“Demand-Pull Stagflation”

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DEMAND-PULL STAGFLATION

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ABSTRACT: This paper explores the possibility of stagflation emanating exclusively from monetary shocks, without concurrent supply shocks or shifts in potential output. This arises in connection with a tight money paradox, in the context of a fiscal theory of the price level. The paper exhibits perfect foresight equilibria with output and inflation fluctuating in opposite directions as a consequence of small monetary shocks, and also following changes in monetary policy regime that launch the economy into hyperinflation or that produce dramatic stabilization of already high inflation. For that purpose, an analytically convenient dynamic general equilibrium macro model is developed where nominal rigidities are represented by a cross between staggered two-period contracts and state dependent price adjustment in the presence of menu costs (JEL E3).

In standard dynamic macroeconomic models, an upward fluctuation of inflation accompanied by a downward fluctuation of output – stagflation – constitutes prima facie evidence of an adverse supply shock. Demand shocks, including shocks from monetary and fiscal policy, should make inflation and output fluctuate in the same direction.

Stagflation caused by monetary policy alone, without contribution from exogenous supply shocks, was a traditional theme in structuralist macroeconomics. Monetary tightening might cause recession and yet be counterproductive on the inflation front because of the cost-push effects of high interest rates. Credit rationing versions of that story (as formalized by Blinder, 1987) were also very popular. But the cost-push effects of tight money constitute shifts in the...

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economy's potential output. They are still adverse shocks to aggregate supply, albeit caused by monetary policy.

A distinct (and so far unexplored) possibility of obtaining stagflation from demand shocks proper, without any dislocation in the supply side of the economy, is suggested by findings of 'tight money paradoxes'. According to Sargent and Wallace's (1981) 'unpleasant monetarist arithmetic', monetary tightening may cause inflation to accelerate despite having no supply side effect. The same happens in the fiscalist approach to price determination advocated by Leeper (1991), Sims (1994) and Woodford (1994, 1995). Working with flexible price models, both strands of literature neglect however to investigate what effects tight money would have on output along with its paradoxical effects on inflation.² If tight money retained the conventional effect of depressing output, the result would be genuine demand-pull stagflation.

Fiscalist models deliver a tight money paradox thanks to wealth effects. Higher nominal interest rates, given the sequence of primary budget deficits, make the liabilities of the government grow faster in nominal terms. The fiscal policy regime is such that private agents rationally regard such liabilities as net worth. Unless inflation picked up, they would feel richer in real terms, and plan to consume more than they will produce. Prices are bid up because there is 'too much nominal wealth chasing too few goods'. Offered that explanation for the tight money paradox, one might intuit that the wealth effect pulling prices up would at the same time cause output to boom, just as any positive demand shock.

As I show, that is not the case. With nominal rigidities, monetary tightening triggers fluctuations in real interest rates and an intertemporal reallocation of spending. A standard economy responds with a temporary recession, although equilibrium output tends to rebound beyond potential later on. At least on impact, monetary tightening does cause stagflation in a fiscalist world, and that result is entirely driven by the demand side of the economy.

² Woodford (1996) investigates the effects of fiscal shocks in a fiscalist model with nominal rigidities. No attention has yet been given to the effects of monetary shocks in such models.
I investigate the effects of monetary policy in three different circumstances. First, I conduct the familiar experiment of exposing the economy to small shocks to the nominal interest rate (section 3). That is interesting in its own right and serves to benchmark my model against better established results before proceeding to exercises involving large fluctuations. Since high or explosive inflation was present in several stagflationary episodes, I study the response of output to changes in monetary regime causing large fluctuations in inflation. Specifically, I study the dynamics of output associated with hyperinflationary episodes (section 4) and with large disinflation programs (section 5). A convenient model capable of withstanding large fluctuations is presented in sections 1 and 2.

1. AN ECONOMY WITH STAGGERED CONTRACTS AND MENU COSTS

A fiscalist account of output dynamics associated with large fluctuations in inflation requires a macroeconomic model with three features: (i) it must be solved from its exact equilibrium conditions, for linear approximations become inaccurate when inflation displays large fluctuations; (ii) it must represent nominal rigidities by a state-dependent pricing rule, thus allowing price duration to shorten as inflation accelerates; (iii) it must be a general equilibrium model built on microfoundations, to ensure a correct determination of equilibrium according to fiscalist principles.

The Dotsey, King and Wolman (1998) formulation of state-dependent pricing can be readily incorporated into a fiscalist general equilibrium model. Each period, every firm draws an individual menu cost from a common and time invariant probability distribution. Decisions about whether or not to adjust prices then generate an endogenously determined number of price ‘vintages’ (prices set at different points in the past and still in force). But the resulting equilibrium conditions are quite unwieldy unless they are linearized. To avoid linearization, my economy will have two-period staggered contracts, and firms will have the option to adjust prices halfway into their contracts by incurring a menu cost à la Dotsey, King and Wolman. This sort of cross between staggered contracts and state-dependent pricing has been used by Ball and Mankiw
(1994) and Ireland (1997), except that in their models all firms face the same deterministic menu cost every period. Substituting the stochastic menu costs allows the proportion of firms refraining from midterm adjustments to fall smoothly as inflation accelerates.\(^3\)

I consider an economy in discrete time inhabited by an infinitely lived representative household, a continuum of monopolistically competitive firms indexed by the unit interval, and a government. The government has no demand for goods and does not interfere with firms: its only business is to make lumpsum transfers to and from the representative household. There is no demand for liquidity services, and hence no money holdings. This is convenient but by no means essential in fiscalist models (Woodford, 1998b). The economy is still monetary insofar as it quotes prices and denominates debt instruments in a nominal unit of account. Monetary policy can be described in terms of direct control of nominal interest rates. The only debt instruments are one-period riskless nominal bonds. Firms neither need financing nor hold assets, settling all sales and purchases and distributing all resulting profits within each period. Cost-push effects of interest rates are thus precluded.

The household cares for the continuum of differentiated goods through the CES aggregator:

\[
c_i = \left[ \int_0^1 c_i(z)^{1/\mu} \, dz \right]^{\mu}
\]

where \(\mu > 1\) and \(c(z)\) is the household's consumption of good \(z\). Expenditures are allocated across goods so as to minimize the cost of obtaining a unit of the aggregator \(c_i\):

\[
c_i(z) = c_i p_i(z)^{\mu/\mu - 1}
\]

---

3 One should resist the temptation to put a spin of realism on a modeling strategy pursued for analytic tractability, which is a step back from a more elegant formulation where the timing of price adjustments is fully endogenized. But there might be a real world interpretation for regularly alternating costless and costly price adjustment dates in the life of a firm. Firms might have explicit or implicit price commitments coinciding with a regular renewal cycle of its product line. The cost of a midterm price adjustment could be interpreted as the cost of breaking such commitments, while price adjustment concurrent with product renewal might not be objectionable. That might apply even to the strictest interpretation of menu costs, as
where:

\[ \int_0^1 p_i(z) c_i(z) \, dz = c_i \]

that is, \( p_i(z) \) is the price of good \( z \) relative to the price of a unit of \( c \) obtained as an expenditure minimizing bundle – which is the aggregate price level in this economy.

Each differentiated good is produced by a monopolistic firm, employing labor and intermediate inputs. Denote by \( h(z) \) and \( x(z', z) \), respectively, the number of hours of labor and of units of good \( z' \) used in the production of \( z \). Denote also:

\[ x_i(z) = \left( \int_0^1 x_i(z', z) \, dz' \right)^{\frac{1}{\theta}} \]

a CES aggregator of all inputs used by firm \( z \), with the same elasticity of substitution as in the household’s preferences. Firms use a Cobb-Douglas technology with constant returns to scale where intermediate inputs enter only through that CES aggregator:

\[ y_i(z) = h(z)^{\theta} \, x_i(z)^{1-\theta} \]

where \( 0 < \theta \leq 1 \). In the limit \( \theta = 1 \), output is simply equal to the number of hours employed, and the input-output structure disappears. Firms allocate expenditures across intermediate inputs so as to minimize the cost of obtaining a unit of the CES aggregator \( x(z) \):

\[ x_i(z', z) = x_i(z) \, p_i(z')^{\frac{\mu}{1-\mu}} \]

Each firm \( z \) faces the household’s consumption demand and the intermediate input demand from all firms:

\[ y_i(z) = c_i(z) + \int_0^1 x_i(z, z') \, dz' = (c_i + x_i) \, p_i(z)^{\frac{\mu}{1-\mu}} \]

where I denoted:

\[ \text{the cost of actually posting new price lists, if that operation is subsumed in the periodical distribution of new catalogs entailed by the product cycle.} \]
\[ x_t = \int_0^1 x_t(z) \, dz \]

Measuring aggregate output by the CES index:

\[ y_t = \left[ \int_0^1 y_t(x)^{\frac{1}{\mu}} \, dx \right]^\mu \]

the demand curves obtained above imply that:

(1) \[ y_t = c_t + x_t \]

Firms also allocate expenditures between intermediate inputs and labor in a cost minimizing way:

(2) \[ \frac{x_t(z)}{w_t h_t(z)} = \frac{1 - \theta}{\theta} \]

where \( w \) is the real wage. The firm-specific indices \( z \) can be dropped from equation 2 by integrating over all \( z \) and using:

\[ h_t = \int_0^1 h_t(z) \, dz \]

to denote the total number of hours of labor employed in the economy.

The firm’s cost minimizing condition combined with the production function yields a total cost function. Total cost for firm \( t \) in real terms is:

\[ \frac{w_t h_t(z)}{\theta} = s_t y_t(z) \]

where:

(3) \[ s_t = w_t^\theta (1 - \theta)^{\theta - 1} \theta^{-\theta} \]

denotes the constant marginal cost common to all firms. In particular, when \( \theta = 1 \) and output equals hours, the real marginal cost is simply the real wage rate.

Replacing \( y_t(z) \) in the cost function by the demand curves derived above and integrating over all \( z \), one obtains:
where I use the following price index:

\[
q_t \equiv \left[ \int_0^1 p_t(z)^{\frac{\mu}{1-\mu}} \, dz \right]^{\frac{1-\mu}{\mu}}
\]

Firms indexed by \( z \in [0, \frac{1}{2}) \) freely adjust prices at even-numbered periods, while firms in \([\frac{1}{2}, 1]\) do so at odd-numbered periods. Once a price is posted, firms must honor all forthcoming demand. Outside its costless price adjustment periods, each firm may still adjust prices, but in order to do so it incurs a small menu cost. That menu cost, denoted \( m_t(z) \) for firm \( z \) at time \( t \), is randomly drawn from a probability distribution that is common to all firms and time invariant in units of the average cost of production:

\[
F(m) = \Pr \left[ \frac{m_t(z)}{s_t} \leq m \right], \forall z \text{ and } t
\]

I assume that the distribution \( F \) has support in \( R_+ \). Randomness of menu costs is the only form of uncertainty in this economy, where all agents have perfect foresight about the aggregate conditions.

Before menu cost payments, time \( t \) profits of firm \( z \) in real terms are:

\[
d_t(z) = [p_t(z) - s_t] y_t p_t(z)^{\frac{\mu}{1-\mu}}
\]

If firms were free to set prices costlessly at each period, their profit maximizing choice would be \( p_t(z) = \mu s_t \), for all \( z \). The parameter \( \mu \) represents the desired mark-up of prices over marginal cost, common to all firms.

Denote by \( n_t(z) \) the new price chosen at \( t \) by a firm \( z \) that can costlessly adjust prices at that date, deflated by the aggregate price level. Let \( a_t(z) \) denote the new price chosen at that same date by a firm \( z \) that must incur menu costs to adjust, also deflated by the aggregate price level. The optimal choice of \( a_t(z) \) is very simple: because firm \( z \) will have a chance to adjust prices
costlessly come next period, it must only care about maximization of current profits, and its
decision boils down to the flexible price profit maximizing choice of:

$$a_t = \mu s_t$$

Because of the symmetry among demand functions, that new price is the same for all firms that
end up adjusting in spite of incurring menu costs.

Now denote by $\alpha_t(z)$ the probability, as seen from time $t-1$, that a firm $z$ subject to menu
costs at $t$ will end by not adjusting prices at that date, once it learns the realization of its own
menu cost. Choosing not to adjust, but instead to maintain the price set costlessly at $t-1$, firm $z$
would profit:

$$\left[ \frac{n_{t-1}(z)}{\pi_t} - s_t \right] y_t \left[ \frac{n_{t-1}(z)}{\pi_t} \right]^{\frac{\rho}{1-\rho}}$$

at time $t$, where $\pi_t$ denotes the rate of inflation between dates $t-1$ and $t$ (the gross variation in the
aggregate price level). The firm would instead profit:

$$(\mu - 1) s_t y_t (\mu s_t)^{\frac{\rho}{1-\rho}} - m_t(z)$$

if it chose to adjust to the optimal $a_t$ found above. Adjustment occurs if and only if the latter is
greater than the former, because only profits at $t$ matter for the pricing decision of a firm that will
have a costless adjustment opportunity at $t+1$. Therefore, the probability of adjustment is:

$$1 - \alpha_t(z) = F_t \left( (\mu - 1) s_t y_t (\mu s_t)^{\frac{\rho}{1-\rho}} - \left[ \frac{n_{t-1}(z)}{s_t \pi_t} - 1 \right] y_t \left[ \frac{n_{t-1}(z)}{\pi_t} \right]^{\frac{\rho}{1-\rho}} \right)$$

The choice of $n_t(z)$ maximizes the part of the discounted sum of current and expected
future profits that depends on that decision. Because a new costless adjustment opportunity
occurs every other period, only profits at $t$ and $t+1$ enter that problem:

$$n_t(z) = \arg \max_{n_t} \left( (n - s_t) y_t n^{\frac{\rho}{1-\rho}} + \frac{\alpha_{t+1}(z)}{R_t} (n - s_t \pi_{t+1}) \pi_{t+1} (n \pi_{t+1})^{\frac{\rho}{1-\rho}} + \right.$$
where \( R_t \) is the gross nominal interest rate between dates \( t \) and \( t+1 \), and:

\[
\overline{m}_n(z) = E \left[ m(z) \left| \frac{m(z)}{s(z)} < F^{-1}[1 - \alpha_{s+1}(z)] \right. \right]
\]

denotes the menu cost firm \( z \) expects to pay conditional on such cost being small enough to trigger price adjustment. Dependence of \( \overline{m}_n(z) \) on \( z \) runs solely through dependence of \( \alpha_{s+1}(z) \) on \( z \), and the latter comes exclusively from dependence of \( n(z) \) on \( z \). Regarding the \( \overline{m}_n(z) \) and \( \alpha_{s+1}(z) \) terms in the objective function above as functions of the maximand \( n \), one notes that the maximization problem is the same for all firms facing a costless price adjustment at \( t \). If all those firms post the same \( n_0 \), then \( \alpha_{s+1} \) and \( \overline{m}_n \) are also common to all of them. As a consequence, the common \( \alpha_{s+1} \) has the interpretation of the proportion of firms facing menu costs at \( t+1 \) that choose not to adjust prices at that date. The firm-specific indices \( z \) can then be dropped from \( \delta \).

The first order condition for optimal choice of \( n \) can be turned into:

\[
n_t = \mu \frac{y_t s_t + \frac{\alpha_{s+1} \mu}{R_t} y_{s+1} \pi_{s+1} s_{s+1} \pi_{s+1}}{y_t + \frac{\alpha_{s+1} \mu}{R_t} y_{s+1} \pi_{s+1}}
\]

The firm applies the desired mark-up to a weighted average of the current and next period's marginal costs, with weights that reflect discounting, the probability of the current price remaining in force in the next period, and the demand conditions faced by the firm in each period. The first order condition may be recognized as the same that would obtain if firms chose \( n_t \), taking \( \alpha_{s+1} \) as given. The envelope property is explained by the fact that \( \alpha_{s+1} \) is specified as resulting, for each \( n_0 \), from a profit maximizing pricing plan for \( t+1 \) contingent on the realization of the menu cost. That could also be regarded as an optimal choice of \( \alpha_{s+1} \) for each \( n_0 \), with the additional proviso that firms adjust prices at the lowest realizations of their menu cost measuring up to
probability $1 - \alpha_{t+1}$. The envelope property holds because the latter choice also satisfies a first order condition.

The definition of the price indices further requires that:

\begin{align}
\frac{1}{2} \pi_t^{-\mu} + \frac{\alpha_t}{2} \left[ \frac{n_{t+1}}{\pi_t} \right]^{1-\mu} + \frac{1-\alpha_t}{2} a_t^{1-\mu} &= 1 \\
\frac{1}{2} \pi_t^{-\mu} + \frac{\alpha_t}{2} \left[ \frac{n_{t+1}}{\pi_t} \right]^{1-\mu} + \frac{1-\alpha_t}{2} a_t^{1-\mu} &= q_t^{1-\mu}
\end{align}

The profits of all firms are distributed to the representative household, as are also the total menu costs incurred each period. In Dotsey, King and Wolman (1998), the menu cost represents labor required for the act of adjusting prices. I do not want to have the output effects of price misalignment – deviations from the trajectory of prices that would obtain in the absence of nominal rigidities – confounded with effects due to variations in real resources absorbed by price adjustment, in cases where inflation changes enough to have a perceptible effect on $\alpha$. That is why I specify the menu costs as lumpsum transfers to the representative household that do not correspond to any use of real resources.

The representative household then maximizes:

$$\sum_{x_0} \beta'[u(c_r) - v(h_r)]$$

subject to the intertemporal budget constraints:

$$b_{c+1} R_{c+1} \pi_t \geq \sum_{x_0} c_{t+2} - w_{t+2} h_{t+2} - d_{t+2} - g_{t+2}$$

In the above,

$$d_t \equiv \int_0^1 d_t(x) dx$$
and \( g_i \) are the real lumpsum transfers the representative household receives from all firms (net profits plus menu costs) and from the government, respectively, and \( b_i \) is the real value at the time of issue of bonds carried by the household from \( t \) to \( t+1 \). The intertemporal budget constraints simply state that the excess of lifetime spending over lifetime disposable income, in present discounted value, cannot be more than the initial financial wealth.

The first order conditions for the household's problem can be turned into:

\[
(10) \quad u'(c_i) = \beta \frac{R_i}{\pi_{t+1}} u'(c_{i+1})
\]

\[
(11) \quad \nu(b_i) = u'(c_i) w_i
\]

For optimality, the intertemporal budget constraint must also hold with equality.

Because firms are assumed not to hold assets from one period to the next, current revenues must be used up in purchases of intermediate inputs, payments of wages, and transfers of menu costs and net profits:

\[
x_i(z) + w_i h_i(z) + d_i(z) = p_i(z) y_i(z)
\]

which integrated over all firms becomes:

\[
w_i h_i + d_i = y_i - x_i
\]

Substituting the latter combined with equation 1 into the intertemporal budget constraint of the household (holding with equality), one obtains:

\[
(12) \quad \frac{b_i R_{t+1}}{\pi_t} = \sum_{\omega \in \omega} \beta^{\omega} \prod_{\omega + 1}^{\omega} \frac{R_{t+1}}{\pi_{t+1}}
\]

which is recognized as the government's intertemporal budget constraint. Note that no such constraint has been imposed on the government's choice of a sequence of budgets. It appears here as an equilibrium condition that results from exhaustion of the household's intertemporal budget constraint together with market clearing. This subtlety lies at the core of fiscalist price determination, as the next section will make clear.
Somewhat of a technical nuisance in characterizing equilibrium in this type of model is created by the fact that the above first order condition for \( n \) is necessary but not sufficient for an interior solution to the profit maximization problem. The firm’s objective function need not be concave, unlike the period by period profit function under flexible prices, or forward looking profit functions with exogenous probabilities of price adjustment. Therefore, one must screen equilibrium candidates satisfying the first order conditions to verify if each involves at every date a global maximum of the firm’s pricing problem given the aggregate variables in that equilibrium.\(^4\)

2. DETERMINACY OF EQUILIBRIUM

Two different equilibrium indeterminacy problems might be expected in this economy. The first is the price level indeterminacy pervasive in rational expectations monetary models. The second is the multiplicity of equilibrium degrees of nominal rigidity common to models of state-dependent price adjustment. I examine each problem in turn.

A. Price level indeterminacy

Price level indeterminacy was the original motivation for the fiscalist approach to price determination. Both the indeterminacy problem and the fiscalist solution can be most easily understood in a flexible price model. Consider the system of equations 1-12 with a distribution \( F \) assigning probability 1 to \( M(\delta) = 0 \), and with \( \theta = 1 \). In this case, \( \alpha_t = 0 \) always, and then \( s_t = 1/\mu \) and \( n_t = 1 \). Also, \( c_t = h_t = y_t \) all constant and determined by equation 11:

\[
\mu v'(y_t) = u'(y_t)
\]

With output tied to the constant ‘potential’ level, the model reduces to the following simplification of equations 10 and 12 (\( \forall t \geq 0 \)):

\[
(n_t - s_t) y_t \pi_t^{-\gamma} + \alpha_t \frac{\pi_m}{R_t} \left[ \frac{n_t}{\pi_m} - s_m \right] y_m \left[ \frac{n_t}{\pi_m} \right]^{\gamma} + (1 - \alpha_t) \frac{\pi_m}{R_t} (\mu - 1) s_m y_m (\mu s_m)^{\gamma} - \frac{\pi_m}{R_t} s_m \int xdF(x)
\]

\(^4\) At every point in time, from all \((n_t, \alpha_t)\) satisfying equations 6 (for \( t+1 \)) and 7, equilibrium must contain those yielding the maximum value of:
where $b_1$ and $R_1$ are given as initial conditions. Equations 13 impose no restriction on $π_0$; if nominal interest rates are exogenous, initial inflation does not even appear there; if nominal interest follows a rule with feedback from past inflation, 13 becomes a difference equation in $π_n$ which does not itself contain an initial condition for $π_0$. If one assumes that $\{g_t\}_{t=0}^\infty$ is always chosen so as to satisfy equation 14 at $t = 0$ for all initial conditions and realizations of $π_0$, then that equation does not pose any restriction to $π_0$ either. Requiring this sort of endogeneity of fiscal budgets can be interpreted as subjecting the government to an intertemporal budget constraint that it must plan to satisfy regardless of the path of the economy. That is the implicit conventional assumption in monetary models, leading to price level indeterminacy.

The monetary theorist’s usual response is to select a unique equilibrium based on locality criteria. Certain monetary policy regimes will launch the economy onto an explosive inflationary trajectory unless it starts at a certain initial price level. When that is the case, the unique price level consistent with bounded inflation is selected as the relevant equilibrium. But certain monetary policies do not create that generic instability – as for instance a pure interest rate peg – and leave indeterminacy immune to selection criteria based on ruling out explosive paths.5

The fiscalist approach to price determination considers instead the case in which the path of fiscal budgets does not adjust endogenously in order to satisfy equation 14. If that is the case, equation 14 may help determine the initial price level. The initial equilibrium price level determined in that way is such as to make the real value of the financial wealth the household

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5 Sargent and Wallace (1975) and McCallum (1981) are classic references on this problem. A good review can be found in Kerr and King (1996). Obstfeld and Rogoff (1983) ask the additional question of whether ruling out ‘speculative hyperinflations’ can be justified from first principles in models derived from intertemporal utility maximization by a representative household. For a more general treatment of this class of indeterminacy problem, see Woodford (1995) and Benhabib, Schmitt-Grohé and Uribe (1998).
brings from the past just enough to compensate for the present discounted value of current and future net taxes. In the attempt to exhaust its intertemporal budget constraint, the household will want to consume as much as it earns period by period, and the market for goods will clear. If the initial price level were instead any lower, say, the household would feel richer in real terms, and try to consume in excess of supply; excess demand would bid prices up towards equilibrium. As for the government, its intertemporal budget constraint is satisfied in the fiscalist equilibrium, although it would be violated at any other initial price level.

In particular, equations 13 and 14 reveal that nominal indeterminacy disappears if \( \{g_t\}_{t \geq 0} \) is set exogenously (with no feedback from endogenous variables in the model), even if monetary policy sets \( \{R_t\}_{t \geq 0} \) exogenously as well. With the nominal rigidities built into equations 1-12, the model contains more restrictions on \( \pi_0 \) than the flexible price version, but on the other hand equilibrium output is no longer tied immutably to potential output. As a result, although the indeterminacy problem just discussed is no longer purely nominal, it persists in sticky price models, and the fiscalist solution also carries through.

For simplicity, I will restrict attention all along to policy regimes in which both nominal interest rates and primary budgets are exogenous. Because I will not be interested in fiscal shocks, I further restrict attention to the case of constant budget deficits \( g \). More specifically, I assume that primary budgets are always in a surplus consistent with the real value of the government debt remaining constant at \( b_1 \) if the real interest rate remained always at the level consistent with constant consumption, namely \( R/K_{t+1} = 1/\beta \). The required primary budgets are:

\[
g_t = \frac{\beta - 1}{\beta} b_1
\]

for all \( t \geq 0 \), which reduce equation 12 (for \( t = 0 \)) to:

\[
(15) \quad \sum_{s \geq 0} \prod_{r \geq 0} R_{r,s}^{-1} = \frac{\beta}{1 - \beta}
\]
The intertemporal budget constraint will hold with equality if and only if any fluctuations in the current and future real interest rates compensate each other so as to keep the sum of products on the left-hand side of equation 15 constant. Substituting the single-dated equation 15 for the sequence of equations 12, I need not make reference to fiscal variables any longer, and the only initial conditions needed are $n_1$ and $R_1$.

**B. Equilibrium degree of nominal rigidity**

Multiplicity of equilibrium degrees of price rigidity in state-dependent pricing models amounts to a static coordination failure. Firms are more willing to adjust prices if more of their competitors also adjust prices in the same direction, because the demand for their goods is a decreasing function of their own relative price. The presence of strategic complementarity in pricing implies that it may be optimal for each firm to have a low probability of adjustment if others are unlikely to adjust, and to have a high probability if others are more likely to adjust. Therefore, for the same rate of inflation, there might be multiple equilibria involving different proportions of firms adjusting prices (Ball and Romer, 1991).

Formal analysis of this problem has traditionally focused on multiplicity of responses of a static or stationary economy to monetary shocks that, without nominal rigidities, would call for a one time and permanent adjustment of prices. John and Wolman (1998) propose, as the natural first exercise to perform in inherently dynamic economies such as mine, to verify whether they display, for each stationary rate of inflation, multiple symmetric steady states with different degrees of price rigidity. They carry that exercise out for the original version of the Dotsey, King and Wolman (1998) model, and find that: (i) multiplicity of symmetric steady state equilibria is a rare event; (ii) symmetric steady state equilibrium may fail to exist for an intermediate, but quite narrow, range of inflation rates. In spite of the modifications made to the price adjustment structure, these results are confirmed by my model.

Symmetric steady state candidates are solutions to 1-11 where all variables remain constant (15 can be safely ignored as it will clearly be satisfied by any such path). Because of the
additional complication of having to screen these candidates for profit maximization, I follow
John and Wolman and solve the steady state model numerically for given functional forms for $u$, $v$ and $F$, and a parametrization that I will maintain for the remainder of the paper. Utility is assumed to be logarithmic in consumption and quadratic in hours of work: $u(c) = \log(c)$ and $v(h) = h^2$. Making $\beta = .99$, which implies a steady state real rate of return of approximately 1%, suggests interpreting the model’s period as a quarter in developed economies (shorter for economies with structurally higher equilibrium real interest rates). A flexible price mark-up of 20% is represented by $\mu = 1.2$. Menu costs are distributed exponentially with mean $1/50$ (i.e., their unconditional expectation is 2% of average costs).

The upper panel of figure 1 depicts the steady state degrees of price rigidity associated with each stationary rate of inflation between 0 and 20%, for $\theta = 1$ (making $\theta$ lower leads to qualitatively similar results). There is no instance of multiplicity in this example, and no pure strategy, symmetric steady state exists for inflation rates between 16.15% and 16.68% per period. These results are perfectly in line with John and Wolman’s. As one should expect, the degree of price rigidity $\alpha$ is unity when inflation is zero (no firm ever adjust prices, let alone when it must pay menu costs), and falls towards zero as inflation becomes higher and higher.

In the lower panel I plot the corresponding steady state output levels (normalized by steady state output with zero inflation). Hours are not plotted because their change is barely perceptible on the same scale – a consequence of my specification of $u$ and $v$. As inflation increases, output initially falls, while the level of employment remains virtually unchanged. In this economy with $\theta = 1$, where $y(x) = h(x)$ for every firm, total hours may also be regarded as a linear aggregator of output. That a wedge is drawn between the CES aggregator $y$ and $h$ reflects

\[\text{If equilibrium candidates were not screened for global profit maximization, multiple equilibria would appear in an intermediate range of inflation rates (roughly between 16.1% and 17.0%) and again for very high inflation (above 70%), and there would be no case of non-existence. Indeed, with the functional forms chosen above, it is straightforward to verify that, for every given rate of inflation, there is always a steady state solution to 1-11.}\]
an increase in price dispersion (as inflation gets higher but $\alpha$ falls too slowly), which causes demand to concentrate on goods that are relatively cheaper. However, output recovers once the fall in $\alpha$ becomes pronounced enough to reduce price dispersion, and converges back to its zero inflation level as the economy approaches full price flexibility. As a matter of fact, all real variables (other than $\alpha$ and $\pi$, of course) converge back to their zero inflation steady state levels as stationary inflation tends to infinity.\[8\]

3. LOCAL ANALYSIS

Now I turn to the model's dynamics in the vicinity of a zero inflation steady state. The response of my economy to small monetary shocks in that region is of interest in its own right, since that is the type of exercise usually conducted with alternative models of price stickiness. Direct comparability with results from familiar time-dependent pricing models may also shed some light upon interesting properties of my economy, which will manifest themselves again in experiments with large shocks.

The model is solved for a perfect foresight equilibria as a two-point boundary value problem. For that purpose, the infinite sequence of equilibrium conditions 1-11 is truncated at some finite terminal date. The infinite sum on the left-hand side of equation 15 must be truncated accordingly. That is done by noting that the intertemporal budget constraint can be written as:

$$\sum_{n=0}^{\infty} \frac{\pi_{t-n}}{R_{t-n}} + \left[ \prod_{n=0}^{\infty} \frac{\pi_{t-n}}{R_{t-n}} \right] \sum_{n=T+1}^{\infty} \prod_{n=T+1}^{\infty} \frac{\pi_{t-n}}{R_{t-n}} = \frac{\beta}{1-\beta}$$

If equation 15 is assumed to hold from date $T+1$ the same way as it holds from date 0:

$$\sum_{n=T+1}^{\infty} \prod_{n=T+1}^{\infty} \frac{\pi_{t-n}}{R_{t-n}} = \frac{\beta}{1-\beta}$$

then one can replace 15 with:

---

7 It is trivial to verify analytically that $\alpha = 1$ is the only equilibrium when $\pi = 1$.
8 It can be shown analytically that all 'real' variables must converge back to their zero inflation levels as inflation tends to infinity, provided that the degree of price rigidity falls fast enough (as it does in all 'confirmed' equilibrium candidates here).
Equation 16 is not an innocuous assumption. It is certainly true that \( b_t \) must hold from any later date \( T+1 \) as well as from zero, with the actual \( b_T \) generated by the model. However, it is not necessarily true that \( b_T = b_1 \), another requirement for 15 to hold from date \( T+1 \) with the given primary budgets. That would be true, in particular, if the real interest rates satisfied \( R_t = \frac{1}{\beta} \) for all \( t \) between 0 and \( T \) since the constant primary budget deficits are consistent with real debt remaining constant at \( b_1 \) under those circumstances. But real interest cannot remain constant at the natural rate while the economy suffers output fluctuations. Another way of obtaining 16 is to assume that all output fluctuations triggered at date 0 have already died away by date \( T+1 \), with real interest remaining at the natural rate \( 1/\beta \) from then on. Although real interest fluctuates with output between 0 and \( T \), it must have balanced upward and downward fluctuations in such a way as to lead \( b_t \) back to starting point \( b_1 \) by \( t = T \). Otherwise, equation 12 could not hold with the same constant primary budgets and real interest at the natural rate forever after. That is exactly the assumption being made here, and terminal dates for the numerical solution of the model will be chosen accordingly.

Equations 1-11 (for \( t = 0 \ldots T-1 \)) and equation 17 involve only variables dated from \( t = 0 \) to \( t = T \), except for \( n \) and \( R \), which appear dated from \( t = -1 \) to \( t = T-1 \). The initial conditions specified for \( n_1 \) and \( R_1 \) and terminal conditions for the variables dated \( t = T \) are all consistent with a zero inflation steady state. The equilibrium conditions form a large system of nonlinear equations that can be solved iteratively by Newton's method, with the sequence of nominal interest rates taken as given. Once a solution is obtained, one can verify whether the equilibrium pairs \((n_t, a_{t+1})\) maximize profits at each date, under constraints 6 and 7 and given the values of all other variables in the solution.

\[
\frac{1 - \beta}{\beta} \sum_{k=0}^{T-1} \frac{\pi_k}{R_{k+1}} + \frac{1}{\beta} \prod_{k=0}^{T-1} \frac{\pi_k}{R_{k+1}} = 1
\]

Equation 16 is not an innocuous assumption. It is certainly true that 12 must hold from any later date \( T+1 \) as well as from zero, with the actual \( b_T \) generated by the model. However, it is not necessarily true that \( b_T = b_1 \), another requirement for 15 to hold from date \( T+1 \) with the given primary budgets. That would be true, in particular, if the real interest rates satisfied \( R_t = \frac{1}{\beta} \) for all \( t \) between 0 and \( T \) since the constant primary budget deficits are consistent with real debt remaining constant at \( b_1 \) under those circumstances. But real interest cannot remain constant at the natural rate while the economy suffers output fluctuations. Another way of obtaining 16 is to assume that all output fluctuations triggered at date 0 have already died away by date \( T+1 \), with real interest remaining at the natural rate \( 1/\beta \) from then on. Although real interest fluctuates with output between 0 and \( T \), it must have balanced upward and downward fluctuations in such a way as to lead \( b_t \) back to starting point \( b_1 \) by \( t = T \). Otherwise, equation 12 could not hold with the same constant primary budgets and real interest at the natural rate forever after. That is exactly the assumption being made here, and terminal dates for the numerical solution of the model will be chosen accordingly.

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9 The iterative solutions in this exercise with small shocks match the responses obtained from a linearized version of the model solved directly by the method of Blanchard and Kahn (1980).
The solid lines in figures 2.a-c are the response of the economy with \( \theta = 1 \) to different trajectories of nominal interest rates. I set \( R_0 \) 1% higher than the level consistent with a zero inflation steady state (since these are gross rates and \( R_1 = 1.01 \), this roughly amounts to the net rate doubling from 100 to 200 basis points). The nominal rate then decays back to the zero inflation steady state according to \( R_t = \delta R_{t-1} + (1 - \delta) \beta^{-1} \). I plot the trajectories of selected variables until \( t = 6 \), where most of the 'real' action concentrates, for \( \delta = 0, 0.5, \) and \( 0.9 \). Output is normalized by its zero inflation steady state, and hours are not plotted because they differ from output by a smaller order term in this local experiment.

The results indicate that: (i) on impact, monetary tightening causes stagflation, as \( \pi_0 \) jumps up and \( y_0 \) jumps down; (ii) real fluctuations are short lived, regardless of the persistence of the monetary tightening, and the economy is very close to potential output after two to three periods; (iii) output returns to potential through dampened two-period cycles, and in particular it rebounds beyond potential in the period following the monetary shock; (iv) increasing the persistence of the monetary shock considerably reduces the size of that overshooting compared to the initial recession.

Lack of persistence in real fluctuations caused by monetary shocks should come as no surprise in a model of staggered two-period price commitments. Adding the midterm price adjustment opportunities is indeed expected to aggravate the problem. That responses take the form of dampened cycles is also a common feature of models with two-period staggered contracts. Although staggering cycles are certainly a part of the story regarding my model, things are little more complicated here: fiscalist equilibrium determination plays a part of its own in creating the tendency for output to boom following the initial recession. This is best discerned by appending a fiscalist demand block to a model of staggered prices that is known not to produce output overshooting under conventionally determined equilibria. One such model is Calvo's (1983); under perfect foresight and after linearization around a zero inflation steady state, its
supply block reduces to \( \dot{\pi}_r - \beta \hat{\pi}'_{\text{hi}} = \kappa \dot{y}_r \), where hatted variables denote percentage deviations from the value of their non-hatted counterparts at the zero inflation steady state. This can be appended to the linearized demand side of my model, and exposed to the same monetary tightening experiments as above \((\delta = 0, 0.5, \text{and} 0.9)\). The dashed lines in figures 2.a-c are the responses of Calvo’s model, with \( \kappa \) calibrated so that the impact on \( y_0 \) is the same as in my model when \( \delta = 0.5 \) (this requires \( \kappa = 1.97 \)). With the fiscalist demand block, Calvo’s model does display overshooting, although not in the form of dampened cycles: after the instantaneous recession, output recovers beyond potential and then monotonically decays back to steady state. Increasing the persistence of the monetary tightening may prolong the recession a little, but it stretches (and flattens) the subsequent boom even more.

This is the point when there may be interest in exploring the economy with an input-output structure (with \( \theta < 1 \)). That has been suggested by Basu (1995) as a possible fix for the lack of persistence of real effects of monetary shocks in sticky price models. It would make other prices feed more directly into the marginal costs faced by each firm, instead of working only through general equilibrium effects on the wage rate. That might further discourage upward price adjustment when other prices do not adjust, besides the loss of demand caused by too high a relative price. Chari, Kehoe and McGrattan (1996) report rather negatively on the gains from that fix; Bergin and Feenstra (1998), on the other hand, offer indication that it might make the real effects of monetary shocks more persistent and eliminate output overshooting in the period following the shock. \(^1\)

Figures 3.a-c display the results obtained with an input-output structure in my fiscalist model. The economy is again exposed to the same paths of nominal interest rates, and in each

\(^{10}\) The parameter \( \kappa \) is fully determined by the same structural parameters appearing in my model and Calvo’s exogenous probability of price adjustment for any firm at each date. That probability is certainly not the same as my \( \alpha \), and to get results that I can meaningfully compare to mine, I treat it as a free parameter here.
case I report the results for $\theta = 1$ (solid lines), 0.5 (dashed) and 0.1 (dotted). Here, decreasing the share of labor in the costs of production makes overshooting more rather than less pronounced. Nevertheless, it does eliminate output cycling; indeed, it makes the responses look more and more like those of the economy with Calvo's supply block. That is consistent with the results of Bergin and Feenstra, since the overshooting they cure is entirely due to staggering cycles. Here, on the other hand, the output rebound inherent to fiscalist equilibrium determination is amplified by the input-output structure.

The occurrence of an output boom following the initial recession is quite robust to parametrization. There seems to be no simple analytical proof that it must always occur, but cursory inspection of the equilibrium conditions above may intuitively clarify why it tends to happen so regularly. Equation 15 implies that, with exogenous primary deficits, fluctuations in real interest rates must resolve themselves in a way that eventually brings real government debt back to $b_1$. If the initial recession takes the form of an unforeseen downward jump in equilibrium output, and output must go up back to potential, that latter movement requires real interest rates to remain higher than the natural rate for some time. The intertemporal budget constraint then requires some balancing realizations of real interest rates below the natural rate. If that is to happen at any date later than $t = 0$, it will only be consistent with output falling at such point, which can be accommodated by output having already overshot potential. Granted, there is also $R_1/\pi_0$ that may realize below the natural rate (that interest rate is only relevant for allocation decisions between $t = -1$ and $t = 0$, which are bygones when monetary news arrive at $t = 0$), thus helping take care of the intertemporal budget constraint and alleviating the need for later output drops. As a matter of fact, it does, because of the immediate inflationary impact of monetary tightening (and predetermined $R_1$). But the initial jump in inflation, which is also restricted by the remainder of the model, is insufficient to allow for a monotonic return of output to potential.

Bergin and Feenstra also substitute translog for CES preferences and find the greatest degree of persistence when those are used in conjunction with an input-output structure. Here, I refer to the results
4. HYPER-STAGFLATION

This section studies the output effects of switching from the zero inflation steady state to a perfect foresight equilibrium where nominal interest rates explode. As a result, given the path of primary budgets, the rate of growth of nominal government debt also explodes, and drags along the rate of inflation as necessary to prevent real government debt from growing out of line with the intertemporal budget constraints.

This exercise is inspired by my suggestion elsewhere (Loyo, 1999) that, under the type of fiscal regime considered here, hyperinflation could be explained as the equilibrium outcome of a monetary policy regime in which higher inflation caused by higher nominal interest rates leads to further nominal interest increase and further inflation acceleration. There, I consider interest rate rules with endogenous response to inflation, explicitly creating such self-reinforcing inflation-interest rate spiral, but here I will be contented with examining exogenously exploding paths of nominal interest rates.

When hyperinflation is accompanied by output contraction, sometimes very sharp, explanations tend to look into adverse supply shocks. Of course, supply shocks by themselves should not lead to permanently higher inflation, let alone to an explosive trajectory of inflation rates. Observers of hyper-stagflationary episodes then face some tension between the need for a particularly accommodative monetary stance to justify the dramatic inflationary explosion, and at the same time the need for a particularly non-accommodative monetary stance to explain the depth of the recession. If my model delivers recession with explosive inflation in response to incessant increases in nominal interest rates, it might be able to explain such episodes even in the absence of supply shocks. At any rate, it would alleviate the tension just mentioned whenever adverse supply shocks are allowed to retain a role.

As inflation explodes, the economy converges to a situation in which every firm adjusts prices every period in spite of menu costs. All real variables converge back to their values at the they report for the input-output economy with CES preferences.
zero inflation steady state – this has been seen in connection with steady states associated with
different rates of inflation, and holds also for dynamic perfect foresight equilibria with exploding
inflation. Convergence of output to a constant value as inflation increases without bound is
important for my numerical solution method. The truncation of the infinite horizon intertemporal
budget constraint relied on real interest rates having stabilized back at the natural rate by the
terminal simulation date. That rules out any noticeable output fluctuation being expected beyond
that date, which is a good approximation provided that inflation has already accelerated
sufficiently by then. In all simulations of this section, initial conditions are consistent with the
zero inflation steady state, and nominal interest rates are raised linearly from $1/\beta$ to 30%. At that
point, $\alpha$ will be sufficiently close to zero. I consider only the case $\theta = 1$, and the structural
parameters used above are all maintained.

Figures 4.a-c display the response of the economy to interest explosions of different
speeds – respectively, cases in which the linear trajectory of $R_{t+1}$ reaches 1.3 at $t = 4, 8$ and 12. As
in the experiments with small interest rate shocks, output falls immediately upon the change in
monetary regime and rebounds above potential later on. But here the recession tends to be more
persistent: in figure 4.a, it already extends to $t = 1$, reaching $t = 5$ in figure 4.c, while recession
from local shocks was limited to $t = 0$. The rebound is still short lived.

Another interesting feature that was absent in the vicinity of the zero inflation steady state
is the divergence between the CES output aggregator and the total number of hours worked. That
wedge first widens, and then closes down again. As mentioned in connection with steady states,
that happens because the initial fall in $\alpha$ is too slow compared with inflation acceleration, leading
to more price dispersion and to concentration of demand on relatively cheaper goods. As inflation
accelerates further, $\alpha$ drops faster and reduces price dispersion. Recession measured by output is
thus deeper than if measured by employment. When inflation explosion is sufficiently slow (as in
figures 4.b-c), output may continue to fall below its initial response to the shock, in spite of
recovering employment. The expected fall in output requires real interest to be lower than the natural rate during some of the initial recession phase (that is, even before output rebounds and needs to fall back to potential).

There is an important caveat to the interpretation of the speed of the inflationary explosion and the length of the ensuing recession, however. In the local analysis of section 3, the calibration suggests interpreting one time period in the model as one quarter. That connection with calendar time becomes more fragile in the explosive case: it would imply that the average price duration is close to two quarters when inflation is sufficiently low but only falls down to one quarter no matter how high inflation becomes. It seems clear that price duration should fall by a factor of much more than 2 when inflation goes from 0 to a terminal rate close to 30%. For that reason, model time cannot be realistically mapped into calendar time when inflation changes a lot, and the responses in figures 4.a-c are meant as a qualitative illustration only. A realistic account in this dimension would require a much richer staggering structure, parametrized to make the model period correspond to a very short calendar time, and yet capable of producing credible price durations when inflation is low. That would bring the model very close to the original formulation of Dotsey, King and Wolman (1998), with the resulting difficulties in solving for equilibrium without linearization.

5. STOPPING HIGH INFLATION

An explanation for slumps concurrent with explosive inflation immediately begs the question of how output responds to changes in monetary regime meant to stop high inflation. In this world of tight money paradoxes and interest rate control, equilibrium inflation can only be persistently high because the nominal interest rate is high, and disinflation simply calls for a cut in nominal interest rates. I examine in this section the real effects of different paths of nominal interest reduction. Again, I restrict attention to the case \( \theta = 1 \).

First of all, note that disinflation improves welfare. In this model there is no liquidity demand and thus no welfare loss from economizing on costly money balances. Also, the act of
price adjustment was assumed not to absorb real resources. But steady state inflation still affects welfare through price dispersion, which decreases consumption relatively to hours of work. Figure 1 reveals that intermediate inflation is the worst of the worlds, because it maximizes price dispersion. Realistically, of course, runaway inflation and frequent price adjustment would absorb real resources, and that would be grounds to prefer zero inflation instead.

Stopping extremely high inflation is an uninteresting exercise in this model: when inflation becomes very high, and \( \alpha \) close enough to 0, price adjustment asynchronization virtually disappears, and instantaneous stabilization can be achieved without output fluctuation. In particular, there is no point in adopting gradual stabilization strategies, as those would only make the economy traverse the intermediate range of inflation rates where price dispersion kicks in.

If the economy lives with high but not yet extreme inflation (in the sense that \( \alpha \) is still far from 0), then one would expect from the results already presented that a reduction in nominal interest rates would cause a temporary boom in activity, with the subsequent output overshooting now showing up in the form of a later recession. Figure 5 confirms these predictions. It displays the response of an economy starting from a 10% inflation steady state, hit at date \( t = 0 \) by news that the nominal interest rate will be at the zero inflation steady state level ever after (that is, \( R_t = 1/\beta \) for all \( t \geq 0 \)). The dotted lines in the panels on the right are the equilibrium levels of \( \alpha \) and \( y \) at the 10% inflation steady state (the latter normalized by equilibrium output at the zero inflation steady state). On impact, output and hours jump up, higher than their steady state levels consistent with zero inflation, to which they converge through the habitual dampened cycles. In particular, output and hours are below the zero inflation steady state at \( t = 1 \). For employment, that is lower than the 10% inflation steady state level, but not for output, which benefits also from a drastic reduction in price dispersion.

Figures 6.a-c show what happens if the 'cold turkey' disinflation strategy is replaced by a more gradual approach. In these figures, \( R_{t+1} \) linearly decays from the 10% inflation to the zero
inflation steady state level, reaching the latter at \( t = 2, 4 \) and 8, respectively. Interestingly, output now jumps up on impact but continues to increase for some time, eventually overshooting its zero inflation level. The more gradual the disinflation, the less it jumps on impact and the longer it keeps increasing. Employment jumps up and gradually decreases back to steady state. These quite persistent fluctuations are noteworthy compared to the short lived effects of local disturbances seen in section 3. Also, expected increases in output require real interest rates to be above the natural rate, and so one expects (as usual) to see high real interest rates associated with a gradual transition from high to low inflation, despite that transition being brought about here by persistent monetary loosening. That is possible thanks to the upward room opened for output as price dispersion disappears.

One might be interested in ranking the different stabilization strategies according to some welfare measure. The natural candidate to measure welfare is the representative household's lifetime utility, which is entirely determined by the trajectories of output and hours. Because the zero inflation steady state is the stationary equilibrium with the highest lifetime utility, I report in the header of each figure for this section the corresponding value of:

\[
w = \sum_{t=0}^{\infty} \beta^t [\log(y_t) - h_t^1] - \sum_{t=0}^{\infty} \beta^t [\log(y_t) - h_t^2]
\]

where the variables with overbars correspond to the zero inflation steady state. Such welfare measures can be approximately computed under the assumption that the terminal date used in the solution of the model (which is not the last date appearing in the figures) is far enough in the future for output and hours to be already sufficiently close to their zero inflation steady state values. As it turns out, the earliest disinflation is completed the better: making the disinflation more gradual only leads to more welfare loss.

Indeed, cold turkey disinflation turns out to be preferable regardless of the initial inflation rate. This result contrasts with the findings of Ireland (1997), which indicate that small inflations are better stopped gradually, whereas very high inflations are better stopped cold turkey. Our
models differ in a number of basic dimensions, such as the calibration of the utility function parameters and the nature of the menu costs (in my model, menu costs are stochastic but involve no use of real resources; in his, menu costs are fixed and represent labor employed in the act of adjusting prices), and that may already affect the comparability of our results. But the most likely reason for our contrasting prescriptions is our very different ways of specifying the monetary and fiscal policy regimes and how macroeconomic policy transmits to the real economy. My model has fiscalist equilibrium determination and no money demand at all, and may be interpreted as the stylization of an economy where an interest sensitive demand for real balances is always satisfied by a monetary authority who controls the nominal interest rates, and where seigniorage revenues are small enough to be disregarded. Ireland's model has a constant velocity money demand, and fiscal variables play no role. His disinflation experiments decelerate linearly the rate of growth of nominal money; mine reduce linearly the nominal interest rate. Not only do our welfare comparisons result different, but the underlying time paths of real fluctuations are virtually reversed: his disinflation is typically accompanied by an initial recession followed by a boom; mine, by an immediate boom followed by a recession.

Interestingly, a 'recession now versus recession later' tradeoff has been identified in connection with the choice between monetary aggregates and the exchange rate as the 'nominal anchor' in disinflation programs. Money based stabilization has been reported to cause immediate output loss, which agrees with Ireland's experiments and with the conventional wisdom among macroeconomists. On the other hand, a seemingly paradoxical boom-bust pattern has been documented in exchange rate based stabilizations, by Rebelo and Végh (1995) among others.

Rebelo and Végh were capable of reproducing the boom-bust pattern by building backward looking indexation into their open economy model, as originally suggested by Rodríguez (1982) and Dornbusch (1982). With interest rate parity, the nominal interest rate falls by as much as the rate of foreign exchange depreciation, but backward looking indexation accounts for inflation rates lagging behind. The initial output boom is due to temporarily lower
real interest rates, while later recession is due to the real exchange rate appreciation that ensues. They could also account for the boom-bust pattern by assuming that stabilization is believed to be temporary, as in Calvo (1986): intertemporal substitution of current for later consumption takes place because transactions requiring money balances are less costly while inflation remains low. De Gregorio, Guidotti and Végh (1998) also suggested that the same boom-bust pattern could arise in credible stabilizations by the presence of durable goods, with the sudden reduction of transaction costs leading to bunching of durables purchases (the boom) and a matching market glut in subsequent periods (since the goods are, after all, durable).

From a fiscalist perspective, a program that pegs the nominal exchange rate (or any other key nominal price) should be interpreted as a drastic reduction in nominal interest rates, which in turn makes the announced peg sustainable by reducing the rate of growth of nominal outside wealth (although it might sound preposterous if announced in these terms). In contrast with conventional formulations, the fiscalist model delivers the boom-bust response to disinflation in a closed economy, where every agent is completely forward looking, stabilization is perfectly credible, and both transactions balances and durable goods are totally absent.

6. CONCLUSIONS

Under fiscalist equilibrium determination, monetary contraction causes inflation to go up rather than down. With sticky prices, the tight money paradox is accompanied by an immediate drop in the level of activity. On impact, therefore, monetary contraction produces stagflation. Output tends to rebound beyond potential later on.

For a small, transitory monetary tightening, output effects are short lived. The more persistent the tightening of monetary policy, however, the more the initial recession stands out compared to the later output boom.

Changes in monetary regime from a stationary to an explosive path of nominal interest rates makes inflation explode too. (Such explosions of inflation and nominal interest rates would be the equilibrium outcome, under the assumption of exogenous primary budgets, and of explicit
interest rate reaction functions with strong feedback from past inflation.) Fairly protracted recessions may occur if inflation explosion is slow enough. Here, movements in output are partly due to equilibrium movements in employment under sticky prices, and partly due to changes in price dispersion. Price dispersion first increases with inflation, while price adjustment is not getting sufficiently more frequent in response, and then starts decreasing as inflation becomes high enough. More price dispersion makes a price-weighted real output index fall relatively to employment because demand concentrates on relatively cheaper goods that take just as much labor to produce as any other.

Conversely, rapid disinflation brought about by reduction in nominal interest rates is accompanied by an immediate output boom followed by some recession. That result is interesting because such a boom-bust pattern has been documented in many episodes of rapid disinflation. Output fluctuations last longer when disinflation is more gradual, and in these cases they may be accompanied by high real interest rates in spite of disinflation being a result of monetary loosening. That happens because price dispersion is being reduced as inflation falls, and output is increasing relatively to employment. Cold-turkey disinflation should be preferred on welfare grounds, regardless of the initial inflation rate.

These results are all obtained in a model with two-period staggered price commitments, where price setters also have the option of adjusting prices halfway into their contracts by paying a menu cost. The state dependent formulation is crucial for the study of the explosive paths and the transition from high to low inflation, because it allows price duration to vary endogenously with inflation (in particular, to fall towards a single period as inflation becomes very high). I superimpose alternating periods of costless price adjustment as a simplification, in order to allow for solution of the exact model, because linear approximations are also counterindicated for large or non-stationary shocks.

Unfortunately, that simplification has drawbacks besides rendering the model less elegant. Two-period staggered contracts tend to produce cyclical responses of output to monetary
shocks. Meanwhile, fiscalist equilibrium determination also makes output overshoot potential when recovering from the initial impact of a monetary shock. One would prefer a model in which the latter effect was not contaminated by staggering cycles. Furthermore, the two-period contracts put the model in a straitjacket when it comes to mapping model periods into calendar time: mean price duration can only range from 1 to 2 periods, and there is no way of making the same calibration of the model realistic for inflation rates very far apart. However inconvenient, these drawbacks are outweighed by the analytical simplicity they afford when it comes to computing perfect foresight equilibria of the nonlinear model.

REFERENCES


FIGURE 2.B
\( \delta = 0.5 \)

\( R \)

\( \pi \)

\( R/\pi \)

\( y \)

FIGURE 2.C
\( \delta = 0.9 \)
Figure 3.C
$\delta = 0.9$

$R$

$\pi$

$R/\pi$

$y$

Figure 4.A
$R_0 = 1.3$

$\pi$ and $R (-)$

$\alpha$

$R/\pi$

$y$ and $h (-)$
Figure 4.B
$R_L = 1.3$

Figure 4.C
$R_{11} = 1.3$
FIGURE 5
Cold Turkey Disinflation ($w = -0.0002$)

FIGURE 6.A
Disinflation in 2 Periods ($w = -0.0024$)
FIGURE 6.B
Disinflation in 4 Periods ($w = -0.0067$)

FIGURE 6.C
Disinflation in 8 Periods ($w = -0.0151$)