\gamma^{*-1}\varepsilon^*}{1 - \alpha - \alpha^*}$$

$$a_{23} = (1 - \alpha^*)\left[\lambda^{*-1} + \frac{\alpha\gamma^{*-1}\varepsilon^* + \gamma^{-1}\varepsilon(1-\alpha) - \gamma^{-1}\delta}{\alpha + \alpha^* - 1}\right] - \frac{\alpha\gamma^{*-1}\delta^*}{\alpha + \alpha^* - 1}$$

$$a_{31} = \frac{\gamma^{-1}\varepsilon}{\alpha + \alpha^* - 1}$$

$$a_{32} = \frac{-\gamma^{*-1}\varepsilon^*}{\alpha + \alpha^* - 1}$$

$$a_{33} = \frac{\gamma^{-1}\delta + \gamma^{*-1}\delta^* - \gamma^{-1}\varepsilon(1-\alpha) - \gamma^{*-1}\varepsilon^*(1 - \alpha^*)}{\alpha + \alpha^* - 1}$$

$b_{11} = 1$; $b_{21} = 0$

$b_{12} = 0$; $b_{22} = 1$

$b_{13} = -\lambda^{-1} + \dfrac{\alpha^*\gamma^{-1}\varepsilon}{1 - \alpha - \alpha^*}$; $b_{23} = \dfrac{(\alpha^* - 1)\gamma^{-1}\varepsilon}{1 - \alpha - \alpha^*}$

$b_{14} = \dfrac{(\alpha-1)\gamma^{*-1}\varepsilon^*}{1 - \alpha - \alpha^*}$; $b_{24} = -\lambda^{*-1} + \dfrac{\alpha\gamma^{*-1}\varepsilon^*}{1 - \alpha - \alpha^*}$

$b_{15} = \dfrac{-\alpha^*\gamma^{-1}\beta}{1 - \alpha - \alpha^*}$; $b_{25} = \dfrac{(1 - \alpha^*)\gamma^{-1}\beta}{1 - \alpha - \alpha^*}$

$b_{16} = \dfrac{(1-\alpha)\gamma^{*-1}\beta^*}{1 - \alpha - \alpha^*}$; $b_{26} = - \dfrac{\alpha\gamma^{*-1}\beta^*}{1 - \alpha - \alpha^*}$

$$b_{17} = -\lambda^{-1}k + \frac{\alpha^*\gamma^{-1} + (1-\alpha)\gamma^{*-1}\eta^*}{1-\alpha-\alpha^*} \quad ; \quad b_{27} = -\frac{[\alpha\gamma^{*-1}\eta^* + (1-\alpha^*)\gamma^{-1}]}{1-\alpha-\alpha^*}$$

$$b_{18} = -\frac{[\alpha^*\gamma^{-1}\eta + (1-\alpha)\gamma^{*-1}]}{1-\alpha-\alpha^*} \quad ; \quad b_{28} = -\lambda^{*-1}k^* + \frac{\alpha\gamma^{*-1} + (1-\alpha^*)\gamma^{-1}\eta}{1-\alpha-\alpha^*}$$

$$b_{19} = \frac{-\alpha^*}{1-\alpha-\alpha^*} \quad ; \quad b_{29} = \frac{1-\alpha^*}{1-\alpha-\alpha^*}$$

$$b_{1,10} = \frac{1-\alpha}{1-\alpha-\alpha^*} \quad ; \quad b_{2,10} = \frac{-\alpha}{1-\alpha-\alpha^*}$$

$$b_{31} = 0$$

$$b_{32} = 0$$

$$b_{33} = \frac{-\gamma^{-1}\varepsilon}{\alpha+\alpha^*-1}$$

$$b_{34} = \frac{\gamma^{*-1}\varepsilon^*}{\alpha+\alpha^*-1}$$

$$b_{35} = \frac{\gamma^{-1}\beta}{\alpha+\alpha^*-1}$$

$$b_{36} = \frac{-\gamma^{*-1}\beta^*}{\alpha+\alpha^*-1}$$

$$b_{37} = -\frac{[\gamma^{-1} + \gamma^{*-1}\eta^*]}{\alpha+\alpha^*-1}$$

$$b_{38} = \frac{[\gamma^{*-1} + \gamma^{-1}\eta]}{\alpha+\alpha^*-1}$$

$$b_{38} = \frac{1}{\alpha+\alpha^*-1}$$

$$b_{3,10} = -\frac{1}{\alpha+\alpha^*-1}$$