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## Monetary Policy, Investment Dynamics, and the Intertemporal Approach to the Current Account

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MONETARY POLICY, INVESTMENT  
DYNAMICS, AND THE INTERTEMPORAL  
APPROACH TO THE CURRENT ACCOUNT

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IN DB

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# Monetary Policy, Investment Dynamics, and the Intertemporal Approach to the Current Account

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# Monetary Policy, Investment Dynamics, and the Intertemporal Approach to the Current Account

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March 1997

## **Abstract:**

This paper applies the intertemporal approach to the current account to the case of monetary shocks. A two-country dynamic general equilibrium model with predetermined wages is proposed as a means to bridge the gap between Mundell-Fleming and modern intertemporal models. Early versions of Mundell-Fleming implied that a monetary expansion must necessarily improve the current account; the alternative result became a possibility in more contemporary versions when intertemporal features were introduced into the asset market. The present model suggests that when intertemporal features are also introduced into the other markets of the economy, the model's prediction is transformed yet further. A calibrated version of the model suggests a **beggar-thy-neighbor** improvement in the current account becomes unlikely for reasonable parameter values.

## 1. Introduction

An emerging priority in international macroeconomics is the need to bridge a particularly awkward gulf. On one hand, modern intertemporal models have become standard for analyzing theoretical issues.<sup>1</sup> However, the more traditional framework of Mundell and Fleming remains the workhorse of international macroeconomics for policy analysis.<sup>2</sup> While this latter tradition does not effectively address intertemporal issues, it has the appeal of incorporating rigidities that give monetary policy significant real effects.<sup>3</sup> A celebrated attempt to bridge this gap has been Obstfeld and Rogoff (1995), which included predetermined prices in a modern intertemporal model.<sup>4</sup>

For some time the intertemporal approach to the current account has been usefully applied to analyze real shocks, such as to output and fiscal policy. When the current account is regarded as national saving minus investment, the effect of these shocks comes through their implications for intertemporal consumption smoothing and the expected future marginal products of capital. A similar analysis can be applied also to monetary shocks, if money and rigidities are introduced into an intertemporal model.

The effect of a monetary expansion on the current account is a recurring question in international macroeconomics and policy debates. For instance, fears currently are voiced that if European countries excluded from monetary union are permitted to float their currencies, they may engineer competitive depreciations to the detriment of their neighbors.<sup>5</sup>

The earliest versions of Mundell-Fleming suggested a monetary expansion should indeed generate a current account surplus, by depreciating the real exchange rate and switching expenditure toward home goods. In these initial

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<sup>1</sup>See Sachs (1982) for an early treatment of the intertemporal approach to the current account. This intertemporal approach is reflected also in international business cycle research, such as in Backus, Kehoe and Kydland (1992), Baxter and Crucini (1993), and Stockman and Tesar (1996).

<sup>2</sup>Fleming (1962) and Mundell (1963).

<sup>3</sup>See Bryant 1988 and 1991 for descriptions and comparisons of these models.

<sup>4</sup>See also Svensson and Van Wijnbergen (1989) and Stockman and Ohanian (1993) for other examples of models employing predetermined prices. An alternative approach has been to use liquidity effects, as in Grilli and Roubini (1991) and Schlagenhauf and Wrase (1995). See Leeper and Sims (1995) for a closed-economy model employing wage and price rigidity. McKibbin and Sachs (1991) also performs policy analysis in a model that incorporates intertemporal features and rigidities.

<sup>5</sup>See Bergin and Moersch (1997) for an application to this issue of the model developed in the present paper.

versions, the fall in the nominal interest rate following a monetary expansion would preclude capital inflows and hence required an improvement in the current account.<sup>6</sup> Later versions suggested capital inflows nevertheless might be attracted if there is an expectation of a future exchange rate appreciation. So by incorporating intertemporal features into the asset market, the augmented Mundell-Fleming story could permit a worsening current account as a possibility. However, this story still ignores intertemporal effects at work in the goods and labor markets, which the intertemporal approach has emphasized.

The analysis in Obstfeld and Rogoff (1995) sheds significant light on the intertemporal effects of monetary policy. However, the model abstracts from investment, to make solution analytically tractable. This clearly is a limitation where the current account is regarded as saving minus investment.<sup>7</sup> Further, the model of Obstfeld and Rogoff is inherently different in spirit from Mundell-Fleming. It uses sticky prices instead of wages. And it features monopolistic competition, which strongly affects the nature of its results in analyzing the effects of monetary policy.

This paper analyzes the intertemporal effects of a monetary expansion in the context of a two-country dynamic general equilibrium model augmented with money and sticky wages. It includes investment decisions and consumption-leisure choices. While the core of the model is an international real business cycle model, it is augmented to capture much of the spirit of Mundell-Fleming, and is able to replicate the basic implications of Mundell-Fleming in a subregion of the parameter space. The model is calibrated to U.S. data for one country and non-U.S. G7 data for the other.

Results from simulations suggest the intertemporal effects of monetary policy work in the direction counter to the expenditure-switching effect characteristic of Mundell-Fleming. Firstly, investment may rise significantly in response to expectations of future profitability. Secondly, consumption may rise significantly to smooth utility intertemporally in the face of falling leisure. For most reasonable regions of the parameter space, these intertemporal effects dominate, suggesting a monetary expansion would worsen the current account.

The next section of this paper presents a dynamic general equilibrium model useful for analyzing monetary policy in an international setting. Section three analyzes the effects of monetary policy on intertemporal investment decisions. Section four shows that intertemporal consumption decisions are also central to

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<sup>6</sup>See Frenkel and Mussa (1988) for a more detailed discussion of this point.

<sup>7</sup>Investment under exchange rate devaluation has been considered by Nielsen (1991) and Risager (1988). These analyses, however, do not explicitly model money or monetary policy.

the net effect on the current account. Section five concludes.

## 2. The Model

The core of the model is a two-country two-good real business cycle model, to which money and wage rigidity are added. Money is introduced via a transactions-cost specification. Wage rigidities are introduced as overlapping contracts that predetermine the nominal wage. Each country has a representative household, a representative firm, and a government. Starred variables relate to the foreign country, unstarred variables to the home country. The notation is listed in table 1.

### 2.1. A Market-Clearing Model: Households and Firms

Begin by considering a market-clearing benchmark model of two countries. The households in both countries are endowed each period with one unit of time, which they divide between leisure and work. They derive utility from consumption of the home and foreign goods ( $c_1$  and  $c_2$ , respectively) and from leisure ( $1 - L$ ), discounting utility at the rate of time preference  $\beta$ . Households can hold three types of nominal assets: non-interest bearing home money ( $M$ ), interest bearing one-period debt issued by the home government ( $B_1$ ), or debt issued by the foreign government ( $B_2$ ). Money holding is motivated via a transactions cost specification. Households hold money because it lowers the transactions cost incurred when purchasing consumption goods, as reflected in a velocity term ( $v$ ).<sup>8</sup>

Households make the investment decision here. This arrangement is convenient for solving the model in that it concentrates all intertemporal decisions in the hands of households, but has no significant effect on results. Household income is derived from selling labor ( $L$ ) to firms at wage rate ( $W$ ), rental of capital ( $k$ ) at the rental rate ( $r$ ), dividends from firms ( $d$ ), and from the interest received on government bonds (at rates  $R$  and  $R^*$ ), less taxes paid on labor income (at rate  $T_1$ ) and in lump sum ( $T_2$ ).

International linkages in the model work through household trade in the goods market and the market in government debt. There is no trade in firm equities,

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<sup>8</sup>Domestic money facilitates purchases of both domestic and imported goods. It is assumed here that the importation of goods is conducted at a wholesale level where a different transactions technology applies. /

For a defense of specifying money demand as a function of consumption, see Mankiw and Summers (1986).

because the logical result in this model would be a perfect-pooling equilibrium, which would imply that supply shocks are insured between countries in a manner that is empirically counterfactual and rather uninteresting. There is also no international mobility in labor.

The home household problem is summarized below. (Here  $P_1$  and  $P_2^*$  are home and foreign prices, and  $e$  is the exchange rate, defined as the domestic currency price of one unit of foreign exchange.)

$$\max E_0 \sum_{t=1}^{\infty} \beta^t U(c_{1t}, c_{2t}, L_t) \quad (2.1)$$

$$\begin{aligned} s.t \quad & (1 + \gamma_t v_t) \left( c_{1t} + e_t \frac{P_{2t}^*}{P_{1t}} c_{2t} \right) + \left( \frac{B_{1t} - B_{1t-1}}{P_{1t}} + e_t \frac{B_{2t} - B_{2t-1}}{P_{1t}} \right) + \left( \frac{M_t - M_{t-1}}{P_{1t}} \right) + I_t \\ & = \left( \frac{R_{t-1} B_{1t-1}}{P_{1t}} + e_t \frac{R_{t-1}^* B_{2t-1}}{P_{1t}} \right) + (1 - T_{1t}) \frac{W_t L_t}{P_{1t}} - T_{2t} + d_t + r_{t-1} k_{t-1} \end{aligned} \quad (2.2)$$

$$\begin{aligned} \text{where } U(c_{1t}, c_{2t}, L_t) &= \frac{1}{1-\sigma} \left( \left( c_{1t}^\theta c_{2t}^{1-\theta} \right)^a (1 - L_t)^{1-a} \right)^{1-\sigma} \\ \sigma > 0, \quad \sigma \neq 1, \quad 0 < a < 1, \quad 0 < \theta < 1 \end{aligned} \quad (2.3)$$

$$\text{and } v_t = \frac{P_{1t}}{M_t} \left( c_{1t} + e_t \frac{P_{2t}^*}{P_{1t}} c_{2t} \right) \quad (2.4)$$

$$\text{and } k_t = I_t + (1 - \delta) k_{t-1} \quad 0 \leq \delta \leq 1 \quad (2.5)$$

$$B_{1t} > 0, B_{2t} > 0, M_t > 0 \quad (2.6)$$

The problem faced by the foreign household is analogous.

Solving the household budget constraint forward and imposing the transversality condition, which requires that households utilize their intertemporal wealth, an intertemporal budget constraint is obtained:

$$\begin{aligned} z_t = \sum_{s=t}^{\infty} \left( \prod_{j=t}^s (1 + R_{j-1})^{-1} \frac{P_{1j}}{P_{1j-1}} \right) & \left[ (1 + \gamma_s v_s) \left( c_{1s} + e_s \frac{P_{2s}^*}{P_{1s}} c_{2s} \right) \right. \\ & \left. - (1 - T_{1s}) \frac{W_s L_s}{P_{1s}} - T_{2s} + d_s + z z_s \right] \end{aligned} \quad (2.7)$$

$$\begin{aligned} \text{where } z_t & \equiv \frac{B_{1t-1}}{P_{1t-1}} + \left( \frac{1 + R_{t-1}^*}{1 + R_{t-1}} e_t \right) \frac{B_{2t-1}}{P_{1t-1}} + \left( \frac{1}{1 + R_{t-1}} \right) \frac{M_{t-1}}{P_{1t-1}} \\ & + \left( \frac{1}{1 + R_{t-1}} \frac{P_{1t}}{P_{1t-1}} (1 + r_{t-1} - \delta) \right) k_{t-1} \end{aligned}$$



$$\begin{aligned} \text{and } zz_s \equiv & \left( e_s - \frac{1+R_s^*}{1+R_s} e_{s+1} \right) \frac{B_{2s}}{P_{1s}} + \left( 1 - \frac{1}{1+R_s} \right) \frac{M_s}{P_{1s}} \\ & + \left( 1 - \frac{1}{1+R_s} \frac{P_{1s+1}}{P_{1s}} (1 + r_s - \delta) \right) k_s \end{aligned}$$

Firms produce output (**y**) using a Cobb-Douglas production function, using as inputs the labor they hire (**L**) and the capital they rent from households (**k**). The firms maximize single period profits, net of wage and rental payments, and these profits are paid to households as dividends (**d**). The home firm's problem is:

$$d_t = \max \left( y_t - \frac{W_t L_t}{P_{1t}} - r_{t-1} k_{t-1} \right) \quad (2.8)$$

$$s.t. y_t = A_t L_t^\alpha k_{t-1}^{1-\alpha} \quad 0 < \alpha < 1 \quad (2.9)$$

The equation system used for simulations uses the Euler equations derived from the problems specified above. First, the choice of home households between the two consumption goods is determined by equating marginal utilities scaled by the relative price:

$$U_{2t} = U_{1t} \left( e_t \frac{P_{2t}^*}{P_{1t}} \right) \quad (2.10)$$

Second, the intertemporal choice of consumption now or in the future is captured in the Euler equation with respect to home bonds:

$$x_t = \beta (1 + R_t) E_t [x_{t+1}] \quad (2.11)$$

$$\text{where } x_t = \frac{U_{1t}}{P_{1t} (1 + 2\gamma v_t)} \quad (2.12)$$

Here present marginal utility is equated to discounted expected future marginal utility. Third, the above Euler equation substituted into that for home money produces a liquidity preference relation:

$$(1 + R_t) = \frac{1}{1 - \gamma v_t^2} \quad (2.13)$$

This relation characterizes the trade-off money presents (reflected in velocity) between lower transaction costs and foregone interest income from not holding interest-bearing assets. It may be viewed as a type of LM equation.

The uncovered interest parity condition emerges when the Euler equation for home bonds above is combined with its counterpart for foreign bonds:

$$e_t = \left( \frac{1 + R_t^*}{1 + R_t} \right) \left( \frac{E_t [e_{t+1} x_{t+1}]}{E_t [x_{t+1}]} \right) \quad (2.14)$$

Note that this parity condition involves marginal utilities, since it is not only the expected depreciation that matters, but the value of expected depreciation in terms of utility.

Investment demand equates the marginal cost of investing to the discounted expected marginal product of capital. It is derived by combining the Euler equations of both firms and households with respect to capital:

$$P_{1t} x_{1t} = \beta E_t \left[ P_{1t+1} x_{t+1} \left( (1 - a) A_{t+1} L_{t+1}^\alpha k_t^{-\alpha} + (1 - \delta) \right) \right] \quad (2.15)$$

Labor demand equates the real wage to the marginal product of labor:

$$\frac{W_t}{P_{1t}} = \alpha A L_t^{\alpha-1} k_t^{-\alpha} \quad (2.16)$$

In the flexible-wage version of the model, labor supply equates the after-tax wage to the relative marginal disutility of work:

$$(1 - T_{1t}) W_t = \frac{-U_{Lt}}{x_t} \quad (2.17)$$

but this equation will be suspended when wages are assumed sticky.

The equations discussed above have their counterparts for the foreign agents.<sup>9</sup>

## 2.2. Government

The government in each country uses consumption goods (in amount  $g$ ) for a purpose that yields no utility to consumers. It derives revenue from distortionary taxes on labor income (at rate  $T_1$ ), from lump sum taxes on households ( $T_2$ ), from issuing money ( $N_1$ ), and from issuing debt ( $D_1$ ). The government also expends

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<sup>9</sup>A foreign counterpart to the interest parity condition again emerges when the bond equations for the foreign household are combined, and in the linearized model, this condition is identical to that for the home agents. This redundancy results because the second order terms that distinguish the two equations, such as the covariances of returns with marginal utilities, drop out under linearization. This redundancy means that the portfolio allocation of bonds is indeterminate in the linearized model. To resolve this indeterminacy for the purpose of simulation, I simply impose an allocation rule, specifying that foreign agents split their portfolios in a certain proportion, that proportion becoming a calibratable parameter.

revenue by paying interest on outstanding debt. The home government budget constraint is as follows:

$$\bar{g}_t + \frac{R_{t-1}D_{1t-1}}{P_{1t}} = \bar{T}_{1t} \left( \frac{W_t L_t}{P_{1t}} \right) + T_{2t} + \left( \frac{M_t - M_{t-1}}{P_{1t}} \right) + \left( \frac{D_{1t} - D_{1t-1}}{P_{1t}} \right) \quad (2.18)$$

$$D_{1t} \geq 0$$

Monetary policy is characterized here by shocks to money base:

$$M_t = M_{t-1} + \varepsilon_t \quad (2.19)$$

A shift in monetary policy takes the form of an unexpected permanent rise in money supply.

Income taxes and government expenditure are held fixed for the present experiments. **Lump-sum** taxes are determined to maintain dynamic stability of the model. If government debt rises, lump-sum taxes respond sufficiently to prevent debt from growing explosively.

$$T_{2t} - T_{2t-1} = \left( \frac{R_{t-1}D_{1t-1}}{P_{1t}} \right) - \left( \frac{R_{t-2}D_{1t-2}}{P_{1t-1}} \right) \quad (2.20)$$

Since the government is guaranteeing dynamic stability of debt, it is sure also to be satisfying its solvency condition, which is necessary if the optimizing households are to willingly hold government debt:

$$\frac{D_{1t-1}}{P_{1t-1}} + \left( \frac{1}{1+R_{t-1}} \right) \frac{M_{1t-1}}{P_{1t-1}} = \sum_{s=t}^{\infty} \left( \prod_{j=t}^{s-1} (1+R_j)^{-1} \frac{P_{1j}}{P_{1j-1}} \right) \left[ \frac{T_{1s}W_sL_s}{P_{1s}} + T_{2s} - g_s + \left( 1 - \frac{1}{1+R_s} \right) \frac{M_{1s}}{P_{1s}} \right] \quad (2.21)$$

The foreign government of course has an analogous budget constraint and policy rules.

The market-clearing for the bond markets are:

$$B_{1t} + B_{1t}^* = D_{1t} \quad (2.22)$$

$$B_{2t} + B_{2t}^* = D_{2t}^* \quad (2.23)$$

Only one of the goods market clearing conditions is necessary, because of Walras' Law. When it is combined with the budget constraints of the home country, it produces the balance of payments constraint<sup>10</sup>:

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<sup>10</sup>Buiter and Eaton (1981).

$$[currentaccount] + [capital account] =$$

$$\begin{aligned} & [(P_{1t}c_{1t}^* - e_t P_{2t}c_{2t}) + e_t R_{t-1}^* B_{2t-1} - R_{t-1} B_{1t-1}^*] \\ & + [(B_{1t}^* - B_{1t-1}^*) - e_t (B_{2t} - B_{2t-1})] = 0 \end{aligned} \quad (2.24)$$

This balance of payments constraint may be regarded as the condition determining the equilibrium exchange rate. If there is an excess demand for foreign currency at a given exchange rate, the home currency will depreciate to clear the market.

### 2.3. Including Wage Rigidity

Now consider augmenting the model with a form of nominal wage rigidity. While New Keynesian work tends to prefer sticky prices to wages, several arguments can be made in favor of the later. First, sticky wages are more closely related to the underlying notion of rigidity in Mundell-Fleming. Second, while sticky wages are often criticized for implying countercyclical real wages in the face of demand shocks, in contrast to empirical correlations that are weakly procyclical, the correlation is easily matched if one considers supply shocks as well as demand shocks. In fact, Cho (1990) and Cho and Cooley (1995) find such a combination is better able to match the empirical correlation than either the Keynesian or the Real Business Cycle extreme. Sticky wages also improve several other key correlations in the labor market, and by amplifying the effects of even technology shocks, they enable a model to explain large output fluctuations without the extremely large technology shocks usually required in Real Business Cycle models. Further, the alternative of sticky prices has several distinct drawbacks. First, positive technology shocks are forced to have perverse negative effects on output and hours. And all labor variables, including the real wage, tend to have correlations with output that are too high compared with the data.<sup>11</sup>

In the simulation experiments with the calibrated model in the following sections, I specify that the nominal wage is predetermined and the equilibrium quantity in the labor market is assumed demand determined. Households take the quantity of labor as given and do not see themselves as having any labor supply decision. So the labor supply Euler equation (2.17) is suspended. Wages are predetermined in contracts that last four periods. The contract wage is set for each period at the level that is rationally expected to clear the labor market and satisfy

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<sup>11</sup>See Cho (1990) for a complete discussion.

the missing Euler equation. Further, to capture the notion of gradual adjustment to shocks, the model specifies staggered contracts along the line of Taylor (1980), in which each year one of four contracting groups sets its four-year contract. This implies a group's contract level is affected by what other groups are expected to do in future periods when their contracts come due, and the effects these future decision will have on the evolution of the economy. Finally, the overall wage level prevailing in the economy is approximated by the average over the contract levels of the four groups. In summary, the wage level,  $W_t$  is determined by the following expressions:

$$W_t = \sum_{i=1}^4 \frac{1}{4} W_{it} \quad (2.25)$$

where

$$W_{it} = E_{t-i+1} \left[ \left( \frac{-U_{Lt}}{U_{1t}} \right) \frac{P_{1t} (1 + 2\gamma v_t)}{1 - T_{1t}} \right] \text{ for } i = 1 \text{ to } 4 \quad (2.26)$$

## 2.4. Solution and Calibration

Analysis will be conducted by simulation exercises on the model when linearized and calibrated. The nonlinear model is comprised of the 49 Euler equations and budget constraints (2.2, 2.4-2.7, 2.9-2.16, 2.18-2.26) with foreign counterparts). I solve the nonstochastic version of these equations for a steady state point on the center manifold and linearize around steady state. See the appendix for a discussion of the method of model solution.

The home country is calibrated to represent the United States, and the foreign country is calibrated to represent an aggregate of the remaining G-7 (Japan, Germany, France, Italy, U.K., and Canada). Some parameters are taken from outside empirical studies. For example regarding the intertemporal elasticity of substitution,  $\frac{1}{\sigma}$ , Eichenbaum, Hansen, and Singleton (1988) suggests a value between  $\frac{1}{3}$  and 2. I begin with a value of 0.5, which is the standard choice in the international real business cycle literature, although I will conduct sensitivity analyses for alternative values. The labor shares in production,  $\alpha$  and  $\alpha^*$ , are set to 0.631 and 0.569 respectively. These are taken from the average labor shares for the U.S. and the set of foreign countries from 1960-1985 in the OECD International Sectoral Data Base. The share of domestically-produced goods in the consumption bundle,  $\theta$ , is roughly 0.85 for the U.S. The reciprocal value is chosen for  $\theta^*$ , to be consistent with balanced trade in the initial steady state. The time discount,  $\beta$ , is set to 0.96

Other parameters are chosen so that the steady state of the model generally reflects levels of key variables in a base year. Data was taken from International Financial Statistics, and U.S. data is in trillions of 1993 dollars, while the foreign aggregate is in 100 trillions of 1993 Yen. The technology parameters,  $A$  and  $A^*$ , are set to match steady state outputs to 1993 levels, suggesting values of 4.8 for the home country and 3.9 for foreign. Depreciation is set to .04 for both countries, so that steady-state investment reflects data for gross-fixed capital formation. The weighting of leisure in the utility functions,  $a$  and  $a^*$ , are set to maintain a twenty-percent share of time allocated to labor in both countries, requiring that  $a = 0.28$  and  $a^* = 0.29$ . Steady state government expenditure on goods and services is set to 1993 levels, approximately 1.1 for both countries when measured in units of the country's respective good. Overall consumption will also reflect the level in the data, as seen residually from national income accounting. The transactions cost parameter,  $\gamma$  and  $\gamma^*$ , are both set to 0.0035 and 0.004 respectively, which roughly make steady state real money balances reflect actual levels in 1993. These transactions costs account for about one percent of consumption, or about 0.6 percent of national income. The mean income tax rates are set to 0.33. The means of lump-sum taxes are set to make steady state debt levels replicate actual levels. Foreign bonds comprise  $\frac{1}{6}$  of home portfolios, reflecting the U.S. figure for 1993. Net foreign assets are set to zero, to be consistent with balanced trade in the initial steady state.

### 3. Intertemporal Effects on Investment

The intertemporal model developed and calibrated above can be used to simulate a hypothetical monetary expansion. By simulating under various assumptions for deep parameters, the model helps trace out the role and the determinants of intertemporal effects. A general lesson is that it is remarkably difficult to get the model to predict improvements in the current account for reasonable choices of parameters. This is primarily because the intertemporal effects tend each to work in the direction opposite to the expenditure switching effects familiar from Mundell-Fleming.

The most familiar rendition of the Mundell-Fleming story suggests a monetary expansion should be expected to improve the current account surplus. Assuming a flexible exchange rate and capital mobility, a rise in the stock of home money leads to a lower interest rate and an incipient capital outflow, which depreciates the value of the home currency and its terms of trade. This real exchange-rate depreciation makes home goods more attractive and tends to improve the current

account. The earliest versions of Mundell-Fleming specified capital flows to be functions just of interest rates, so the fact that home interest rates fell implied capital outflows. This capital account fall necessarily implied that the current account rise. More contemporary versions of Mundell-Fleming allow for a worsening current account as a possibility. By incorporating intertemporal features into the asset market, it can be seen that even if domestic interest rates are lower, exchange rate overshooting and an expected exchange rate appreciation could attract the capital inflows necessary to finance a worsening current account. The present model goes still further, incorporating intertemporal effects into the other markets of the economy. In this context, intertemporal effects on investment and consumption appear to be potent forces working in the direction of a worsening current account.

Consider first a simulation of a permanent one percent increase in the money supply. A benchmark case of the model is used, with parameter values described in the calibration section above. Impulse responses are plotted in figure 1 as percent deviations from steady state. For the current account, however, deviations from steady state must be plotted in levels, since the steady state level is assumed to be zero. Figure 1 plots the current account in billions of dollars, but if one considers that the U.S. current account in the base year of 1993 was not far from 100 billion dollars, the magnitudes reported here could be regarded as percent deviations from a typical level. Column 1 of table 2 presents deviations from steady state for the initial period of the shock, both in levels and percents. As can be seen in figure 1, several of the impulse responses to a monetary expansion here coincide with some of the basic predictions of the Mundell-Fleming story. The monetary expansion does cause a depreciation in the nominal and real exchange rates, and it does strongly stimulate domestic output and employment. (Note that since the exchange rate is defined as the domestic price of foreign currency, a rise in the variable  $e$  is a depreciation of the home currency).

However, there are two large surprises. First, the real and nominal interest rates here rise. Second, the current account falls. These effects may seem surprising in the face of strongly rising output. One might expect that for the goods market to clear either households would need to be induced by lower interest rates to lower saving and consume the additional output, or alternatively, that this output should be consumed abroad and thereby improve the current account. This situation of excess supply in the goods market does not arise here because investment demand rises dramatically by 3.4 percent. While output, measured in table 2 as GNP, rises \$48.2 billion, investment rises three quarters as much as this. As a result, the sum of consumption and investment rises slightly more than

output, producing a current account that worsens by about \$1 billion. Investment rises here in response to the expectation of higher demand for output and higher marginal products of capital in future periods. This dominant investment response, of course, could not be considered in Obstfeld and Rogoff (1995).

This result is also distinct from earlier findings in Mundell-Fleming. While Mundell-Fleming would also suggest investment should rise after a monetary expansion, this is due to falling interest rates and is relatively small in magnitude. Investment in the present model is not responding to a fall in interest rates but instead to future expectations. In fact, investment is rising so much due to this separate effect that the equilibrium real interest rises rather than falls. Certainly in early versions of Mundell-Fleming investment could not overturn the expenditure switching effect. Investment was a function of current interest rates and current output, and the fall in interest rates necessary to move down an IS curve would be inconsistent with the rise in interest rates necessary to finance a current account deficit. The lesson here is that introducing expectations into aggregate demand provides a mechanism that may strongly shifts the IS curve in response to a monetary expansion.

The implication that this intertemporal effect is so strong as to raise the real interest rate may seem questionable empirically. King (1996) encountered a similar theoretical prediction for investment when experimenting with nominal rigidities in a closed-economy intertemporal model. He speculated that a simple intertemporal model might exaggerate the degree of investment response because it ignores the possibility of costs for installing that capital. Consider introducing quadratic investment adjustment costs to the present model. This would entail augmenting the budget constraint (equation 2.2) on the left hand side with a cost of investment  $J$ , where:

$$J_t = \frac{\psi (k_t - k_{t-1})^2}{k_{t-1}} \quad (3.1)$$

and where the parameter  $\psi$  is a scale factor indicating the magnitude of adjustment costs. The Euler equation characterizing the investment decision (2.15) becomes:

$$P_{1t}x_{1t} \left( 1 + \frac{2\psi(k_t - k_{t-1})}{k_{t-1}} \right) = \beta E_t \left[ P_{1t+1}x_{t+1} \left( (1-a) A_{t+1} L_{t+1}^\alpha k_t^{-\alpha} + (1-\delta) + \left( \frac{2\psi(1-\delta)k_t(k_{t+1}-k_t) + \psi(k_{t+1}-k_t)^2}{k_t^2} \right) \right) \right] \quad (3.2)$$

Investment demand here equates the marginal cost of investing (including adjustment costs) to the discounted expected marginal product of capital plus expected



saving on future adjustment costs due to a larger capital stock. The choice of a calibrated value for the adjustment cost parameter ( $\psi$ ) is not obvious, since most empirical studies do not assume a particular functional form. Further, it is relatively rare for international real-business cycle models to incorporate such an adjustment cost.<sup>12</sup> One empirical study which uses a functional form similar to that above is Craine (1975), which transformed for the present model's steady state would imply a  $\psi$  of about 0.65.<sup>13</sup>

Figure 2 and column 2 of table 2 show impulse responses when the 1 percent monetary expansion is simulated in the model augmented with adjustment costs where  $\psi = 0.65$ . The primary change is that investment is indeed dampened enough to allow the real interest rate to fall. However, while the fall in the current account is less pronounced, it is not reversed. Adjustment costs here are quite small, representing only .08 percent of new investment expenditure. It is perhaps interesting that introducing even so small an adjustment cost can have noticeable effects on the model's predictions.

Other empirical studies into investment, building upon the Q-theory approach, suggest adjustment costs may be larger. This research, which typically does not assume a particular functional form, does not map exactly into the parameters of my model. However, it may be computed that the findings of a significant example of such studies, Hayashi and Inoue (1991), implies for the case of my model roughly that  $\psi = 10$ .<sup>14</sup> A simulation of the model under this assumption is presented in figure 3 and column 3 of table 2. Under these larger adjustment costs, investment rises much less (about 0.5 percent). The worsening of the current account is likewise reduced, but it is still not quite overturned. (It falls by \$0.12 billion.) In fact further simulations suggest that as adjustment costs are set progressively higher, changes in investment and the current account can be brought arbitrarily near zero, but the sign of the current account effect will not be reversed.

While the responsiveness of investment to intertemporal incentives is a po-

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<sup>12</sup>One example is Mendoza (1991).

<sup>13</sup>Craine (1975) uses a form  $J_t = \psi (k_t - k_{t-1})^2$  and finds a value  $\psi = 0.025$ . This result could be applied in the case of my model near steady state, adjusting for the level of steady state capital stock.

<sup>14</sup>Hayashi and Inoue (1991) suggest that for Japanese firms investment adjustment costs account on average for about 9 percent of new capital accumulation. To map this into my model, note that for a simulation starting from steady state, my specification suggests this cost as a fraction of total new investment is a function of the  $\psi$  as well as the percent change in investment, and depreciation. Taking a one-standard deviation fluctuation of investment (5 percent) as a representative change in investment to calibrate to, average adjustment costs of 9 percent as suggested by Hayashi and Inoue (1991) would roughly imply  $\psi = 10$ .

tent force to worsen the current account, it is not the only intertemporal effect at work. Figures 1 through 3 and table 2 show that as investment is progressively dampened by higher adjustment costs, consumption rises and output falls in a nearly off-setting manner.<sup>15</sup> The next section will examine the additional intertemporal force affecting consumption.

#### 4. Consumption and the Current Account

The experiment in figure 3 suggests that a monetary expansion in the context of predetermined wages can strongly stimulate consumption. One explanation for the consumption rise is that the fall in the real interest rate induces households to shift consumption to the present from the future. This "interest-rate effect" on the current account plays a significant role in traditional Mundell-Fleming analysis, and it has been emphasized more recently in work by Svensson and VanWijnbergen (1989) in an intertemporal model with predetermined prices. It was found in the latter to stimulate consumption sufficiently to worsen the current account only if the elasticity of intertemporal substitution were high. This suggests that the response of consumption in figure 3 might be overstated if the intertemporal elasticity of substitution ( $1/\sigma$ ) were calibrated at too high a level, making consumers overly responsive to the real interest rate. However, in the present model with predetermined wages rather than prices this proposition does not hold. Recall from the discussion of model calibration, that empirical work suggests values for this elasticity between  $\frac{1}{3}$  and 2. When the intertemporal elasticity of substitution is lowered to  $\frac{1}{3}$  in the present model, the current account worsens even further in response to the monetary expansion. (See column 4 in

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<sup>15</sup>The fall in output reflects the same phenomenon as the consumption rise. In short: consumption determines money demand and thereby the equilibrium price level; this in turn affects the fall in the real wage thereby the rise in labor demand and finally output. First, note that the production function (equation 2.9) makes clear that output in the period of a monetary expansion will only change if labor input changes. Further, since the labor is demand determined in the initial period at an unchanged nominal wage, the labor supply specification (2.16) states that the real wage will drop and labor demand rise to the degree that the price level rises. In this particular case, the percent change in output will be  $\alpha$  times the percent change in labor and  $\frac{\alpha}{1-\alpha}$  times the percent change in price level, where  $\alpha$  is the labor share in production. Next, how much the price level changes depends on how money demand changes, given the higher money supply. The liquidity preference relation (2.13) suggests there is a relationship between the three components of velocity: price level, consumption and the money supply. If the interest rate did not change, this relationship would be quite simple: the percent change in price level equals the percent change in money supply less that of consumption. Since figures one and two show that the nominal interest rate is similar in experiments one and two, the relationship above describes fairly well why output falls from experiment 1 to experiment 2 as consumption rises.

table 2.) Consumption rises even a bit more in this case, and the current account falls a bit more. Conversely, as the intertemporal elasticity is raised, the worsening of the current account approaches zero. However, the current account cannot be induced to actually improve for this set of calibrated parameters.

A different explanation for consumption behavior seems to be at work. Note that households here are not smoothing consumption, per se, but are smoothing utility, which is a function of leisure as well as consumption. Recall here that the rise in production is due to the increase in labor demand, since real wages fall. Although workers have no labor-supply decision and are forced by their contracts to work more and raise output, they do retain all other intertemporal decisions. In particular, they can adjust their consumption over time to smooth their path of utility. Since they are forced to give up large amounts of leisure in the next few periods, they will compensate themselves by increasing consumption.

This utility-smoothing effect works in the same direction as the interest-rate effect, both stimulating consumption. However, the utility-smoothing effect becomes stronger for a lower intertemporal elasticity, whereas the interest rate effect becomes weaker. For a low elasticity, households are less willing to transfer consumption from the future and unsmooth utility in response to lower interest rates. However, the fact that households wish more strongly to smooth utility implies that they will be more inclined to raise consumption to compensate for lost leisure. Consider the limiting case of a zero intertemporal elasticity, in which traditional arguments built around the interest-rate effect suggest consumption would not respond at all and the current account should improve the most. It is in this very case that the utility-smoothing effect is sufficiently strong to guarantee a worsening current account in the present model.<sup>16</sup> As the intertemporal elasticity is backed away from this limiting case, the utility-smoothing effect exerts a weaker

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<sup>16</sup>This proposition is proved in Bergin (1997) for the case of a small open economy with one good and no investment. The principle can be extended to the present model under some simplifying conditions. Suppose we abstract from changes in investment by assuming high adjustment costs. Suppose also that wage? were predetermined only one period and the fall in transaction costs are ignored (which are second order in magnitude here). Then as the intertemporal elasticity approaches zero, equations 2.10 and 2.11 could be combined to express the percent deviation of total consumption from steady state ( $c$ ) as a function of that of leisure ( $l$ ) and real exchange rate ( $q = eP_2^*/P_1$ ):  $\tilde{c}_t = \frac{1-\alpha}{\alpha} \left( \tilde{l}_t \right) + (1-\theta) \tilde{q}_t$ , where the real interest rate has no effect. Since the ratio in steady state of labor to leisure is  $\left( \frac{\alpha}{1-\alpha} \right)$ , the expression above states that the percent rise in consumption is equal to the percent rise in labor, plus a bit more because of a real exchange/rate depreciation. In cases where the steady state labor share in production ( $\alpha$ ) is less than or equal to the share of consumption in output, the change in levels of consumption will exceed the change in output. For the U.S., the two values are nearly equal, so the current account change will be negative but close to balance.

downward force on the current account, but the force of the interest rate effect increases in its place.

The predictions given above depend somewhat on the simple, but commonly-used, functional form of utility used in the present model. In particular, the utility function assumes an elasticity of substitution between consumption and leisure equal to unity. This is a standard assumption within the intertemporal and real business cycle literatures, in which the benchmark version of the present model is rooted. Typically this assumption is justified, if acknowledged at all, on the grounds that historically post-war labor hours have not risen while real wage levels have. Alternative choices for this elasticity can be examined if the utility function is expanded as follows:

$$U(c_{1t}, c_{2t}, L_t) = \frac{1}{1-\sigma} \left( \left( a \left( c_{1t}^\theta c_{2t}^{1-\theta} \right)^{-\nu} + (1-a) (1-L_t)^{-\nu} \right)^{-\frac{1}{\nu}} \right)^{1-\sigma} \quad (4.1)$$

$\nu \neq 0, \nu > -1, \sigma > 0, \sigma \neq 1, , 0 < a < 1, 0 < \theta < 1$

Here is the elasticity of substitution between consumption and leisure is  $\frac{1}{1+\nu}$ .

While the existing intertemporal and real business cycle literature does not help in calibrating this new parameter, estimates are hotly debated within the public finance literature. A review in Hausman (1985) suggests a variety of estimates for the elasticity, some above unity and some below. When the model is simulated under various choices of  $\nu$  (and  $\psi = 10$ ), a monetary expansion can generate a positive current account effect if the elasticity is below .935. Figure 4 and column 6 in table 2 show impulse responses for an elasticity of about 0.8. Allowing an elasticity lower than unity can finally allow a reversal of the current account sign, although the elasticity implies the labor supply curve is backward bending.

Another assumption implicit in the given utility functional form is that the elasticity of substitution between home and foreign goods is unity.<sup>17</sup> If this elasticity were smaller, households would have to import more foreign goods to smooth utility in the same way. Consider the following utility function:

$$U(c_{1t}, c_{2t}, L_t) = \frac{1}{1-\sigma} \left( \left( \left( \theta c_{1t}^{-\zeta} + (1-\theta) c_{2t}^{-\zeta} \right)^{-\frac{1}{\zeta}} \right)^a (1-L_t)^{-a} \right)^{1-\sigma} \quad (4.2)$$

$\zeta \neq 0, \zeta > -1, \sigma > 0, \sigma \neq 1, , 0 < a < 1, 0 < \theta < 1$

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<sup>17</sup>Such a specification was assumed, for example, in Dornbusch's 1983 study of the intertemporal approach to the current account with two goods, and in many real business cycle investigations.

Here the elasticity of substitution between home and foreign goods in consumption is  $\frac{1}{1+\zeta}$ . The experiment reported in column 7 of table 2 suggests that if this elasticity is lowered below unity, the monetary shock can improve the current account ( $\frac{1}{1+\zeta} = .9$  in column 7). However, empirical studies by Deardorff and Stern (1990) and Whalley (1985) suggest this elasticity does not lie below unity for the U.S., perhaps being as high as two.

The intertemporal effects at work here made it remarkably difficult to find a case in which a monetary expansion in this model can generate an improvement in the current account. However, this does at least become possible when the class of utility functions is broadened beyond those typically considered in the intertemporal current account literature.

## 5. Conclusion

A standard intertemporal business cycle model is augmented here with money and nominal wage rigidity. Alternatively, it may be viewed as a modified Mundell-Fleming model which takes seriously the intertemporal features that have been shown to be important by the intertemporal approach to the current account. Within the reasonable range of parameter values, the model tends to predict that a monetary expansion will worsen the current account. This prediction results from taking seriously the intertemporal features of investment and consumption decisions. First, investment expenditure responds strongly to enhanced expected future profits, depending on the size of investment adjustment costs. Secondly, consumption responds not only to lower interest rates, but also to the desire to smooth utility in the face of a drop in leisure.

This prediction stands in contrast to the predictions of standard versions of Mundell-Fleming that do not incorporate these intertemporal features. In fact, original versions of Mundell-Fleming implied exactly the opposite prediction, that a monetary expansion could not possibly worsen current account. More contemporary versions of the approach permit the possibility of a worsening account, by incorporating intertemporal features into the asset market. The model here suggests that when intertemporal features are fully incorporated also into the other markets, the transformation of the current account prediction is more extreme — for reasonable parameter values a worsening current account is unlikely.

This finding has relevance for the recurring policy question of competitive devaluations. For instance, it is feared that if European countries excluded from monetary union are permitted to float their currencies, they may engineer competitive depreciations. Fingers point to the devaluation of Italy of a few years

previous as an example of such a beggar-thy neighbor policy. However, if in the context of a future floating regime a country such as Italy wished to engineer a currency depreciation, this would entail a monetary expansion. This would then imply intertemporal effects, in which rising consumption and investment would strongly limit a beggar-thy-neighbor improvement in the current account.

It would be desirable to test the models' prediction empirically. Such tests are severely limited by the need to identify truly exogenous monetary policy shocks, as opposed to endogenous monetary policy responses to other shocks, which might have their own intertemporal effects on the current account. One possibility, currently in progress, is to fit a stochastic version of the present model to the data by maximum likelihood. Likelihood-based goodness of fit statistics suggest a stochastic version of the calibrated model here does fit data respectably well, compared to a reduced form VAR benchmark.

## 6. Appendix: Model Solution

Regarding the steady state solution, there is no unique steady state point because international asset markets are incomplete. This was intentional, since the world is probably poorly approximated by a model that suggests all asymmetric shocks are perfectly insured internationally, so as not to affect the relative wealths of home and foreign agents. However, since asymmetric shocks induce borrowing they have permanent effects on net foreign asset positions. As a result a steady state is contingent on shocks affecting net foreign assets. It has been demonstrated in Baxter and Crucini (1995) that the usual solution methods of linearizing around an initial steady state can still be employed in such a case, so long as the state space is expanded to track the distribution of wealth between the two agents.<sup>18</sup> An initial steady state is chosen where initial money base and net foreign assets are set to the actual levels in the calibration year. For any given finite time span, the linearization will be arbitrarily accurate over the whole span if the shock variances are small enough. This steady state is also consistent with the sticky-wage version of the model.

In solving the linearized model, a method similar but not identical to that of Blanchard and Kahn (1980) is used. Write the system as  $y_t = Ay_{t-1} + Fz_t + He_t$ , where  $y_t$  is a vector of endogenous variables,  $z_t$  is a vector of exogenous variables, and  $e_t$  is a vector of expectational error terms, and where the Jordan decomposition of  $A$  is  $C^{-1}JC$  with  $m$  roots greater than unity in the lower right corner

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<sup>18</sup>The absence of a unique steady state point in two-country models is discussed in Mendoza and Tesar (1995) and Devereux and Saito (1995).

of  $J$ . A solution to this system exists if and only if the column space of  $C(2,:)H$  spans that of  $C(2,:)F$ , where  $C(2,:)$  is the last  $m$  rows of  $C$ . Further, the solution is unique if and only if the row space of  $C(2,:)H$  spans that of  $C(1,:)H$ . These criteria differ from Blanchard and Kahn (1980) in that they do not require  $H$  to be  $[0 \ I]'$ . These conditions involve the system having the number of unstable roots which matches the number of forward-looking first-order conditions. In the version of the model used for calibration there are seven unstable roots, corresponding to jumping variables in seven equations: the linearized version of the capital accumulation decision (2.23) for home and foreign agents, the nominal asset accumulation decision (2.18) for both agents, the single uncovered interest rate parity condition (2.22), and the equation specifying the predetermined wage level in each country. These unstable roots are eliminated by imposing the corresponding stability conditions. In particular, the left eigenvectors associated with the unstable roots give the linear constraints on the model's variables that must hold in order to suppress the unstable component of the solution. Combining these relationships with the remaining equations in the model produces a complete linearized solution.

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Table 1: Model Notation

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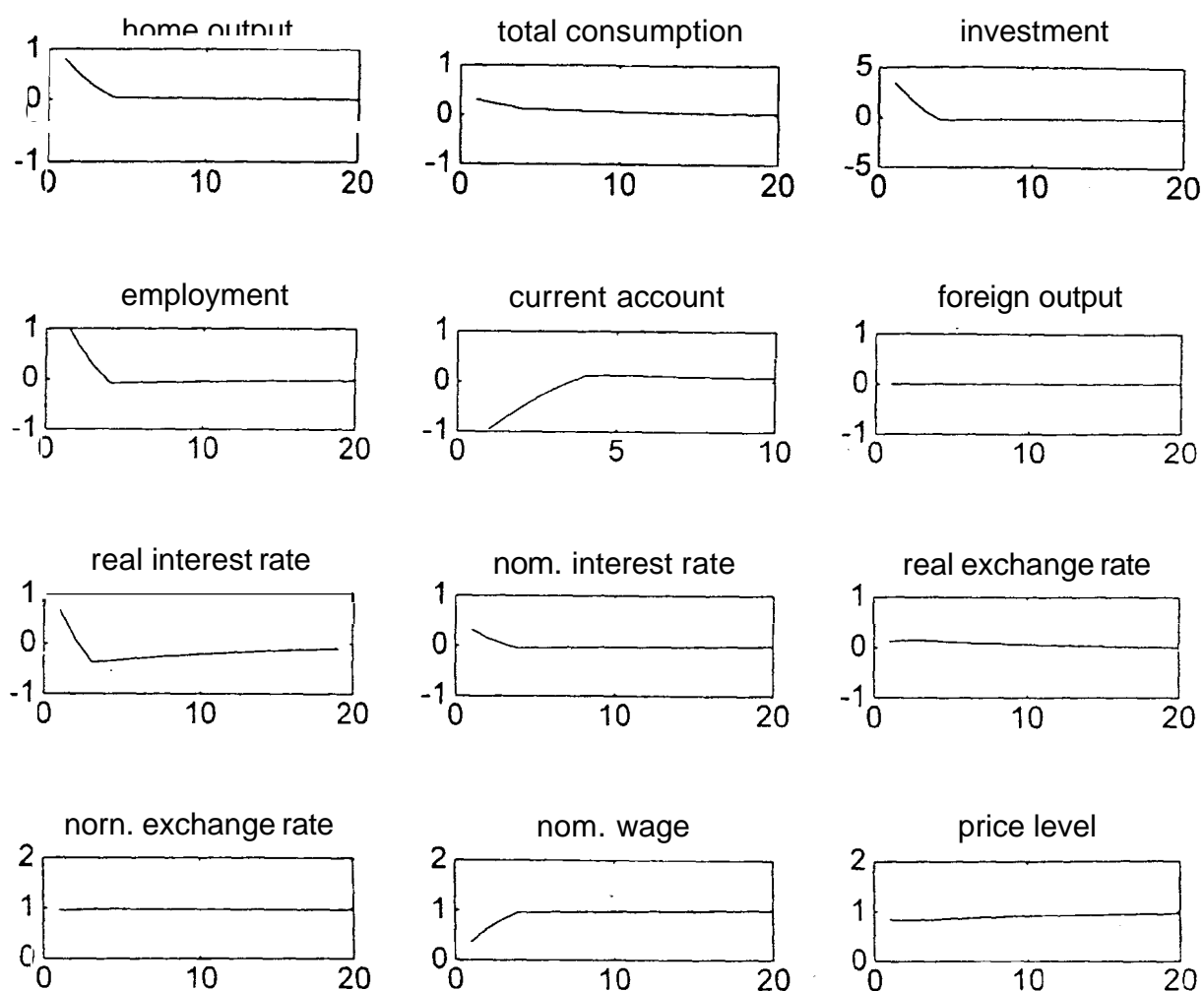
$c_1$	- home consumption of home good
$c_2$	- foreign consumption of home good
$c_1^*$	- home consumption of foreign good
$c_2^*$	- foreign consumption of foreign good
$y$	- home output
$y^*$	- foreign output
$g$	- home government expenditure
$g^*$	- foreign government expenditure
$l$	- home investment expenditure
$l^*$	- foreign investment expenditure
$M$	- home money (nominal)
$M^*$	- foreign money (nominal)
$B_1$	- home household holdings of home bonds (nominal)
$B_2$	- home household holdings of foreign bonds (nominal)
$B_1^*$	- foreign household holdings of home bonds (nominal)
$B_2^*$	- foreign household holdings of foreign bonds (nominal)
$D_1$	- home government debt (nominal)
$D_2^*$	- foreign government debt (nominal)
$v$	- home velocity
$v^*$	- foreign velocity
$P_1$	- price of home good in home currency
$P_2^*$	- price of foreign good in foreign currency
$e$	- nominal exchange rate
$R$	- home nominal interest rate
$R^*$	- foreign nominal interest rate
$r$	- home rental rate on capital
$r^*$	- foreign rental rate on capital
$d$	- home dividends
$d^*$	- foreign dividends
$k$	- home capital stock
$k^*$	- foreign capital stock
$L$	- home labor
$L^*$	- foreign labor
$W$	- home nominal wage rate
$W^*$	- foreign nominal wage rate
$T_1$	- home income tax rate
$T_1^*$	- foreign income tax rate
$T_2$	- home real lump-sum tax
$T_2^*$	- foreign real lump-sum tax

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Table 2:  
Effects of Monetary Contraction  
In Initial Period of Shock

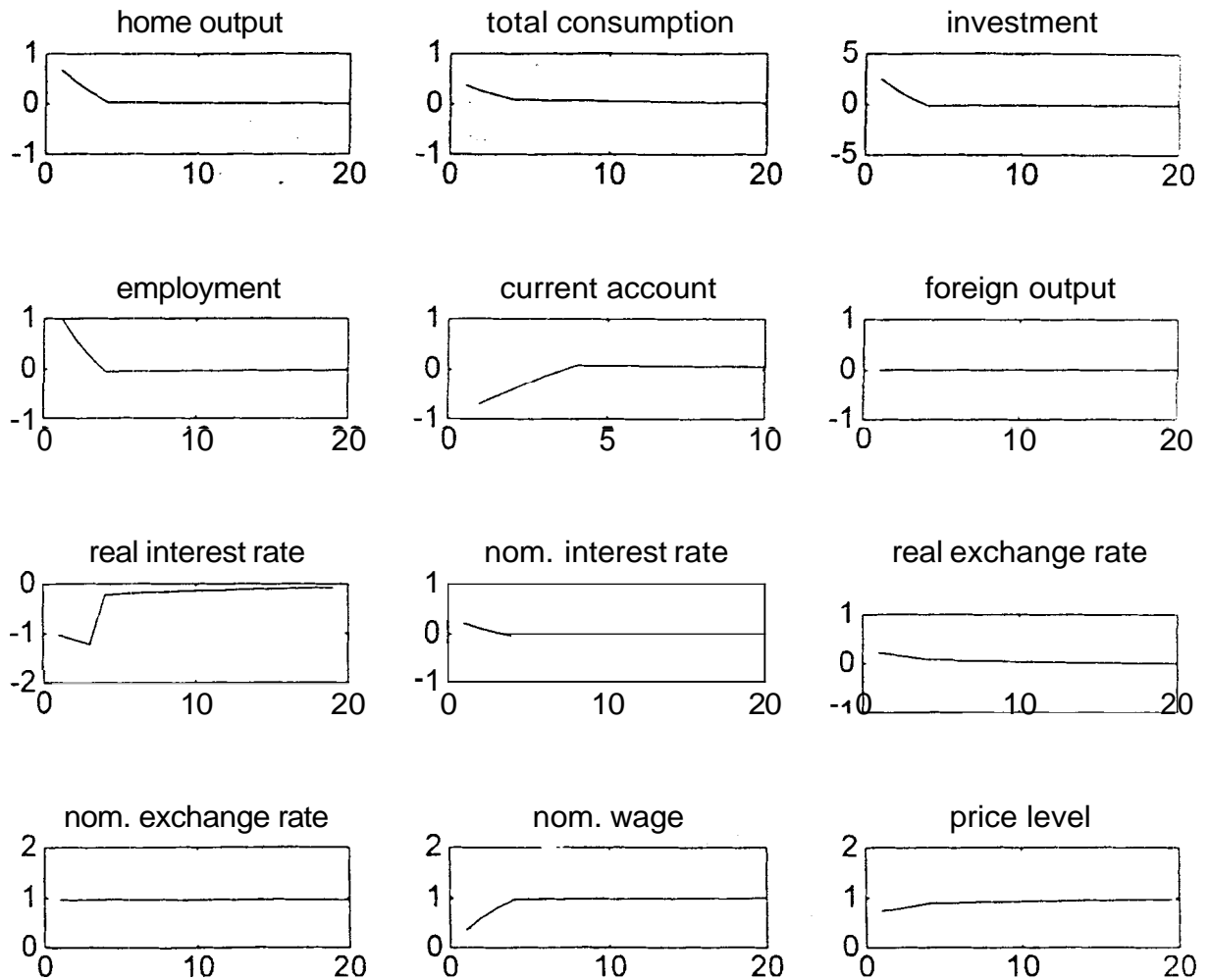
	(1) original parameters	(2) small invest costs	(3) large invest costs	(4) lower intertemp elasticity	(5) raise intertemp elasticity	(6) lower C-leisure elasticity	(7) lower goods elasticity
<u>Percent deviations from steady state:</u>							
Output	0.808	0.679	0.398	0.399	0.396	0.370	0.385
Consumption	0.310	0.364	0.481	0.485	0.475	0.433	0.456
Investment	3.432	2.535	0.548	0.545	0.553	0.576	0.547
Real interest rate	0.675	-1.026	-4.202	-4.178	-4.249	4.480	4.317
Real exchange rate	0.119	0.220	0.441	0.439	0.445	0.490	0.444
<u>Deviations in billions of 1993 \$:</u>							
Output	48.2	40.6	23.8	23.9	23.7	19.1	23.0
Consumption	11.7	13.7	18.1	18.2	17.8	13.5	17.2
Investment	37.4	27.5	5.9	5.8	5.9	5.4	5.9
Current Account	-0.95	-0.69	-0.13	-0.15	-0.06	+0.02	+0.02

Figure 1  
Monetary Expansion  
Base Case Parameter Settings



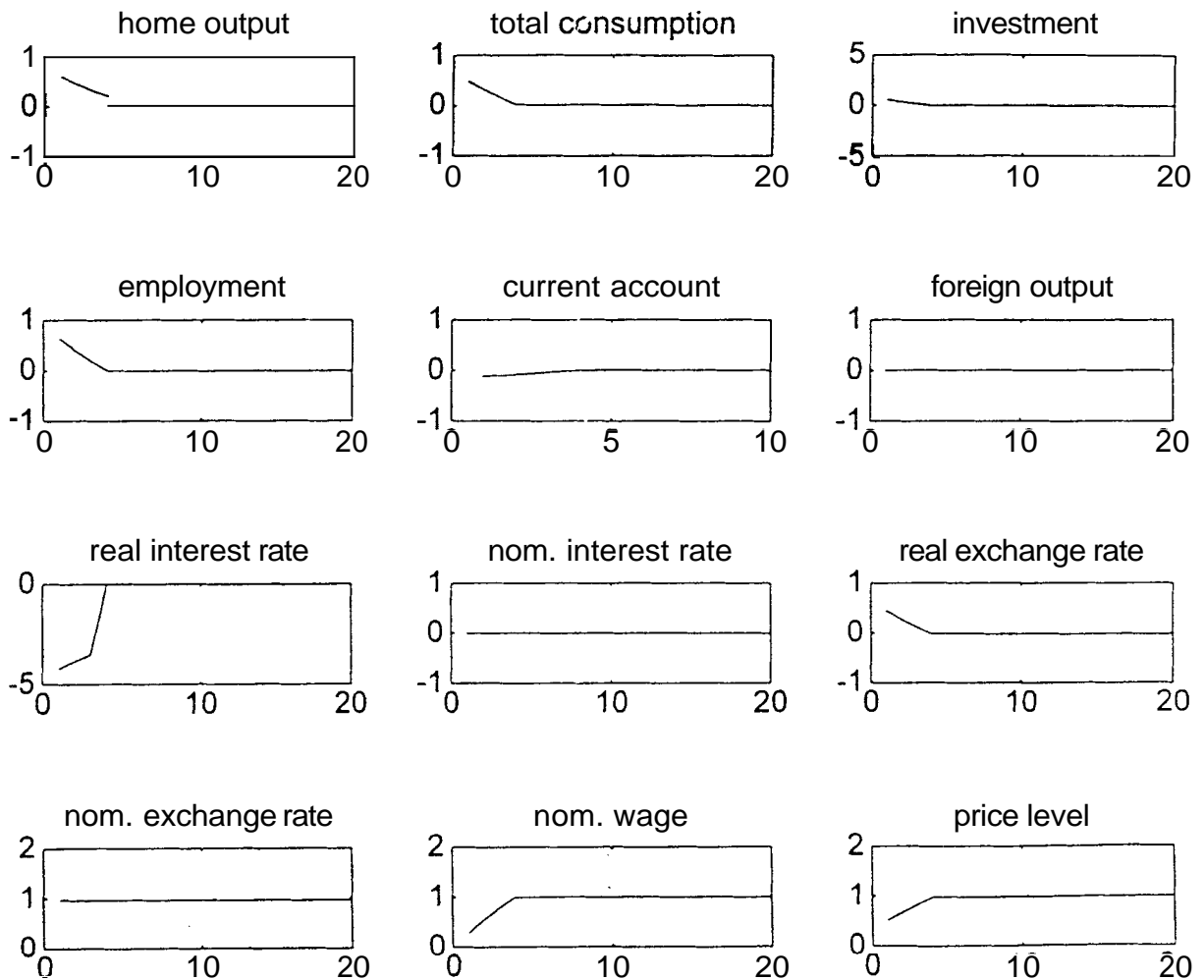
Impulse responses in percent deviations from steady state, except for current account in billions of 1993 dollars.

Figure 2  
Monetary Expansion  
Dampened Investment I ( $\psi=0.65$ )



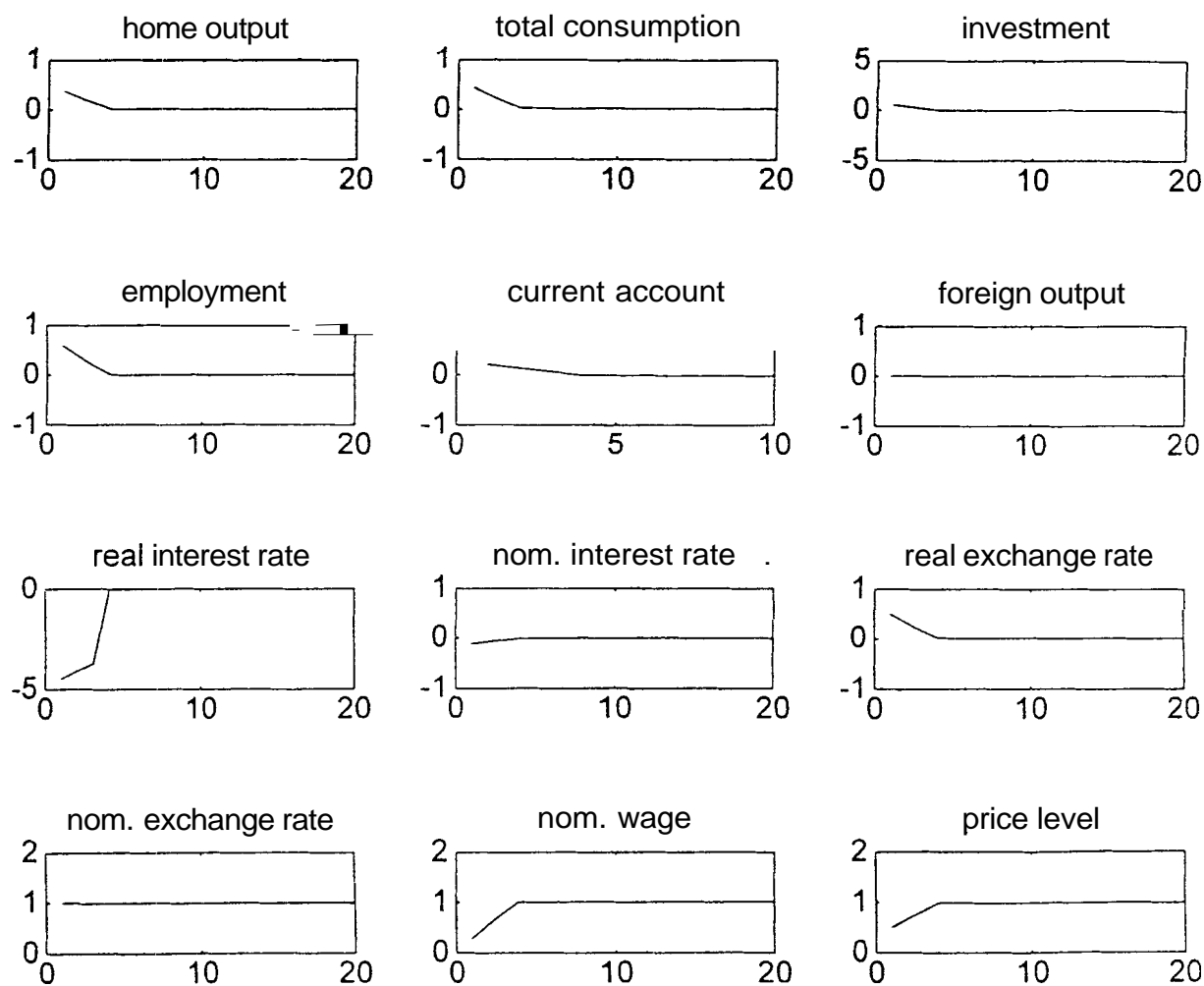
Impulse responses in percent deviations from steady state, except for current account in billions of 1993 dollars.

Figure 3  
Monetary Expansion  
Dampened Investment 2 ( $\psi=10$ )



Impulse responses in percent deviations from steady state, except for current account in billions of 1993 dollars.

Figure 4  
Monetary Expansion  
Dampened Consumption ( $\nu=0.23$ ,  $\psi=0.10$ )



Impulse responses in percent deviations from steady state, except for current account in billions of 1993 dollars.