Exchange Rate Dynamics Redux

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We develop an analytically tractable two-country model that marries a full account of global macroeconomic dynamics to a supply framework based on monopolistic competition and sticky nominal prices. The model offers simple and intuitive predictions about exchange rates and current accounts that sometimes differ sharply from those of either modern flexible-price intertemporal models or traditional sticky-price Keynesian models. Our analysis leads to a novel perspective on the international welfare spillovers due to monetary and fiscal policies.

I. Introduction

This paper offers a theory that incorporates the price rigidities essential to explain exchange rate behavior without sacrificing the insights of the intertemporal approach to the current account. Until now, thinking on open-economy macroeconomics has been largely schizophrenic. Most of the theoretical advances since the late 1970s have been achieved by assuming away the awkward reality of sticky prices and instead developing the implications of dynamic optimization by the private sector. While the intertemporal approach has proved valu-

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able for some facets of current-account analysis, many of the most fundamental problems in international finance cannot be seriously addressed in a setting of frictionless markets. Because the newer paradigm seems so ill equipped to explain, for example, the effects of macroeconomic policies on output and exchange rates, empirical practitioners and policymakers have not yet been persuaded to abandon traditional aggregative Keynesian models.

While the time-tested appeal of those models is undeniable, their lack of microfoundations presents problems at many levels. They ignore the intertemporal budget constraints central to any coherent picture of the current account and fiscal policy. They provide no clear description of how monetary policy affects production decisions. Because the traditional approach embodies no meaningful welfare criteria, it can yield profoundly misleading policy prescriptions even for problems it was designed to address, as we shall show.

This paper builds a bridge between the rigor of the intertemporal approach, as exemplified by Sachs (1981), Obstfeld (1982), and Frenkel and Razin (1987), and the descriptive plausibility of the classic contributions of Fleming (1962), Mundell (1963, 1964), and Dornbusch (1976). We develop a model of international policy transmission that embodies the main elements of the intertemporal approach along with short-run nominal price rigidities and explicit microfoundations of aggregate supply. Our general approach permits the formal welfare evaluation of international macroeconomic policies and institutions, a procedure central to public finance and trade theory but largely absent from previous discussions of international economic fluctuations.

A framework integrating exchange rate dynamics and the current account yields a new perspective on both. For example, the model predicts that money supply shocks can have real effects that last well beyond the time frame of any nominal rigidities, because of induced short-run wealth accumulation via the current account. Another finding is that an unanticipated permanent rise in world government purchases temporarily lowers world real interest rates: when prices are sticky, the government spending shock raises short-run output above long-run output, and world real interest rates fall as agents attempt to smooth consumption. Beyond such specific results, the real payoff from the new approach, once again, is a framework within which one can address the most important issues in international finance (exchange rate regimes, international transmission of macroeconomic policies, sources of current-account imbalances, and so on) without sacrificing either empirical realism or the rigor of explict welfare analysis.

Our model embeds features of the static, closed-economy models of Blanchard and Kiyotaki (1987) and Ball and Romer (1989) in an analytically tractable, dynamic, two-country framework. Section II sets out an infinite-horizon monetary model of a monopolistically competitive world economy. We show how to solve for the long-run and short-run equilibria of a log-linearized version of the model. In Section III we analyze positive and normative aspects of monetary and fiscal policy. Section IV catalogs a number of possible extensions of the model, and Section V presents conclusions.

Various elements of our approach can be found in earlier work by several authors. Each component of Mussa's (1984) aggregative model is inspired by individual maximization, but the model as a whole lacks an integrative foundation. McKibbin and Sachs (1991) and Stockman and Ohanian (1993) develop numerical sticky-price models that incorporate intertemporal maximization but lack foundations on the supply side. The model of Calvo and Végh (1993) assumes sticky prices and demand-determined output but presents no rationale for the latter assumption. Also, its small-country setting prevents analysis of international transmission issues. Romer (1993) models a world of two interacting monopolistically competitive economies, but his analysis is static and its microfoundations are not fully specified. Dixon (1993) surveys other static open-economy models based on imperfect competition. Perhaps the closest precursor to our study is the paper by Svensson and van Wijnbergen (1989); but its assumption of perfectly pooled international risks, aside from uneasily matching its pricing and rationing assumptions, precludes discussion of the international wealth redistributions that are central to our analysis.[1]

II. Macroeconomic Policies in a Two-Country Model with Monopolistic Competition: Flexible Prices

In this section we describe the setup of the model and some of its properties when nominal output prices are flexible.

A. *Preferences, Technology, and Market Structure*

The world is inhabited by a continuum of individual producers, indexed by $z \in [0, 1]$, each of whom produces a single differentiated

[1] Recently Beaudry and Devereux (1994) have explored multiple equilibria within a related framework with flexible prices, investment, and increasing returns. They focus on an equilibrium isomorphic to one with predetermined nominal goods prices. Several of the properties of that equilibrium (e.g., long-run real effects due to purely nominal shocks) are consistent with predictions of our model.

perishable product. The home country consists of producers on the interval $[0, n]$, and the remaining $(n, 1]$ producers reside in the foreign country.

Individuals everywhere in the world have the same preferences, which are defined over a consumption index, real money balances, and effort expended in production. Let $c(z)$ be a home individual's consumption of product z. The consumption index, on which utility depends, is given by

$$C = \left[\int_0^1 c(z)^{(\theta-1)/\theta} dz\right]^{\theta/(\theta-1)}, \tag{1}$$

where $\theta > 1$. The foreign consumption index C^* is defined analogously (throughout, asterisks denote foreign variables).

There are no impediments or costs to trade between the countries. Let E be the nominal exchange rate, defined as the home-currency price of foreign currency, $p(z)$ the domestic-currency price of good z, and $p^*(z)$ the price of the same good in foreign currency. Then the law of one price holds for every good, so that

$$p(z) = Ep^*(z). \tag{2}$$

The consumption-based money price index[2] in the home country is

$$\begin{aligned} P &= \left[\int_0^1 p(z)^{1-\theta} dz\right]^{1/(1-\theta)} \\ &= \left\{\int_0^n p(z)^{1-\theta} dz + \int_n^1 [Ep^*(z)]^{1-\theta} dz\right\}^{1/(1-\theta)}. \end{aligned} \tag{3}$$

Since both countries' residents have the same preferences, equation (2) implies that

$$P = EP^*. \tag{4}$$

There is an integrated world capital market in which both countries can borrow and lend. The only asset they trade is a real bond, denominated in the composite consumption good. Let r_t denote the real interest rate earned on bonds between dates t and $t + 1$, and let F_t and M_t denote the stocks of bonds and domestic money held by a home resident entering date $t + 1$. Residents of a country derive utility from that country's currency only, and not from foreign cur-

[2] The price index is defined as the minimal expenditure of domestic money needed to purchase a unit of C.

rency. Individual z's period budget constraint therefore is

$$P_tF_t + M_t = P_t(1 + r_{t-1})F_{t-1} + M_{t-1} + p_t(z)y_t(z) - P_tC_t - P_tT_t, \quad (5)$$

where $y(z)$ is the individual's output and T denotes real taxes paid to the domestic government (which can be negative in the event of money transfers).

A home resident z maximizes a utility function that depends positively on consumption and real balances and negatively on work effort, which is positively related to output:[3]

$$U_t = \sum_{s=t}^{\infty} \beta^{s-t}\left[\log C_s + \frac{\chi}{1-\epsilon}\left(\frac{M_s}{P_s}\right)^{1-\epsilon} - \frac{\kappa}{2}y_s(z)^2\right]. \quad (6)$$

In equation (6), $0 < \beta < 1$ and $\epsilon > 0$.[4]

Given the utility function (6), a home individual's demand for product z in period t is

$$c_t(z) = \left[\frac{p_t(z)}{P_t}\right]^{-\theta} C_t,$$

so that θ is the elasticity of demand with respect to relative price. Foreign residents have the same demand functions.

We assume that home and foreign government purchases of consumption goods do not directly affect private utility. Per capita real home government consumption expenditure, G, is a composite of government consumptions of individual goods, $g(z)$, in the same manner as private consumption; for simplicity, we assume identical weights.[5] The same is true for G^*. Since Ricardian equivalence holds

[3] Here we adopt a money-in-the-utility-function approach to introducing currency, but a cash-in-advance version of the model yields qualitatively similar results (see Obstfeld and Rogoff 1996). The most significant difference in the cash-in-advance model is that welfare results on the international transmission of policies (see Sec. III*C*) do not depend on any parameter assumptions. Feenstra (1986) discusses the equivalence of money-in-the-utility-function and transaction-technology approaches to money demand.

[4] A more general formulation than eq. (6) allows the elasticity of intertemporal substitution, σ, to differ from one and the elasticity of disutility from output, denoted by $\mu \geq 1$, to differ from two:

$$U_t = \sum_{s=t}^{\infty} \beta^{s-t}\left[\frac{\sigma}{\sigma-1}C_s^{(\sigma-1)/\sigma} + \frac{\chi}{1-\epsilon}\left(\frac{M_s}{P_s}\right)^{1-\epsilon} - \frac{\kappa}{\mu}y_s(z)^{\mu}\right].$$

Allowing for this more general formulation enriches the comparative statics results but is not essential for any of the central points made below. For a discussion of the more general case, see Obstfeld and Rogoff (1994).

[5] That is,

$$G = \left[\int_0^1 g(z)^{(\theta-1)/\theta} dz\right]^{\theta/(\theta-1)}.$$

in this model, nothing is lost by simply assuming that all government purchases are financed by taxes and seigniorage:

$$G_t = T_t + \frac{M_t - M_{t-1}}{P_t},$$
$$G_t^* = T_t^* + \frac{M_t^* - M_{t-1}^*}{P_t^*}. \tag{7}$$

Governments take producer prices as given when allocating their spending among goods. Adding up private and government demands therefore shows that the producer of good z faces the period t world demand curve:

$$y_t^d(z) = \left[\frac{p_t(z)}{P_t}\right]^{-\theta} (C_t^W + G_t^W), \tag{8}$$

where

$$C_t^W \equiv nC_t + (1 - n)C_t^* \tag{9}$$

is world *private* consumption demand, which producers take as given, and

$$G_t^W \equiv nG_t + (1 - n)G_t^* \tag{10}$$

is world *government* demand. Equation (8) makes use of (2) and (4), which imply that the real price of good z is the same at home and abroad.

Each individual producer has a degree of monopoly power. Thus, in the aggregate, a country faces a downward-sloping world demand curve for its output, as in Dornbusch (1976). Purchasing power parity holds for consumer price indexes (eq. [4]), but only because both countries consume identical commodity baskets. Purchasing power parity does not hold for national output deflators, and thus the terms of trade can change.[6]

B. Individual Maximization

Use (8) to eliminate $p_t(z)$ from (5),[7] and then maximize lifetime utility (6) subject to the resulting budget constraint, taking world demand,

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The model can be extended to give the government a preference for home goods, but the case in the text is notationally simpler.

[6] In an extended version of the model incorporating nontraded goods, many of the basic results derived below still follow despite the fact that eq. (4) need no longer hold.

[7] The substitution yields

$$p_t(z)y_t(z) = P_t y_t(z)^{(\theta-1)/\theta}(C_t^W + G_t^W)^{1/\theta}.$$

$C_t^W + G_t^W$, as given. Define the home-currency nominal interest rate on date t, i_t, by

$$1 + i_t = \frac{P_{t+1}}{P_t}(1 + r_t), \tag{11}$$

with an analogous definition for the foreign-currency nominal interest rate. Note that, because purchasing power parity holds, real interest rate equality implies uncovered interest parity:

$$1 + i_t = \frac{E_{t+1}}{E_t}(1 + i_t^*).$$

The first-order conditions for the maximization problems of home and foreign individuals are

$$C_{t+1} = \beta(1 + r_t)C_t, \tag{12}$$

$$C_{t+1}^* = \beta(1 + r_t)C_t^*, \tag{13}$$

$$\frac{M_t}{P_t} = \left[\chi C_t\left(\frac{1 + i_t}{i_t}\right)\right]^{1/\epsilon}, \tag{14}$$

$$\frac{M_t^*}{P_t^*} = \left[\chi C_t^*\left(\frac{1 + i_t^*}{i_t^*}\right)\right]^{1/\epsilon}, \tag{15}$$

$$y_t(z)^{(\theta+1)/\theta} = \left(\frac{\theta - 1}{\theta\kappa}\right)C_t^{-1}(C_t^W + G_t^W)^{1/\theta}, \tag{16}$$

$$y_t^*(z)^{(\theta+1)/\theta} = \left(\frac{\theta - 1}{\theta\kappa}\right)C_t^{*-1}(C_t^W + G_t^W)^{1/\theta}. \tag{17}$$

Equations (12) and (13) are standard consumption Euler equations. The money market equilibrium conditions (14) and (15) equate the marginal rate of substitution of composite consumption for the services of real money balances to the consumption opportunity cost of holding real balances. Notice that money demand depends on consumption rather than on income, a distinction that can be even more important in open than in closed economies.[8] Equations (16) and (17) state that the marginal utility of the additional revenue earned from producing an extra unit of good z equals the marginal disutility of the needed effort.

[8] A role for consumption spending rather than output in U.S. money demand receives empirical support from Mankiw and Summers (1986). In a model with firm and government holdings of transactions balances, a broader expenditure measure would be appropriate for analyzing money demand.

C. A Symmetric Steady State

In a steady state, all exogenous variables are constant.[9] Since this implies that consumption is constant, the steady-state world real interest rate $\bar{r}$ is tied down by the consumption Euler conditions (12) and (13):

$$\bar{r} = \frac{1 - \beta}{\beta}. \tag{18}$$

In equation (18) and below, steady-state values are marked by overbars.

All producers in a country are symmetric, which implies that they set the same price and output in equilibrium. Let $p(h)$ be the home-currency price of a typical home good and $p^*(f)$ the foreign-currency price of a typical foreign good; y and y^* are the corresponding output levels. If composite consumption is constant in both countries, then each country's intertemporal budget constraint requires that real consumption spending be equal to net real interest payments from abroad plus real domestic output less real government spending.[10] Thus steady-state per capita consumption levels are

$$\bar{C} = \bar{r}\bar{F} + \frac{\bar{p}(h)\bar{y}}{\bar{P}} - \bar{G} \tag{19}$$

and

$$\bar{C}^* = -\bar{r}\left(\frac{n}{1 - n}\right)\bar{F} + \frac{\bar{p}^*(f)\bar{y}^*}{\bar{P}^*} - \bar{G}^*. \tag{20}$$

(Notice that eq. [20] makes use of the identity $nF + [1 - n]F^* = 0$: world net foreign assets must be zero.) We stress again that, even though people in different countries face the same relative price for any given good, the relative price of home and foreign goods (the terms of trade) can vary. Even the steady-state terms of trade change as relative wealth changes because the marginal benefit from production is declining in wealth.

In the special case of zero net foreign assets and equal per capita government spending levels, there is a closed-form solution for the steady state, in which the countries have identical per capita outputs and real money holdings. We shall denote by zero subscripts the particular steady state with both $\bar{F}_0 = \bar{F}_0^* = 0$ and $\bar{G}_0 = \bar{G}_0^* = 0$;

[9] It is simple to allow for steady-state growth in the money supplies and other exogenous variables.

[10] It is at this point that we are imposing the countries' intertemporal budget constraints, which rule out Ponzi schemes of unlimited borrowing.

in it,

$$\bar{y}_0 = \bar{y}_0^* = \left(\frac{\theta - 1}{\theta\kappa}\right)^{1/2} \tag{21}$$

and

$$\frac{\overline{M}_0}{\overline{P}_0} = \frac{\overline{M}_0^*}{\overline{P}_0^*} = \left(\frac{1-\beta}{\chi}\right)^{-1/\epsilon} \bar{y}_0^{1/\epsilon}. \tag{22}$$

Equation (21) is analogous to the output equation in the static closed-economy model of Blanchard and Kiyotaki (1987): producers' market power pushes global output below its competitive level, which is approached only as $\theta \to \infty$. Because this model is dynamic, real money balances in general depend on nominal interest rates. We have assumed a zero-inflation steady state, so this effect shows up in (22) only as an effect of the steady-state value of $\bar{r}/(1 + \bar{r}) = 1 - \beta$.

D. A Log-Linearized Model

To go further and allow for asymmetries in policies and current accounts, it is helpful to log-linearize the model around the initial symmetric steady state with $\overline{F}_0 = \overline{F}_0^* = 0$ and $\overline{G}_0 = \overline{G}_0^* = 0$. We implement this linearization by expressing the model in terms of deviations from the baseline steady-state path. Denote percentage changes from the baseline by hats; thus, for any variable, $\hat{X}_t \equiv dX_t/\overline{X}_0$, where $\overline{X}_0$ is the initial steady-state value.

The easiest equation to start with is the purchasing power parity relation (4), which requires no approximation:

$$\hat{E}_t = \hat{P}_t - \hat{P}_t^*. \tag{23}$$

Given the symmetry among each country's producers, equation (3) yields

$$P_t = \{np_t(h)^{1-\theta} + (1-n)[E_t p_t^*(f)]^{1-\theta}\}^{1/(1-\theta)},$$

$$P_t^* = \left\{n\left[\frac{p_t(h)}{E_t}\right]^{1-\theta} + (1-n)p_t^*(f)^{1-\theta}\right\}^{1/(1-\theta)}.$$

Small percentage deviations of consumer price levels from their initial paths thus are given by

$$\hat{P}_t = n\hat{p}_t(h) + (1-n)[\hat{E}_t + \hat{p}_t^*(f)] \tag{24}$$

and

$$\hat{P}_t^* = n[\hat{p}_t(h) - \hat{E}_t] + (1-n)[\hat{p}_t^*(f)], \tag{25}$$

where we have used the fact that at the initial symmetric steady state, $\bar{p}_0(h) = \bar{E}_0\bar{p}_0^*(f)$.

Next, take a population-weighted average of (5) and its foreign counterpart. Combining the result with (7) and (9) gives the global goods market equilibrium condition:

$$C_t^W = n\left[\frac{p_t(h)y_t}{P_t}\right] + (1-n)\left[\frac{p_t^*(f)y_t^*}{P_t^*}\right] - G_t^W.$$

Thus linearizing implies that the change in world private demand is

$$\begin{aligned}\hat{C}_t^W &= n\hat{C}_t + (1-n)\hat{C}_t^* \\ &= n[\hat{p}_t(h) + \hat{y}_t - \hat{P}_t] + (1-n)[\hat{p}_t^*(f) + \hat{y}_t^* - \hat{P}_t^*] - \frac{dG_t^W}{\bar{C}_0^W}.\end{aligned} \tag{26}$$

Remember that in the initial symmetric steady state, $\bar{p}_0(h) = \bar{P}_0$ and $\bar{p}_0^*(f) = \bar{P}_0^*$. Remember also that because world population is normalized at one and initial net foreign assets and government purchases are zero, $\bar{C}_0^W = \bar{C}_0 = \bar{C}_0^* = \bar{y}_0 = \bar{y}_0^*$.

The log-linearized versions of (8) and its foreign counterpart, interpreted as world demand schedules for typical domestic and foreign products, are

$$\hat{y}_t = \theta[\hat{P}_t - \hat{p}_t(h)] + \hat{C}_t^W + \frac{dG_t^W}{\bar{C}_0^W} \tag{27}$$

and

$$\hat{y}_t^* = \theta[\hat{P}_t^* - \hat{p}_t^*(f)] + \hat{C}_t^W + \frac{dG_t^W}{\bar{C}_0^W}. \tag{28}$$

Equations (16) and (17), which describe the optimal flexible-price output levels, are approximated by

$$(\theta + 1)\hat{y}_t = -\theta\hat{C}_t + \hat{C}_t^W + \frac{dG_t^W}{\bar{C}_0^W} \tag{29}$$

and

$$(\theta + 1)\hat{y}_t^* = -\theta\hat{C}_t^* + \hat{C}_t^W + \frac{dG_t^W}{\bar{C}_0^W}. \tag{30}$$

The consumption Euler equations (12) and (13) take the log-linear form

$$\hat{C}_{t+1} = \hat{C}_t + (1-\beta)\hat{r}_t \tag{31}$$

and

$$\hat{C}^*_{t+1} = \hat{C}^*_t + (1 - \beta)\hat{r}_t \tag{32}$$

near the initial steady-state path. Finally, the money demand equations (14) and (15) become

$$\hat{M}_t - \hat{P}_t = \frac{1}{\epsilon}\hat{C}_t - \frac{\beta}{\epsilon}\left(\hat{r}_t + \frac{\hat{P}_{t+1} - \hat{P}_t}{1 - \beta}\right) \tag{33}$$

and

$$\hat{M}^*_t - \hat{P}^*_t = \frac{1}{\epsilon}\hat{C}^*_t - \frac{\beta}{\epsilon}\left(\hat{r}_t + \frac{\hat{P}^*_{t+1} - \hat{P}^*_t}{1 - \beta}\right). \tag{34}$$

E. *Comparing Steady States*

To solve the model, we still need the intertemporal budget constraints, which are implicit in equations (19) and (20) when the exogenous variables are constant. Linearizing these two equations, and letting $\hat{\overline{X}} \equiv d\overline{X}/\overline{X}_0$ denote the percentage change in a *steady-state* value, yields

$$\hat{\overline{C}} = \bar{r}\frac{d\overline{F}}{\overline{C}^W_0} + \hat{\bar{p}}(h) + \hat{\bar{y}} - \hat{\overline{P}} - \frac{d\overline{G}}{\overline{C}^W_0} \tag{35}$$

and

$$\hat{\overline{C}}^* = -\left(\frac{n}{1 - n}\right)\bar{r}\frac{d\overline{F}}{\overline{C}^W_0} + \hat{\bar{p}}^*(f) + \hat{\bar{y}}^* - \hat{\overline{P}}^* - \frac{d\overline{G}^*}{\overline{C}^W_0}. \tag{36}$$

The final step in solving for the steady state is to observe that equations (26)–(30) hold across steady states, so that they remain valid after time-subscripted changes are replaced by steady-state changes. Together with (35) and (36), they furnish seven equations in the seven unknowns, $\hat{\overline{C}}$, $\hat{\overline{C}}^*$, $\hat{\bar{y}}$, $\hat{\bar{y}}^*$, $\hat{\bar{p}}(h) - \hat{\overline{P}}$, $\hat{\bar{p}}^*(f) - \hat{\overline{P}}^*$, and $\hat{\overline{C}}^W$, which we can use to determine the new real steady state. The solutions for consumption are[11]

$$\hat{\overline{C}} = \frac{1 + \theta}{2\theta}\left(\frac{\bar{r}d\overline{F}}{\overline{C}^W_0}\right) + \left(\frac{1 - n}{2\theta}\right)\frac{d\overline{G}^*}{\overline{C}^W_0} - \left(\frac{1 - n + \theta}{2\theta}\right)\frac{d\overline{G}}{\overline{C}^W_0} \tag{37}$$

[11] The mechanics of solving the model are greatly simplified by exploiting the symmetry across countries. In particular, it is very straightforward to solve for differences between home and foreign variables, and for population-weighted sums. The efficacy of this approach will be apparent in Sec. III*B* when we solve for the short-run exchange rate and interest rate. For a more extended discussion, see Obstfeld and Rogoff (1996).

and

$$\hat{C}^* = -\frac{n}{1-n}\left(\frac{1+\theta}{2\theta}\right)\frac{\bar{r}d\bar{F}}{\bar{C}_0^W} + \left(\frac{n}{2\theta}\right)\frac{d\bar{G}}{\bar{C}_0^W} - \left(\frac{n+\theta}{2\theta}\right)\frac{d\bar{G}^*}{\bar{C}_0^W}. \tag{38}$$

Consider equation (37) for home private consumption. An exogenous increase $d\bar{F}$ in home per capita foreign assets would increase steady-state consumption by the amount $\bar{r}d\bar{F}$ were output exogenous. Instead, consumption increases here by less (since $\theta > 1$). The reason is that higher wealth leads to some reduction in work effort and production: as (29) shows, higher consumption lowers the marginal utility of consumption and, thus, marginal revenue measured in utility units. We also see from (37) that a steady-state rise in foreign government consumption increases domestic private consumption because part of the spending falls on domestic output, which rises in response. When steady-state home government consumption rises, however, home private consumption falls. There is a positive effect on output, as we shall explain in a moment, but it is more than offset by a higher domestic tax burden. Positive output effects do, however, allow private consumptions to fall by less than the associated tax increases.

To see the effects of net foreign assets and fiscal policies on outputs and the terms of trade, observe that equations (24)–(30), (37), and (38) imply

$$\hat{\bar{y}} = -\frac{\theta}{1+\theta}\hat{\bar{C}} + \left[\frac{1}{2(1+\theta)}\right]\frac{d\bar{G}^W}{\bar{C}_0^W}, \tag{39}$$

$$\hat{\bar{y}}^* = -\frac{\theta}{1+\theta}\hat{\bar{C}}^* + \left[\frac{1}{2(1+\theta)}\right]\frac{d\bar{G}^W}{\bar{C}_0^W}, \tag{40}$$

and

$$\hat{\bar{p}}(h) - \hat{\bar{p}}^*(f) - \hat{\bar{E}} = \frac{1}{\theta}(\hat{\bar{y}}^* - \hat{\bar{y}}) = \frac{1}{1+\theta}(\hat{\bar{C}} - \hat{\bar{C}}^*). \tag{41}$$

Equations (39) and (40) show the multiplier effects of domestic government spending on output emphasized by Mankiw (1988) and Startz (1989). Higher lump-sum taxes cause producers to cut consumption but also to work harder. One can show that the net stimulus to aggregate demand is greater than under perfect competition. Equation (41) shows that the increase in the domestic terms of trade (the rise in the relative price of home products) is proportional to both the increase in relative foreign output and the increase in relative domestic consumption.[12] Note that because the infinitely lived citizens in both countries have equal constant discount rates, an international transfer of assets leads to a *permanent* change in the terms of trade.[13]

With flexible prices, the classical invariance of the real economy with respect to monetary factors holds in this model. Across steady states, inflation and the interest rate do not change, so (33) and (34) imply that

$$\hat{\bar{P}} = \hat{\bar{M}} - \frac{1}{\epsilon}\hat{\bar{C}} \tag{42}$$

and

$$\hat{\bar{P}}^* = \hat{\bar{M}}^* - \frac{1}{\epsilon}\hat{\bar{C}}^*. \tag{43}$$

III. The Two-Country Model with Sticky Prices

We are now ready to understand the short-run behavior of exchange rates, the current account, and other key variables. In the short run, nominal producer prices $p(h)$ and $p^*(f)$ are predetermined; that is, they are set a period in advance but can be adjusted fully after one period. We shall not explicitly model the underlying source of stickiness here, though one can straightforwardly reinterpret all the results below in a setting with menu costs of price adjustment à la Akerlof and Yellen (1985*a*, 1985*b*), Mankiw (1985), or Blanchard and Kiyotaki (1987).[14]

A. *Short-Run Equilibrium Conditions*

With preset nominal prices, output becomes demand determined for small enough shocks. Because a monopolist always prices above marginal cost, it is profitable to meet unexpected demand at the preset price.[15] In the short run, therefore, the equations equating marginal

[12] This proportionality follows from the specific types of shocks assumed and does not hold in general. Permanent productivity shocks, which we shall mention later, would cause a negative correlation between a country's terms of trade and its consumption. National bias in government spending also would modify the simple proportionality in (41).

[13] In other types of models—e.g., in an overlapping generations model—a transfer of assets has only temporary effects since the generations that receive the transfer eventually die out.

[14] One can potentially extend the model to incorporate richer price dynamics, e.g., staggered price setting. Pricing-to-market issues (e.g., Dornbusch 1987; Krugman 1987) do not arise here because there are no impediments to trade.

[15] It would be more profitable still to raise the price if this were possible in the short run. If there is an unexpected fall in demand and the monopolist cannot cut the price, there is no choice but to produce and sell less.

revenue and marginal cost in the flexible-price case, (29) and (30), need not hold. Instead, output is determined entirely by the demand equations, (27) and (28).

Although prices are preset in terms of the producers' own currencies, the *foreign-currency* price of a producer's output must change if the exchange rate moves. How do exchange rate changes affect relative prices and demands in the short run? With rigid output prices, equations (24) and (25) imply

$$\hat{P} = (1 - n)\hat{E} \tag{44}$$

and

$$\hat{P}^* = -n\hat{E}. \tag{45}$$

In (44) and (45), and henceforth, we use hatted variables without time subscripts or overbars to denote *short-run* deviations from the symmetric steady-state path. Combining these price changes with (27) and (28) shows that short-run aggregate demands can be expressed as

$$\hat{y} = \theta(1 - n)\hat{E} + \hat{C}^W + \frac{dG^W}{\overline{C}_0^W} \tag{46}$$

and

$$\hat{y}^* = -\theta n\hat{E} + \hat{C}^W + \frac{dG^W}{\overline{C}_0^W}, \tag{47}$$

where $\hat{C}^W$ is given by (26) and differentials without time subscripts (such as dG^W) refer to short-run changes. The remaining equations of short-run equilibrium include (31)–(34), which *always* hold.

In the specific policy experiments we do, where we consider either one-period (temporary) or permanent changes from the baseline policies, the world economy reaches its new steady state after a single period.[16] Thus we can replace all $(t + 1)$–subscripted variables in the linearized consumption-Euler and money demand equations (31)–(34) with steady-state changes. All t-subscripted variables in (31)–(34) are now interpreted as short-run values.

In the last section, we solved for the new steady state as a function of the permanent changes in money supplies and government spending, as well as the change in net foreign assets (the current account). The change in net foreign assets, however, is endogenous and can be determined only in conjunction with a full solution of the model's intertemporal equilibrium.

[16] With more general assumptions on the exogenous variables, the economy would reach a (possibly moving) flexible-price equilibrium after one period, in the absence of further shocks.

In the long run here, current accounts are balanced, as implied by the steady-state conditions (19) and (20). In the short run, however, the home country's per capita current-account surplus is given by

$$F_t - F_{t-1} = r_{t-1}F_{t-1} + \frac{p_t(h)y_t}{P_t} - C_t - G_t,$$

and similarly for the foreign country. Thus, since $F_0 = 0$, the linearized short-run current-account equations are

$$\frac{d\overline{F}}{\overline{C}_0^W} = \hat{y} - \hat{C} - (1 - n)\hat{E} - \frac{dG}{\overline{C}_0^W} \tag{48}$$

and

$$\frac{d\overline{F}^*}{\overline{C}_0^W} = \hat{y}^* - \hat{C}^* + n\hat{E} - \frac{dG^*}{\overline{C}_0^W} = -\left(\frac{n}{1 - n}\right)\frac{d\overline{F}}{\overline{C}_0^W}, \tag{49}$$

where we have made use of (44) and (45). Note that $d\overline{F}$ and $d\overline{F}^*$ appear above because the asset stocks at the end of period t are steady-state levels.

B. *Solution of the Model: Money Shocks*

One can formally solve the model in two stages. The first stage, already dealt with in Section II*E*, is to solve for all the steady-state variables (those marked with overbars) as functions of the steady-state macroeconomic policy shifts and the first-period current account, $d\overline{F}$. Ten short-run variables remain to be determined: $\hat{C}$, $\hat{C}^*$, $\hat{y}$, $\hat{y}^*$, $\hat{P}$, $\hat{P}^*$, $\hat{E}$, $\hat{C}^W$, $\hat{r}$, and $d\overline{F}$. The 10 equations that jointly determine them are (26), (31)–(34), and (44)–(48). Though a direct solution is possible, we prefer an intuitive approach that exploits the model's symmetry.

To simplify, we look at monetary and fiscal shocks separately, taking the former first and, thus, assuming temporarily that $dG = d\overline{G} = dG^* = d\overline{G}^* = 0$. Nothing is lost through this approach since the effects are additive.

1. Exchange Rate Dynamics

Some of the model's main predictions can be seen by looking at international differences in macroeconomic variables. Subtracting the foreign Euler equation (32) from its home counterpart (31) gives

$$\hat{C} - \hat{C}^* = \hat{\overline{C}} - \hat{\overline{C}}^*. \tag{50}$$

A similar operation on the money demand equations (34) and (33) leads to

$$(\hat{M} - \hat{M}^*) - \hat{E} = \frac{1}{\epsilon}(\hat{C} - \hat{C}^*) - \frac{\beta}{(1-\beta)\epsilon}(\hat{\bar{E}} - \hat{E}) \qquad (51)$$

after (23) is used (eq. [23] holds in the short and in the long runs alike).

Equation (50) states that all shocks have permanent effects on the difference between home and foreign per capita consumption. Individuals need not have flat consumption profiles if the real interest rate differs from its steady-state value. However, since real interest rates have the same effect on home and foreign consumption growth, *relative* consumptions still follow a random walk. Equation (51) is virtually identical to the central equation of the *flexible-price* monetary model of exchange rates, despite the presence of sticky prices here.[17] The only essential difference is that in (51), relative money demand depends on consumption differences, not on output differences as the monetary model supposes. In the present model, the decision to hold money involves an opportunity cost that depends on the marginal utility of consumption. A prediction that money demand depends on consumption or expenditure rather than output is common, however, to many other intertemporal monetary models.[18]

A recognition that consumption rather than output enters money demand has potentially important empirical implications, especially in an open economy that can smooth its consumption through foreign borrowing and lending. For example, transitory output shocks that induce permanent relative consumption movements will have permanent exchange rate effects.[19]

Consider the classic Dornbusch (1976) exercise of an unanticipated permanent rise in the relative home money supply. To see the exchange rate implications of equation (51), let us first lead it by one period to obtain

$$\hat{\bar{E}} = (\hat{\bar{M}} - \hat{\bar{M}}^*) - \frac{1}{\epsilon}(\hat{\bar{C}} - \hat{\bar{C}}^*),$$

[17] See Frenkel (1976) and Mussa (1976) for discussions of the monetary model.

[18] As noted above, Mankiw and Summers (1986) argue that consumption expenditure rather than output should enter empirical money demand models. They do not, however, emphasize the implications of intertemporal consumption smoothing for financial asset prices or the price level.

[19] Rogoff (1992) presents a model in which transitory productivity and government spending shocks can have long-lasting effects on the *real* exchange rate due to traded goods consumption smoothing.

which is simpler than (51) because all variables are constant in the assumed steady state.[20] Using the expression above to substitute for $\hat{\bar{E}}$ in (51) and noting that $\hat{C} - \hat{C}^* = \hat{\bar{C}} - \hat{\bar{C}}^*$ by (50) and that $\hat{M} - \hat{M}^* = \hat{\bar{M}} - \hat{\bar{M}}^*$ (since the money supply shock is permanent), we obtain

$$\hat{E} = (\hat{M} - \hat{M}^*) - \frac{1}{\epsilon}(\hat{C} - \hat{C}^*). \tag{52}$$

Thus $\hat{E} = \hat{\bar{E}}$. The exchange rate jumps immediately to its long-run level despite the inability of prices to adjust in the short run. The intuition behind this result is apparent from equation (51). If consumption differentials and money differentials are both expected to be constant, then agents must expect a constant exchange rate as well.

Indeed, although we have considered only permanent money supply shocks, the random-walk behavior of consumption differences simplifies the analysis of more general shocks. For more general money shock processes, the usual forward solution to (51) is just

$$\begin{aligned}\hat{E}_t = {} & \frac{(1-\beta)\epsilon}{\beta + (1-\beta)\epsilon} \sum_{s=t}^{\infty} \left[\frac{\beta}{\beta + (1-\beta)\epsilon}\right]^{s-t} \\ & \times (\hat{M}_s - \hat{M}_s^*) - \frac{1}{\epsilon}(\hat{C} - \hat{C}^*).\end{aligned} \tag{53}$$

The general result here is that the exchange rate jumps immediately to the flexible-price path corresponding to the new permanent international consumption differential. This does not mean, of course, that the model behaves exactly like a flexible-price model: in a flexible-price model there would be no consumption effect. Here, in contrast, the exchange rate change and the consumption effect are jointly determined.

2. A Graphical Solution for the Exchange Rate

A simple diagram (fig. 1) illustrates this interdependence for permanent money shocks ($\hat{M} - \hat{M}^* = \hat{\bar{M}} - \hat{\bar{M}}^*$). The **MM** schedule graphs equation (52), which shows how relative consumption changes affect the exchange rate by changing relative money demand. (Remember that the consumption Euler equations therefore are built into **MM**.) The **MM** schedule's vertical intercept equals the relative percentage increase in the home money supply, and the schedule slopes downward because relative domestic money demand rises as relative do-

[20] Implicitly, we are assuming away speculative exchange rate bubbles.

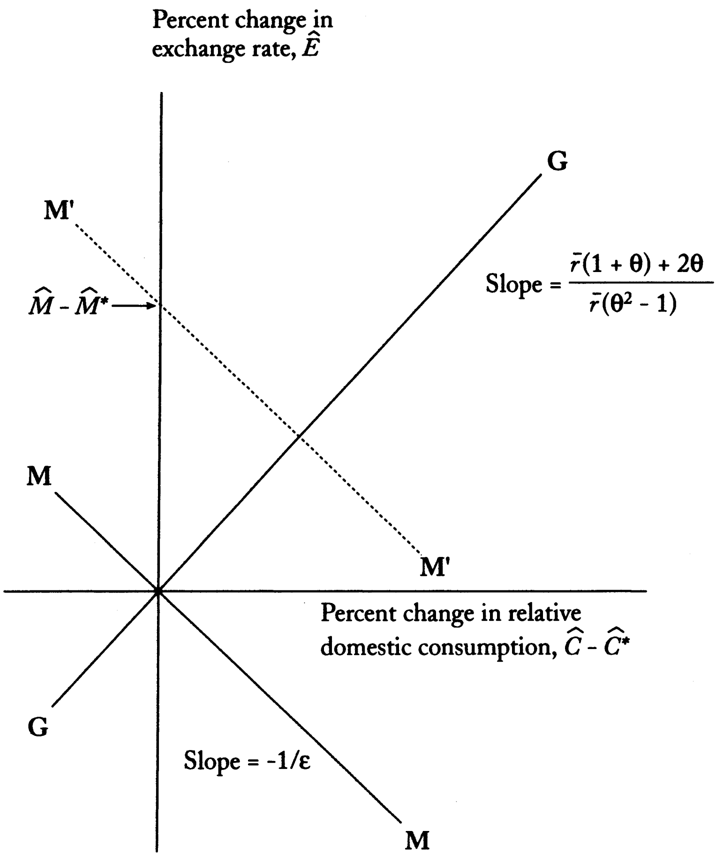

FIG. 1.—An unanticipated permanent relative domestic money supply increase

mestic consumption rises. Prior to the monetary shock, the relevant **MM** schedule passes through the origin.

A second schedule in $\hat{E}$ and $\hat{C} - \hat{C}^*$ is derived by using the current-account equations (48) and (49) together with the long-run consumption equations (37) and (38) to write the long-run consumption difference as

$$\bar{\hat{C}} - \bar{\hat{C}}^* = \frac{\bar{r}(1+\theta)}{2\theta}[(\hat{y} - \hat{y}^*) - (\hat{C} - \hat{C}^*) - \hat{E}].$$

Equations (46) and (47) show that domestic output rises relative to foreign output as the domestic currency depreciates and makes domestic products cheaper in the short run: $\hat{y} - \hat{y}^* = \theta\hat{E}$. Combining this equation with the one preceding it and with the relative Euler equation (50), we arrive at the **GG** schedule:

$$\hat{E} = \frac{\bar{r}(1+\theta) + 2\theta}{\bar{r}(\theta^2 - 1)}(\hat{C} - \hat{C}^*). \tag{54}$$

This relationship shows the domestic currency depreciation needed to raise relative home output enough to justify a given permanent rise in relative home consumption; it therefore is upward sloping.

Figure 1 shows the shift of the initial **MM** schedule to **M′M′** that occurs when there is a permanent unanticipated relative home money supply shock of size $\hat{M} - \hat{M}^*$. The intersection of **M′M′** and **GG** is the short-run equilibrium. The domestic currency depreciates, but by an amount proportionally smaller than the increase in the relative home money supply. Since $\hat{E} = \hat{\bar{E}}$, this is true in the long run as well.[21]

The exchange rate rises less than the relative domestic money supply because, as figure 1 also shows, domestic relative consumption must rise. With nominal prices fixed in the short run, the initial currency depreciation switches world demand toward domestic products and causes a short-run rise in relative domestic income.[22] Home residents save part of this extra income: by running a current-account surplus, they smooth the increase in their relative consumption over the future.

The exchange rate change is smaller the less monopoly power producers have, that is, the larger is the price elasticity of demand, θ. As $\theta \rightarrow \infty$ and a perfectly competitive economy is approached, **GG** becomes horizontal and the exchange rate effects of monetary changes disappear. If domestic and foreign goods are perfect substitutes in demand and their nominal prices are fixed, there is no scope for an exchange rate change.[23]

This diagrammatic analysis extends easily to the case of temporary money shocks. The **MM** equation (52) is replaced by (53), and the **GG** equation continues to hold for the initial period. Thus the new **MM** schedule's slope is unchanged but its intercept is the discounted sum of future monetary changes from (53). The effects of a tempo-

[21] Figure 1 presents an interesting parallel with the textbook diagram of the Mundell-Fleming model that places the exchange rate on the vertical axis and output on the horizontal axis (see, e.g., Dornbusch 1980; Krugman and Obstfeld 1994). The **MM** schedule is analogous to the Mundell-Fleming model's *LM* schedule, and **GG** is analogous to its *IS* schedule. The similarity between this model's results and those of the Mundell-Fleming model is, however, superficial and partial, as we discuss below.

[22] The increase in relative domestic real income is $\hat{\mathcal{Y}} - \hat{\mathcal{Y}}^* - \hat{E} = (\theta - 1)\hat{E} > 0$. Because demand has been assumed to be relatively elastic ($\theta > 1$), a country's revenue rises when it sells more because of a fall in its products' prices.

[23] Stockman and Ohanian (1993) highlight this possibility in a model in which perfect competition always obtains.

rary money supply shock on both the exchange rate and current account are smaller than those of a permanent shock. The level of $\hat{C} - \hat{C}^*$ determined by the diagram is still permanent, but equation (53) must be used to calculate the exchange rate's path after the initial, sticky-price period.

3. The Current Account, the Terms of Trade, and World Interest Rates

More can be learned by algebraically solving the model, as we illustrate using the example of a permanent money shock. Together, (52) and (54) imply that the exchange rate change is

$$\hat{E} = \frac{\epsilon[\bar{r}(1+\theta)+2\theta]}{\bar{r}(\theta^2-1)+\epsilon[\bar{r}(1+\theta)+2\theta]}(\hat{M}-\hat{M}^*) \leq \hat{M}-\hat{M}^*, \quad (55)$$

and the relative consumption change is

$$\hat{C} - \hat{C}^* = \frac{\epsilon\bar{r}(\theta^2-1)}{\bar{r}(\theta^2-1)+\epsilon[\bar{r}(1+\theta)+2\theta]}(\hat{M}-\hat{M}^*). \quad (56)$$

To find the equilibrium current account, we combine (37) and (38) to solve for $\hat{\bar{C}} - \hat{\bar{C}}^*$ as a function of $d\bar{F}/\bar{C}_0^W$; then we note that $\hat{C} - \hat{C}^* = \hat{\bar{C}} - \hat{\bar{C}}^*$ by (50) and, finally, use equation (56) to obtain

$$\frac{d\bar{F}}{\bar{C}_0^W} = \frac{2\theta\epsilon(1-n)(\theta-1)}{\bar{r}(\theta^2-1)+\epsilon[\bar{r}(1+\theta)+2\theta]}(\hat{M}-\hat{M}^*). \quad (57)$$

We see from equation (57) that the larger the home country (the greater n), the less the positive impact of a home money increase on its current account. Armed with the derivative $d\bar{F}/\bar{C}_0^W$, we can solve for all the steady-state values. For example, the long-run terms of trade are found by combining (57) with (37), (38), and (41):[24]

$$\hat{\bar{p}}(h) - \hat{\bar{p}}^*(f) - \hat{\bar{E}} = \frac{\epsilon\bar{r}(\theta-1)}{\bar{r}(\theta^2-1)+\epsilon[\bar{r}(1+\theta)+2\theta]}(\hat{M}-\hat{M}^*). \quad (58)$$

A positive home money shock generates a long-run improvement in the home terms of trade because it leads to an increase in wealth. With higher long-run wealth, home residents choose to enjoy more leisure (the opposite happens abroad): a rise in relative home output

[24] Note that both the short-run and the long-run terms-of-trade effects are *independent* of relative country size. A country's size determines the global impact of its policies, and not their relative (per capita) impact.

prices results. In the short run, of course, nominal domestic goods prices are fixed, and the home terms of trade deteriorate by $\hat{E}$. Thus the short-run and the long-run terms-of-trade effects go in opposite directions. Intuitively, one would expect the short-run effect to be larger in absolute value; in the long run, it is only the interest income on $d\overline{F}/\overline{C}_0^W$ that is driving the substitution from work effort into leisure. Comparing equation (55) with equation (58), we see that this indeed is the case.

The possibility that money shocks may have long-lasting real effects would seem to be quite general, and not simply an artifact of this particular model. As long as there exists any type of short-run nominal rigidities, unanticipated money shocks are likely to lead to international capital flows. The resulting transfers will extend the real effects of the shock beyond the initial sticky-price time horizon. In our infinitely lived agent model with intertemporally separable utility, the real effects are permanent; but in an overlapping generations setting, the effects should still last much longer than, say, the year or two horizon of a typical nominal wage contract. Of course, one must be careful not to overstate the importance of the long-run terms-of-trade effects since, as we have shown, they are in general an order of magnitude smaller than the short-run terms-of-trade effects.

One can ask whether Dornbusch (1976) type exchange rate overshooting occurs here, although the issue is complicated by the long-run nonneutrality of money. The more interesting question is whether sticky prices lead to more or less exchange rate volatility than one would observe in a world of flexible prices. In the present model, preset prices actually *reduce* exchange rate volatility due to monetary shocks. The fact that the inflating country experiences an improvement in its long-run terms of trade tempers the need for initial nominal depreciation. In the Appendix we present a model with sticky-price nontraded consumption goods in which a Dornbusch overshooting result can hold. Given the lack of empirical support for the overshooting hypothesis, however, it is unclear that this should be regarded as an essential property of an exchange rate model.[25]

It is straightforward to solve for the remaining variables in the model. To see how an unanticipated permanent monetary expansion affects the world real interest rate, for example, use the short-run price equations (44) and (45) and the long-run equations (42) and (43) to express the money market equilibrium conditions (33) and

[25] One empirical regularity apparently inconsistent with overshooting is the well-documented tendency for spot and forward exchange rates to move in tandem (see, e.g., Flood 1981).

(34) as

$$\hat{C} + \frac{\beta}{(1-\beta)\epsilon}\hat{\bar{C}} - \left(\epsilon + \frac{\beta}{1-\beta}\right)[\hat{M} - (1-n)\hat{E}] = \beta\hat{r}$$

and

$$\hat{C}^* + \frac{\beta}{(1-\beta)\epsilon}\hat{\bar{C}}^* - \left(\epsilon + \frac{\beta}{1-\beta}\right)(\hat{M}^* + n\hat{E}) = \beta\hat{r}.$$

Multiply the first of these expressions by n, the second by $1 - n$, and add. Because, by (37) and (38), $\hat{\bar{C}}^W = n\hat{\bar{C}} + (1-n)\hat{\bar{C}}^* = 0$ for a pure monetary shock, the consumption Euler equations (31) and (32) imply that

$$\hat{C}^W = n\hat{C} + (1-n)\hat{C}^* = -(1-\beta)\hat{r} \tag{59}$$

in the short run, and so

$$\hat{r} = -\left(\epsilon + \frac{\beta}{1-\beta}\right)\hat{M}^W, \tag{60}$$

where

$$\hat{M}^W \equiv n\hat{M} + (1-n)\hat{M}^*.$$

A monetary expansion either at home or abroad lowers the world real interest rate in proportion to the increase in the "world money supply" $\hat{M}^W$ and, thus, raises global consumption demand. The liquidity effect is greater the higher is ϵ, which is inversely related to the interest elasticity of money demand. Relatively interest inelastic money demand (a high value of ϵ) means that a monetary expansion will cause a proportionally large decline in the real interest rate. As in equation (18), there is no effect on the long-run real interest rate, which is tied to the rate of time preference.

What about the nominal interest rate? One can show that a permanent monetary expansion in either country lowers nominal interest rates worldwide provided $\epsilon > 1$. (This probably is the empirically relevant case.)

While a monetary expansion raises global demand in the short run by lowering the world real interest rate, it has asymmetric output effects in the two countries if the exchange rate changes. Equations (46) and (47) show the short-run output changes. Consider the effects of a unilateral increase in the home money supply. The world real interest rate falls and world demand rises, but because the domestic currency depreciates ($\hat{E} > 0$), some world demand is shifted toward home products at foreign producers' expense. As a result, home output rises relatively more; in fact, foreign output actually can fall.[26] A similar ambiguity is familiar from two-country versions of the Mundell-Fleming-Dornbusch model.[27]

C. *Welfare Analysis of International Monetary Transmission*

On a superficial reading, the preceding analysis suggests that the effects of a home monetary expansion on foreign welfare easily can be negative. In the long run, foreign agents work harder but, because of foreign debt and a deterioration in their terms of trade, consume less. Moreover, foreign output may fall in the short run. But even in that case there are some short-run benefits for foreigners: they enjoy more leisure, improved terms of trade, and consumption higher than income. The advantage of our dynamic utility-theoretic approach is that the overall welfare effect of these opposing forces can be rigorously evaluated. As in Section III*B*, monetary changes are assumed permanent.

We divide the problem of evaluating welfare changes into two parts by writing the intertemporal utility function (6) as $U = U^R + U^M$, where U^R consists of the terms depending on consumption and output and U^M consists of the terms depending on real money balances.

Consider the change in U^R first. Since the economy reaches a steady state after one period, the change in a home resident's lifetime welfare due to consumption and output changes is

$$dU^R = \hat{C} - \kappa y_0^2 \hat{y} + \frac{\beta}{1-\beta}(\hat{\bar{C}} - \kappa y_0^2 \hat{\bar{y}}).$$

Equation (21) and the assumption that $C_0 = y_0 = C_0^W$ show that this equation can be rewritten as

$$dU^R = \hat{C} - \left(\frac{\theta - 1}{\theta}\right)\hat{y} + \frac{\beta}{1-\beta}\left[\hat{\bar{C}} - \left(\frac{\theta - 1}{\theta}\right)\hat{\bar{y}}\right]. \tag{61}$$

[26] To solve for $\hat{y}^*$, combine eqq. (47), (55), (59), and (60). If $\epsilon = 1$, the resulting expression simplifies to

$$\hat{y}^* = \frac{2n(1-\theta)}{\bar{r}(1+\theta)+2}\hat{M} + \frac{\bar{r}(1+\theta) + 2(1-n+\theta n)}{\bar{r}(1+\theta)+2}\hat{M}^*,$$

so that, in this special case, the effect of home monetary expansion on short-run foreign output is unambiguously negative. One can show, however, that as ϵ gets large, the effect of home money on foreign output becomes positive.

[27] See, e.g., Canzoneri and Henderson (1991), who discuss the importance of international transmission effects for monetary policy coordination issues.

Equation (46) shows the value of $\hat{y}$; $\hat{C}$'s value follows from (55), (56), and (59) as

$$\hat{C} = \frac{\bar{r}(1 - n)(\theta^2 - 1)}{\bar{r}(1 + \theta) + 2\theta}\hat{E} + \hat{C}^W.$$

The long-run home consumption change $\hat{\bar{C}}$ can be derived from (37), (55), and (57):

$$\hat{\bar{C}} = \frac{\bar{r}(1 - n)(\theta^2 - 1)}{\bar{r}(1 + \theta) + 2\theta}\hat{E};$$

(39) shows that the long-run home output change is

$$\hat{\bar{y}} = -\frac{\bar{r}\theta(1 - n)(\theta - 1)}{\bar{r}(1 + \theta) + 2\theta}\hat{E}.$$

The corresponding foreign variables are obtained by replacing $1 - n$ with $-n$ in the exchange rate coefficients of these expressions. Thus all asymmetric effects of the monetary shock are transmitted through the exchange rate.

Returning to (61), we see from the preceding equations and equation (18) that the impact of the exchange rate terms on home welfare is zero, leaving

$$dU^R = \frac{\hat{C}^W}{\theta} = \frac{\beta + \epsilon(1 - \beta)}{\theta}\hat{M}^W. \tag{62}$$

This change is the product of the aggregate demand level change, dC^W, and the initial (positive) difference between the marginal utility of consumption and the marginal cost in utility terms of producing consumer goods. The obvious symmetry of the preceding calculation shows that, for the foreign country as well,

$$dU^{*R} = \frac{\hat{C}^W}{\theta} = \frac{\beta + \epsilon(1 - \beta)}{\theta}\hat{M}^W. \tag{63}$$

Thus the *only* effect of the money shock on U^R and U^{*R} comes from the general increase in world demand in the initial period, and both countries share the benefits equally. This is true despite the permanent increase in home relative consumption caused by the shock.

The fact that unanticipated monetary expansion can raise welfare is familiar from the static closed-economy analyses of Akerlof and Yellen (1985*a*, 1985*b*) and Blanchard and Kiyotaki (1987). Because price exceeds marginal cost in a monopolistic equilibrium, aggregate demand policies that coordinate higher work effort move the economy closer to efficient production, with a first-order impact on welfare. The surprising result in (62) and (63) is that the terms-of-trade and current-account effects that accompany unilateral monetary changes—effects long central to the international policy coordination literature—are of strictly second-order importance here. How can this be?

The crux of the matter is that if home producers lower prices and produce more, they gain revenue but work harder to get it. Starting in the initial equilibrium, where marginal revenue and cost are equal, the utility effects cancel exactly. An unexpected home-currency depreciation, which lowers the real price of home goods when domestic-money prices are sticky, has the same effect: home producers sell more but work harder too. Foreign producers face the opposite situation. The first-order effect of the monetary expansion thus is to raise global aggregate demand and world output. The associated expenditure-switching effects are only second-order. Does the fact that a current-account imbalance arises upset this conclusion? No. Here, at the margin, all effects from reallocating consumption and leisure over time have to be second-order as well.

Obviously, our result holds in its extreme form only for small monetary expansions. For large shifts, the envelope theorem no longer applies and assessments of welfare outcomes require numerical methods. Nevertheless, our analysis suggests that, even in cases in which the conventional Mundell-Fleming-Dornbusch paradigm yields empirically sensible results, its ostensible welfare implications can be quite misleading. For example, the earlier models may overstate the importance of the "beggar-thy-neighbor" effects that a country inflicts on trading partners when it depreciates its currency. Our theoretical analysis provides support for Eichengreen and Sachs's (1985) and Eichengreen's (1992) contention that, during the Great Depression, the global aggregate-demand benefits of unilateral inflationary devaluations were at least as important as the expenditure-switching effects.[28]

A crucial assumption underlying the model's welfare prediction is that producers' market power is the only distortion in the initial equilibrium. Home monetary expansion would not necessarily raise welfare in, say, a foreign economy with involuntary unemployment due to an efficiency-wage mechanism.

Our symmetrical international transmission result can similarly be reversed when distorting income taxes discourage labor effort. Sup-

[28] Embedded in our results is the assumption that initially there is no net international debt. If such debt were present, the fall in the interest rate caused by a monetary expansion would cause a first-order income redistribution from the creditor country to the debtor.

pose, for example, that income from labor is taxed in both countries at rate τ, with the proceeds being remitted to the private sector in lump-sum fashion. In this case, the expenditure-switching effect of a currency depreciation allows the home country to achieve an ex post reduction in its tax distortion at foreign expense. This can be seen by inspecting the welfare effects of monetary changes in this case, which are

$$dU^R = \left[\frac{1}{\theta} + \tau\left(\frac{\theta - 1}{\theta}\right)\right]\hat{C}^W + \tau(1 - n)\left[\frac{(1 + \bar{r})(\theta^2 - 1)}{\bar{r}(1 + \theta) + 2\theta}\right]\hat{E}$$

and

$$dU^{*R} = \left[\frac{1}{\theta} + \tau\left(\frac{\theta - 1}{\theta}\right)\right]\hat{C}^W - \tau n\left[\frac{(1 + \bar{r})(\theta^2 - 1)}{\bar{r}(1 + \theta) + 2\theta}\right]\hat{E}.$$

These expressions show that the tax distortion τ enhances the gain both countries potentially derive from an unanticipated rise in world aggregate demand (compare with [62] and [63]) but that the accompanying exchange rate change redistributes the overall benefit toward the depreciating country.

Which distortions are likely to dominate? One cannot draw any concrete conclusions without empirical analysis. We note, however, that the monopoly effects emphasized in our model have figured prominently in a number of recent attempts to explain the main features of business cycles (see, e.g., Hall 1986; Rotemberg and Woodford 1992). What our analysis clearly does show is that the intermediate policy targets typically emphasized in earlier Keynesian models—for example, output, the terms of trade, and the current account—can easily point in the wrong direction.

Thus far we have not discussed real-balance effects, which change U^M and U^{*M}, but they should not reverse our conclusions. Because the marginal utility of money is positive, policies that raise real monetary balances can be Pareto improving. In the case of a unilateral home monetary expansion, home real balances rise in all periods. Foreign real balances, however, rise in the first period but fall in the long run because long-run foreign consumption falls. The net effect abroad is ambiguous. But unless χ in (6) is implausibly large, so that real balances have a high weight in total welfare relative to consumption, the aggregate demand effects captured in (62) and (63) are the dominant ones.[29]

[29] It can be shown that, for empirically reasonable parameter values, $dU^{*M} > 0$. As we observed in n. 3, no such parameter restrictions need to be invoked in the cash-in-advance version of the model.

D. Government Spending Shocks

A government's spending falls on both home and foreign goods, but the taxes that finance it are borne entirely by its own citizens. Their consumption falls, but because they reduce their leisure at the same time, the net effect on world aggregate demand is positive. We have already studied government spending under flexible prices (in Sec. II*E*); now we turn to the sticky-price case, in which the results can be surprisingly different. Again we draw on the log-linearized equations of Sections II*D*, II*E*, and III*A*, abstracting from monetary changes by assuming $\hat{M} = \hat{\overline{M}} = \hat{M}^* = \hat{\overline{M}}^* = 0$.

The solution approach is completely parallel to the one followed in Section III*B*. In particular, the **MM** schedule for this case is still given by equation (52), but with monetary changes set to zero. Instead of (54), the equation

$$\hat{E} = \frac{\bar{r}(1+\theta)+2\theta}{\bar{r}(\theta^2-1)}(\hat{C}-\hat{C}^*) + \frac{1}{\theta-1}\left[\frac{dG-dG^*}{\overline{C}_0^W} + \left(\frac{1}{\bar{r}}\right)\frac{d\overline{G}-d\overline{G}^*}{\overline{C}_0^W}\right]$$

describes the new **GG** schedule, **G'G'**. The latter has the same positive slope as before, but its vertical intercept is proportional to the present discounted value of differential government spending changes. (Recall that dG and dG^* are the first-period fiscal shifts, and $d\overline{G}$ and $d\overline{G}^*$ are the shifts in all subsequent periods.)

Figure 2 illustrates a permanent unilateral increase in home government spending, with $dG = d\overline{G}$ (in the case of a temporary change, the exchange rate and relative consumption effects would be muted). Home consumption falls relative to foreign consumption because domestic residents are paying for the government spending. Because this relative consumption change lowers the relative demand for home money, E rises (a depreciation of home currency relative to foreign).[30] As in our analysis of monetary disturbances above, the exchange rate moves immediately to its new steady state, that is, $\hat{E} = \hat{\overline{E}}$. This result does not require that the fiscal shock be permanent. Because individuals smooth consumption over time, even temporary fiscal shifts induce a random walk in the exchange rate.

To derive algebraic solutions for the model, one proceeds exactly as in the case of money shocks. (To simplify the resulting expressions, we hold G^* at zero when this is convenient.) The short-run exchange rate change is

$$\hat{E} = \frac{\bar{r}(1+\theta)}{\bar{r}(\theta^2-1)+\epsilon[\bar{r}(1+\theta)+2\theta]}\left[\frac{dG}{\overline{C}_0^W} + \left(\frac{1}{\bar{r}}\right)\frac{d\overline{G}}{\overline{C}_0^W}\right].$$

[30] Remember that in the fiscal policy experiment we are considering, relative demands for national outputs do not change.

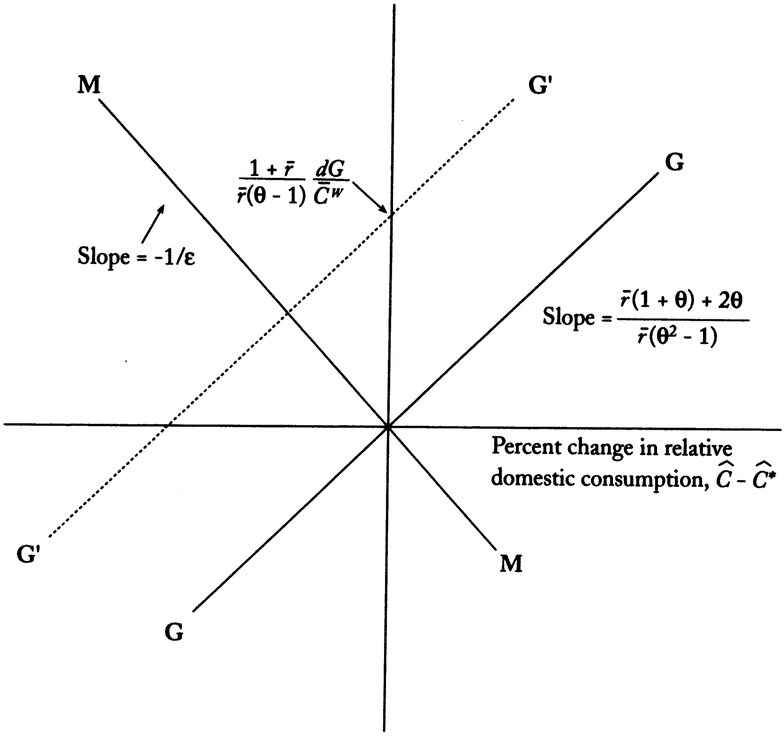

FIG. 2.—An unanticipated permanent increase in home government spending

By equation (52), $\hat{C} - \hat{C}^* = -\epsilon\hat{E}$. The current account is given by

$$\frac{d\bar{F}}{\bar{C}_0^W} = \frac{\bar{r}(1+\theta)(1-n)(\epsilon+\theta-1)}{\bar{r}(\theta^2-1)+\epsilon[\bar{r}(1+\theta)+2\theta]} \times \left[\frac{dG}{\bar{C}_0^W} + \left(\frac{1}{\bar{r}}\right)\frac{d\bar{G}}{\bar{C}_0^W}\right] - (1-n)\frac{dG}{\bar{C}_0^W}. \tag{64}$$

In the case of a transitory spending increase ($d\bar{G} = 0$), it is clear that the home country runs a current-account deficit. The dominant mechanism is similar to that in flexible-price models: because the tax increase is temporary, consumption falls by less than the rise in government spending. There is a partially offsetting effect here, however, because the home-currency depreciation causes a short-run rise in home relative to foreign output. In fact, for a *permanent* increase in domestic government spending, equation (64) implies that the home country runs a surplus if $\theta + 1 > \epsilon$. The usual result in flexible-price, representative-agent economies is that permanent government spending changes have no current-account effects because they do not tilt the time profile of output net of government expenditure.[31] With sticky prices, however, an unanticipated permanent rise in G can tilt the time profile of output, producing a surplus or deficit.

The effects of government spending on the world real interest rate provide an even more surprising contrast with the flexible-price case. Allowing once again for foreign government spending, one finds the short-run change in the world real interest rate to be

$$\hat{r} = -\left[\frac{\beta + (1 - \beta)\epsilon}{(1 - \beta)\epsilon}\right]\frac{d\overline{G}^W}{\overline{C}_0^W}. \tag{65}$$

The startling implication of equation (65) is that only innovations in *future* government spending affect the real interest rate. Current temporary innovations in government spending have *no* effect. With sticky prices and demand-determined output, global output rises by the same amount as government spending, so there is no change in the time path of output available for private consumption when the government spending increase is temporary. Equation (65) also shows that permanently higher government spending temporarily lowers the real interest rate. This contrasts with the textbook flexible-price result of an unchanged interest rate (Barro 1993). Because an unexpected permanent rise in government spending generates a bigger output effect in the short run than in the long run, it results in a declining path of output available for private consumption.

Obviously, some of the precise positive implications of our model depend on the exact manner in which government spending enters it. The standard intertemporal approach admits a plethora of possibilities (government purchases can be used for investment, government consumption can be a substitute for private consumption, etc.). One result likely to be fairly robust to changes in the specific details of the model, however, is that unanticipated increases in government spending do not raise interest rates as much (or lower them more) in

[31] The result just mentioned does not generally hold in flexible-price economies with domestic investment. A permanent increase in government consumption may permanently reduce leisure, thus raising the long-run home stock of capital. The result is a rise in investment accompanied by a deficit in the current account. Baxter (1992) explores this mechanism.

a world with short-run price rigidities as in a world with fully flexible prices.[32]

As was the case for monetary shocks, nominal exchange rates may be less volatile under sticky prices than under flexible prices. A consequence of equations (42), (43), and (23) is that the **MM** equation, $\hat{E} = -(1/\epsilon)(\hat{C} - \hat{C}^*)$, holds in both the sticky-price and flexible-price cases for any fiscal shock (with money held constant). Thus the exchange rate impact of fiscal policy is proportional to the induced consumption differential regardless of whether prices are sticky or flexible. But from our preceding discussion of the current account, one can readily confirm that both temporary and permanent fiscal shocks have smaller absolute effects on relative consumption under sticky prices. Hence, the absolute exchange rate effects are smaller as well.

An explicit welfare analysis of fiscal policy along the lines of Section III*C* is straightforward. Again, the induced expenditure switching effects are of second-order significance. The major new issue that arises is that the citizens whose government expands foot the entire tax bill for the resulting expansion in world aggregate demand.

In concluding this section, we note that our analysis, which has focused entirely on monetary and fiscal policy shocks, can easily be extended to incorporate productivity shocks. They can be modeled as changes in the parameter κ in equation (6); a fall in κ can be interpreted as implying that less labor is required to produce a given amount of output. When κ can vary, equations (29) and (30) become

$$(\theta + 1)\hat{y}_t = -\theta\hat{C}_t + \hat{C}_t^W + \frac{dG_t^W}{\overline{C}_0^W} - \theta\hat{\kappa}_t$$

and

$$(\theta + 1)\hat{y}_t^* = -\theta\hat{C}_t^* + \hat{C}_t^W + \frac{dG_t^W}{\overline{C}_0^W} - \theta\hat{\kappa}_t^*;$$

all the other equations of the linearized model remain the same.[33]

[32] Our results on the interest rate effects of fiscal policies, which apply equally to closed- and open-economy sticky-price models, appear to be new. Mankiw (1987) shows that when durables as well as capital accumulation are present in a flexible-price model, higher government spending may temporarily lower the real interest rate.

[33] Since the supply equations, (29) and (30), are not binding in the sticky-price short run, the output effects of purely *temporary* unanticipated fluctuations in κ are offset entirely by fluctuations in leisure. No other variables need adjust. In contrast, a *permanent* unanticipated fall in home κ (a rise in home productivity) causes a short-run improvement in the home terms of trade, a long-run deterioration, and a short-run increase in the world real interest rate.

IV. Extensions

To highlight both the potential and the limitations of our framework, we briefly catalog a number of possible extensions.[34] Just as there are many variants of the Mundell-Fleming-Dornbusch model that allow for intermediate goods, nontraded goods, international differences in wage setting, and so on, one can imagine numerous variants of the present model. In the Appendix, we develop a small-open-economy variant that allows for nontraded consumption goods. This model is much simpler to solve than the two-country model explored above. An extended general equilibrium version must be used to address international transmission issues.

Our analysis has not allowed for uncertainty except for one-time unanticipated shocks. However, standard techniques can be used to develop a stochastic version of the model.[35] A further limitation is our treatment of monetary policy as exogenous. But the fact that unanticipated monetary policy expansion raises welfare implies that credibility problems can arise in a model in which monetary policy is determined endogenously. Using the model to look at inflation credibility issues as well as problems of international monetary policy coordination would seem a fruitful area for further research.[36]

The model's dynamics can be extended in a number of dimensions. Introducing overlapping generations in place of homogeneous infinitely lived agents would enrich the dynamics while permitting real effects of government budget deficits. The analysis above considered only one-period nominal rigidities, but allowing for richer price dynamics would enhance the model's empirical applicability. The exclusion of domestic investment, while a useful strategic simplification for some purposes, prevents discussion of some important business cycle regularities.

Attempts to extend the framework clearly become much easier if one is willing to settle for numerical results rather than analytical ones. For many purposes (such as analyzing large shocks), resort to numerical methods is a necessary compromise. We believe, however, that analytical results such as those presented here are a vital aid to intuition, even intuition about more elaborate numerical models.

[34] Several of the extensions discussed below, including the cash-in-advance model of money demand and applications to monetary policy credibility, are taken up in Obstfeld and Rogoff (1996, chaps. 9, 10).

[35] Explicitly introducing uncertainty would raise the question of international diversification of country-specific risks. In Obstfeld and Rogoff (1995), we argue that the assumption made here—that risk-free bonds are the only assets countries trade—is a closer approximation to reality than the alternative extreme of complete state-contingent markets. Obstfeld and Rogoff (1996, chap. 6) consider intermediate cases in which the degree of capital market completeness is endogenously determined.

[36] Romer's (1993) related static model focuses on the credibility of monetary policy.

V. Conclusions

We have developed a framework that offers new foundations for thinking about some of the fundamental problems in international finance. Existing models, whether traditional static Keynesian models or newer flexible-price intertemporal models, are too incomplete to offer a satisfactory integrative treatment of exchange rates, output, and the current account. While our model is seemingly quite complex, it yields simple and intuitive insights into the international repercussions of monetary and fiscal policies. It can be extended in a number of dimensions, including the addition of nontraded goods, pricing to market behavior, home bias in government spending, labor market distortions, and so on.

By design, our model inherits much of the empirical sensibility of the still-dominant Mundell-Fleming-Dornbusch approach to international finance. We have gone beyond that essentially static approach in offering a framework that simultaneously handles current-account and exchange rate issues, as well as the dynamic repercussions of fiscal shifts. Most important, though, the new approach allows one to analyze meaningfully the welfare implications of alternative policies. We find that some of the intermediate policy targets emphasized in earlier Keynesian models of policy transmission (the terms of trade, the current account, and so on) turn out, on closer inspection, to be important individually but largely offsetting taken jointly. This would never be apparent without carefully articulated microfoundations.

Appendix

A Model with Nontraded Goods

Here we sketch a simple model of a small open economy with nontraded consumption goods in which exchange rate overshooting is possible. Now, the nontraded-goods sector is monopolistically competitive with preset nominal prices, but there is a single homogeneous tradable good that sells for the same price all over the world. The tradables sector is perfectly competitive, and therefore the money price of the tradable good is flexible. A home citizen is endowed with a constant quantity of the traded good each period, $\bar{y}_T$, and has a monopoly over production of one of the nontradables $z \in [0, 1]$.

The utility function of the representative producer is

$$U_t = \sum_{s=t}^{\infty} \beta^{s-t}\left[\gamma \log C_{Ts} + (1-\gamma)\log C_{Ns} + \frac{\chi}{1-\epsilon}\left(\frac{M_s}{P_s}\right)^{1-\epsilon} - \frac{\kappa}{2} y_{Ns}(z)^2\right],$$

where C_T is consumption of the traded good and C_N is composite nontraded goods consumption, defined by

$$C_N = \left[\int_0^1 c_N(z)^{(\theta - 1)/\theta} dz \right]^{\theta/(\theta - 1)} .$$

Here, P is the utility-based nominal price index:

$$P \equiv \frac{P_T^{\gamma} P_N^{1-\gamma}}{\gamma^{\gamma}(1 - \gamma)^{1-\gamma}}, \tag{A1}$$

with $P_T = EP_T^*$ the nominal price of the traded good and P_T^* exogenous and constant. The nominal price P_N is the nontraded goods price index

$$P_N = \left[\int_0^1 p_N(z)^{1-\theta} dz \right]^{1/(1-\theta)} ,$$

with $p_N(z)$ the money price of good z. Bonds are denominated in tradables, and the individual's period budget constraint, with r denoting the constant world interest rate in tradables, is

$$P_{Tt}F_t + M_t = P_{Tt}(1 + r)F_{t-1} + M_{t-1} + p_{Nt}(z)y_{Nt}(z)$$
$$+ P_{Tt}\bar{y}_T - P_{Nt}C_{Nt} - P_{Tt}C_{Tt} - P_tT_t,$$

where per capita taxes T are also denominated in tradables. It is convenient to assume that there is no government spending, so that the government budget constraint is given by

$$0 = T_t + \frac{M_t - M_{t-1}}{P_{Tt}}.$$

Parallel to equation (8) in the text, the demand curve for nontraded good z is

$$y_{Nt}^d(z) = \left[\frac{p_{Nt}(z)}{P_{Nt}} \right]^{-\theta} C_{Nt}^A,$$

where C_{Nt}^A is aggregate home consumption of nontraded goods. Producers take C_{Nt}^A as given.

Assuming $(1 + r)\beta = 1$, we can write the first-order conditions for individual maximization as

$$C_{Tt+1} = C_{Tt}, \tag{A2}$$

$$\frac{\gamma}{C_{Tt}} = \chi \frac{P_{Tt}}{P_t} \left(\frac{M_t}{P_t} \right)^{-\epsilon} + \beta \frac{P_{Tt}}{P_{Tt+1}} \left(\frac{\gamma}{C_{Tt+1}} \right), \tag{A3}$$

$$C_{Nt} = \frac{1 - \gamma}{\gamma} \left(\frac{P_{Tt}}{P_{Nt}} \right) C_{Tt}, \tag{A4}$$

and

$$y_{Nt}(z)^{(\theta + 1)/\theta} = \left[\frac{(\theta - 1)(1 - \gamma)}{\theta \kappa} \right] C_{Nt}^{-1} (C_{Nt}^A)^{1/\theta}. \tag{A5}$$

Substituting (A2) into (A3) yields

$$\frac{M_t}{P_t} = \left[\frac{\chi P_{Tt} C_{Tt}}{\gamma P_t}\left(\frac{1+i_t}{i_t}\right)\right]^{1/\epsilon}, \tag{A6}$$

where the nominal interest rate is $i_t = (P_{Tt+1}/P_{Tt})(1+r) - 1$.

Note that, under the present separable utility function, agents smooth consumption of traded goods independently of nontraded goods production or consumption. Since production is constant at $\bar{y}_T$, this implies that

$$C_{Tt} = \bar{y}_T \tag{A7}$$

for all t, under the assumption of zero initial net foreign assets. Thus the economy runs a balanced current account regardless of shocks to money or productivity in nontraded goods.

We again begin by deriving the steady-state equilibrium in which prices are fully flexible and the money supply is constant. In the symmetric (among domestic residents) market equilibrium, $C_{Nt} = y_{Nt}(z) = C^A_{Nt}$ for all z; thus equation (A5) implies that, in the steady state,

$$\bar{y}_N = \bar{C}_N = \left[\frac{(\theta-1)(1-\gamma)}{\theta\kappa}\right]^{1/2}. \tag{A8}$$

In a steady state with a constant money supply, prices of traded goods must be constant. The equilibrium price level, $\bar{P}$, may be found using equations (A4) and (A6)–(A8), together with $P_{Tt+1} = P_{Tt}$, which follows from the no speculative bubbles condition. Here long-run monetary neutrality obtains since money shocks do not affect wealth.

In the short run, prices of nontraded goods are fixed at $\bar{p}_N$ and output of nontraded goods is demand determined. Because $\bar{p}_N(z)/\bar{P}_N = 1$, the short-run demand for nontraded goods is given by

$$y^d_N(z) = C_N. \tag{A9}$$

Combining equations (A4), (A7), and (A9) yields

$$y_N = C_N = \frac{1-\gamma}{\gamma}\left(\frac{P_T}{\bar{P}_N}\right)\bar{y}_T, \tag{A10}$$

which gives y_N and C_N as functions of P_T. To solve for short-run P_T (recall that traded goods prices are flexible), log-linearize the money demand equation (A6):

$$\epsilon(\hat{M} - \hat{P}) = \hat{P}_T - \hat{P} + \frac{\beta}{1-\beta}(\hat{P}_T - \hat{\bar{P}}_T). \tag{A11}$$

As in the text, hatted variables are short-run deviations from the initial steady state and hatted variables with overbars are long-run deviations from the initial steady state. Log-differentiating the price index equation (A1), with P_N fixed, yields the short-run price-level response

$$\hat{P} = \gamma\hat{P}_T. \tag{A12}$$

Finally, since money is neutral in the long run and the money shock is permanent, we have

$$\hat{\bar{P}}_T = \hat{\bar{M}} = \hat{M}. \tag{A13}$$

Substituting the last two relationships into equation (A11) yields

$$\hat{P}_T = \hat{E} = \frac{\beta + (1 - \beta)\epsilon}{\beta + (1 - \beta)(1 - \gamma + \gamma\epsilon)}\hat{M}. \tag{A14}$$

Note that the price of traded goods changes in proportion to the exchange rate because the law of one price holds for tradables and the country does not have any market power in tradables.

From (A14), we can see that, if $\epsilon > 1$, the nominal exchange rate overshoots its long-run level. To understand why overshooting depends on ϵ, notice that $1/\epsilon$ is the consumption elasticity of money demand. Suppose, for the moment, that $\hat{P}_T = \hat{M}$, so that there is neither over- nor undershooting. Then, by equation (A12), the supply of real balances would have to rise by $\hat{M} - \hat{P} = (1 - \gamma)\hat{M}$. From equations (A6), (A7), and (A12), we see that, in this case, the demand for real balances will rise by $(1/\epsilon)(1 - \gamma)\hat{M}$. If $\epsilon > 1$, the demand for real balances will rise by less than the supply and the price of tradables (the exchange rate) would have to rise further to reach equilibrium, thereby overshooting its long-run level.

Finally, observe that an unanticipated rise in money supply is unambiguously welfare improving at home: output rises in the monopolistic nontraded-goods sector and (as one can show) real money balances also rise.

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