Macroeconomic Dynamics, **14** (2010), 365–387. Printed in the United States of America.
doi:10.1017/S1365100509090336

SAVINGS, INVESTMENT, EMPLOYMENT, AND INFLATION IN A SMALL OPEN ECONOMY WITH HABIT PERSISTENCE

ARMAN MANSOORIAN
York University

LEO MICHELIS
Ryerson University

MOHAMMED MOHSIN
University of Tennessee

The effects of inflation are studied for a small open economy with a cash-in-advance constraint on consumption in which the representative agent has preferences with habit persistence. An increase in the inflation rate requires a fall in the steady state living standards. On impact, to maintain living standards, the representative agent reduces his savings and labor supply. Investment falls and the current account turns into a deficit. In support of this model, we provide evidence from eight high-inflation countries suggesting that after an increase in the inflation rate, output and investment fall, and the net foreign asset position deteriorates over time.

Keywords: Savings, Investment, Inflation, Habits

1. INTRODUCTION

Several developing and emerging economies have attempted to tackle their high inflation problems in recent decades. Prominent papers, such as Cooley and Hansen (1989), have studied the effects of inflation on important macroeconomic variables in a closed economy setting. In that setting, if money is introduced into the model through a cash-in-advance constraint on consumption, as in Stockman (1981), then inflation, by taxing consumption expenditures, will lead to an increase in leisure, reducing the labor supply and the steady state capital stock.

The closed economy setting may be a good approximation for a large country such as the United States, but to discuss the important role of inflation in developing

We thank an anonymous referee, an associate editor, and the editor for very helpful comments, Greg Johnson for expert research assistance, and the Social Sciences and Humanities Research Council of Canada for financial support. The second author is also grateful to Ryerson University for financial support through an RRC award. Address correspondence to: Arman Mansoorian, Department of Economics, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada; e-mail: arman@yorku.ca.

 1365-1005/10

and emerging economies, which have had high inflation rates in recent decades, it is essential to employ a small open economy setting. The focus would then be on the effects of inflation on open economy issues, such as the effects on the country's net foreign assets, savings, and investment movements, as well as the effects on employment and output.

Mansoorian and Mohsin (2006) consider the effects of inflation in a small open economy setting, assuming that the representative household has time-separable preferences, as in Cooley and Hansen. In that setting, an increase in the inflation rate increases the cost of consumption goods relative to leisure, leading to a reduction in the labor supply, which reduces the marginal productivity of capital, leading to a fall in investment. The country starts running a current account surplus.

An important drawback with using time-separable preferences in studying open economy issues is that for a meaningful steady state to exist, the rate of time preference must be set equal to the given world interest rate. This severely restricts savings dynamics; essentially, with the rate of time preference set equal to the world interest rate, the representative household wishes to jump to its new steady state instantly. For this reason, in the Mansoorian and Mohsin setting, the dynamics of the current account is essentially driven by the investment effects, with savings effects playing a minor role.

Nevertheless, as is well established in the empirical open economy literature, for small open economies savings and investment move closely together after a shock, a phenomenon referred to as the Feldstein–Horioka (1980) puzzle. Further, as will be documented in this paper, for several high-inflation countries a permanent increase in the inflation rate leads to a current account deficit (not surplus), while reducing investment. This implies that after an increase in the inflation rate, savings must fall by substantially more than investment: hence, the model can account for the Feldstein–Horioka puzzle due to inflation shocks. Although several authors have accounted for the Feldstein–Horioka puzzle as a response to real shocks, to date the puzzle has not been accounted for as a response to monetary shocks.[1]

To control for these limitations of time-separable preferences in studying the effects of inflation in a small open economy setting, in this paper we consider a model in which preferences of the representative agent exhibit habit formation, as in Ryder and Heal (1973). Hence, instantaneous utility depends not only on current consumption and leisure, but also upon habits, which are a weighted average of past levels of consumption and leisure. Several authors have used the habit persistence model to successfully analyze a variety of issues. For example, Constantinides (1990) uses the model to solve the Mehra–Prescott (1985) equity premium puzzle; Backus et al. (1993) show that habit persistence helps to account for the high variation in the expected returns in the forward relative to spot markets for currencies; and Carrol et al. (2000) use the habit persistence model to reexamine the causal relationship between growth and savings. Empirical evidence in favor of habit persistence has been provided by Ferson and Constantinides (1991), Fuhrer and Klein (1998), Heaton (1993), and Naik and Moore (1996), among other authors.[2]

In this paper we work out the implications of habit persistence in a small open economy for the adjustment of these important variables in response to a permanent increase in the rate of inflation, or equivalently a permanent increase in the rate of devaluation. We use an infinite horizon model in which the representative household, whose preferences exhibit habit persistence, makes consumption–leisure decisions, whereas firms make investment decisions. Money is introduced into the model by assuming that households face a cash-in-advance (CIA) constraint on their expenditures [Stockman (1981)]. We assume that monetary policy involves targeting the inflation rate, rather than the rate of growth of money per se. This assumption precludes complicated, yet not so crucial, off–steady state effects, similar to those analyzed by Fischer (1979). Thus, it reduces the dimensions of the dynamic system corresponding to the model, considerably simplifying the analysis.[3]

We start with a simplified version of the model without capital, in which output is produced with a Ricardian production function. This model, although incomplete, brings out very clearly the importance of habit formation in the dynamics of the model. It is shown that an increase in the rate of inflation, or equivalently the rate of devaluation, would lead to a fall in the steady state habitual standard of living if the nominal interest rate were initially positive.[4] If we follow the asset pricing literature and assume that preferences exhibit adjacent complementarity, then immediately after the monetary shock the household tries to maintain the habitual standards of living it has inherited from the past.[5] Hence, immediately after an increase in the rate of inflation, consumption expenditures fall by less than in the long run, and there is a fall in savings. Also, on impact, to maintain habits, there is a large substitution of leisure for consumption, and labor supply falls by more than in the long run. After this, consumption will be falling and employment will be rising until the new steady state is reached.[6]

From this it is clear how the complete model with capital and investment will behave. The fall in labor input will reduce the marginal productivity of capital and investment. With investment adjustment costs, capital adjusts slowly. With reasonable parameter values, along the adjustment path capital and consumption will be declining over time, whereas employment will be rising. There is also a sharp fall in savings, leading to a fall in wealth over time. In fact, the fall in savings is substantially larger than the fall in investment, so that the country's net foreign asset position deteriorates over time.

The model thus generates a positive correlation between savings and investment (the Feldstein–Horioka puzzle) due to *monetary shocks*.[7] As discussed above, the literature concerned with the Feldstein–Horioka puzzle has by and large used models without money.

Further, we provide some new empirical evidence from a sample of eight Latin American countries, with traditionally high inflation rates, in support of the theoretical predictions of the model. Using annual data over the period 1961–2006, we compute empirical impulse response functions for output, investment, and net foreign assets for each country, following a permanent increase in the rate of inflation. In addition, we provide cross-sectional evidence on the relationship between net foreign assets and inflation. Overall, the empirical results support the theoretical predictions of our model regarding the negative short-run and long-run effects of inflation on each of the three variables. In particular, we provide some new evidence on the negative effects of inflation on these countries' net foreign assets.

The paper is organized as follows. The simple model without capital is presented in Section 2. The complete model is presented in Section 3. The new empirical evidence is presented in Section 4. Some concluding remarks are made in Section 5.

2. THE MODEL WITHOUT INVESTMENT

2.1. The Model

The model is that of a small open economy with only one good. The foreign currency price of the good is fixed at P^*, which the economy takes as given. The domestic currency price of this good is $P = EP^*$, where E is the exchange rate (the price of foreign currency in terms of domestic currency). The inflation rate is equal to the rate of depreciation of the domestic currency ($\dot{E}/E$), which is denoted by ε.

The preferences of the representative household are represented by the habit persistence utility function of Ryder and Heal, extended to incorporate labor–leisure choice:

$$\int_0^\infty U(\omega(c_t, l_t), S_t)\, e^{-\delta t} dt, \tag{1}$$

where $\omega(.)$ is a homothetic subutility function, c_t is consumption at time t, l_t is leisure, δ is the rate of time preference, and S_t is the habitual standard of living. Note that $\omega(c_t, l_t)$ is a utility measure of the household's consumption and leisure at time t. Henceforth, we will refer to it as full consumption. Therefore, momentary utility depends not only on full consumption, but also on the habitual standard of living inherited from the past.

We assume that the momentary utility function satisfies assumptions (P.1)–(P.5) of Ryder and Heal (pp. 2–3). Thus, instantaneous utility is increasing in ω ($U_\omega > 0$) (P.1), nonincreasing in S ($U_S \leq 0$) (P.2), increasing in uniformly maintained ω – that is, $U_\omega(\omega, \omega) + U_S(\omega, \omega) > 0$ (P.3), concave in ω and S (P.4), and $\lim_{\omega \to 0} U_\omega(\omega, S) = \infty$, $\lim_{\omega \to 0} [U_\omega(\omega, \omega) + U_S(\omega, \omega)] = \infty$ (P.5).

Also, as in Ryder and Heal, the habitual standard of living is a weighted sum of $\omega(c_j, l_j)$ ($j < t$), with exponentially declining weights given to more distant values of $\omega(c_j, l_j)$:

$$S_t = \rho e^{-\rho t} \int_{-\infty}^{t} \omega(c_j, l_j) e^{\rho j} dj, \tag{2}$$

where $\rho > 0$. This implies that

$$\dot{S}_t = \rho \left[\omega(c_t, l_t) - S_t \right]. \tag{3}$$

Money is introduced through the CIA constraint

$$m_t \geq c_t, \tag{4}$$

which requires that at any point in time the representative household should hold enough real money balances $m_t \equiv M_t/P_t$ to finance its consumption purchases,[8] where M_t is its nominal money holdings and P_t is the price level.

In this section we abstract from investment and capital. Output Y is produced with a Ricardian technology, with labor as the only input:

$$Y_t = 1 - l_t, \tag{5}$$

where $1 - l_t$ is employment at time t, assuming that at any instant one unit of time is available to the representative agent.

There are two kinds of assets in the model, real money balances and internationally traded bonds, whose foreign currency price is fixed, and which have a fixed rate of return of r. Thus, the real assets of the representative agent are

$$a_t = m_t + b_t, \tag{6}$$

where b_t is its bond holdings.

The representative household receives real monetary transfers of τ_t from the government. Its flow budget constraint is

$$\dot{a}_t = 1 - l_t + r a_t + \tau_t - c_t - (r + \varepsilon_t) m_t, \tag{7}$$

and it should also satisfy the intertemporal solvency condition

$$\lim_{t \to \infty} a_t e^{-rt} \geq 0. \tag{8}$$

To solve for the perfect foresight path, we assume that the government does not purchase goods and services, and that monetary policy is directed at maintaining a constant rate of inflation ε (that is, a constant rate of depreciation of the domestic currency). The government chooses τ_t to satisfy its flow constraint

$$\tau_t = r R_t + \varepsilon m_t + \dot{m}_t, \tag{9}$$

which states that it should finance its expenditures from the interest on its international bond holdings or international reserves, $r R_t$, and seigniorage, $\varepsilon m_t + \dot{m}_t$.

There are two alternative methods by which the central bank can maintain ε at a constant level: it can adjust R_t appropriately, or it can adjust τ_t. In the present paper, we will assume that it adjusts τ_t appropriately, and that we have a flexible exchange rate system.

2.2. The Perfect Foresight Path

In this section we derive the perfect foresight path of the model. To do so we first solve the representative household's problem. Then we consider the country's external adjustment along the equilibrium path in light of the assumptions we have made about government policies.

The representative household's problem is to maximize (1), subject to (3), (4), (6)–(8), and the initial conditions (a_0, S_0), taking the paths of $\{\tau_t\}$, and $\{\varepsilon_t\}$ as given. Along a perfect foresight path, the agent's expectations about $\{\tau_t\}$ and $\{\varepsilon_t\}$ coincide with the actual paths of these variables.

As money does not yield direct utility, and as the return on real balances is dominated by the return on bonds, (4) will hold with strict equality. Setting $c_t = m_t$ in (7), the Hamiltonian for this problem can then be written as

$$H = U\left(\omega(c_t, l_t), S_t\right) + \lambda_t\left[\rho(\omega(c_t, l_t) - S_t)\right] + \mu_t\left[1 - l_t + ra_t + \tau_t - (1 + r + \varepsilon)c_t\right],$$

where λ_t and μ_t are the shadow prices of S_t and a_t, respectively.

The optimality conditions are

$$H_c \equiv U_\omega\omega_c + \lambda\rho\omega_c - \mu(1 + r + \varepsilon) = 0, \quad \textbf{(10)}$$

$$H_l \equiv U_\omega\omega_l + \lambda\rho\omega_l - \mu = 0, \quad \textbf{(11)}$$

$$-H_s + \delta\lambda \equiv -U_S + (\rho + \delta)\lambda = \dot{\lambda}, \quad \textbf{(12)}$$

$$-H_a + \delta\mu \equiv -r\mu + \delta\mu = \dot{\mu}, \quad \textbf{(13)}$$

along with the standard transversality conditions.

From (13) it is clear that a steady state can be reached only if $\delta = r$. This is a standard assumption that is made in the literature [see, for example, Sen and Turnovsky (1989a, 1989b)], and we will maintain it from now on. This then means that $\dot{\mu} = 0$, and that μ is always at its steady state level.

Next note that, as $\omega(.)$ is homothetic, $U(.)$ can be formulated so that $\omega(.)$ is homogeneous of degree one, so that $c\omega_c + l\omega_l = \omega$. The indirect utility function corresponding to $\omega(.)$ can then be written as $Z_t V(r + \varepsilon)$, where $Z_t \equiv [l_t + (1 + r + \varepsilon)c_t]$ is total "expenditures" on consumption and leisure at time t, and $V(r + \varepsilon)$ is the indirect utility from each unit of these "expenditures".[9] It is then clear, from (10) and (11), that

$$\frac{[cH_c + lH_l]}{ZV} = U_\omega + \lambda\rho - \frac{\mu}{V} = 0. \quad \textbf{(14)}$$

Linearizing (3), (12), and (14), using the fact that along the stable path $d\mu = 0$, we obtain

$$\begin{bmatrix} \dot{S}_t \\ \dot{\lambda}_t \end{bmatrix} = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} S_t - \bar{S} \\ \lambda_t - \bar{\lambda} \end{bmatrix}, \quad \textbf{(15)}$$

where bars denote steady state values,

$$\alpha_{11} = \frac{-\rho(U_{\omega S} + U_{\omega\omega})}{U_{\omega\omega}}, \quad \alpha_{12} = \frac{-\rho^2}{U_{\omega\omega}}, \quad \alpha_{21} = \frac{(U_{\omega S}^2 - U_{SS}U_{\omega\omega})}{U_{\omega\omega}},$$

$$\text{and } \alpha_{22} = r + \frac{\rho(U_{\omega S} + U_{\omega\omega})}{U_{\omega\omega}}.$$

As S is a state variable, whereas λ is a jump variable, for saddle point stability of this system the coefficient matrix should have one positive and one negative eigenvalue. This requires that the determinant of the coefficient matrix be negative, which, given our assumptions (P.1)–(P.5), could be satisfied easily. If θ is the negative eigenvalue of this matrix, then the stable path of the system will be given by

$$(S_t - \bar{S}) = (S_0 - \bar{S})e^{\theta t}, \tag{16}$$

$$(\lambda_t - \bar{\lambda}) = (S_0 - \bar{S})\frac{\theta - \alpha_{11}}{\alpha_{12}}e^{\theta t}. \tag{17}$$

To determine the country's external adjustment along the perfect foresight path, first note that the government's flow constraint (9), together with the representative agent's flow constraint (7), implies that

$$\dot{f}_t = 1 - l_t + rf_t - c_t, \tag{18}$$

where f_t is the country's net foreign asset position $(b_t + R_t)$. Thus, from (18), the country's asset accumulation is equal to national income less absorption.

To characterize the evolution of f_t along the perfect foresight path, first note that by Roy's identity $c_t = -Z_t V'/V$. Thus, (18) can be rewritten as

$$\dot{f}_t = rf_t - Z_t\left[1 + \frac{(r+\varepsilon)V'}{V}\right]. \tag{19}$$

Linearizing (14) and (19), using (16) and (17), we obtain

$$\dot{f}_t = r(f_t - \bar{f}) + \Omega(S_0 - \bar{S})e^{\theta t}, \tag{20}$$

where

$$\Omega = \left[\frac{-(1+\theta/\rho)}{V}\right]\left[1 + \frac{(r+\varepsilon)V'}{V}\right].$$

The solution to (20) is

$$(f_t - \bar{f}) = \frac{\Omega}{\theta - r}(S_0 - \bar{S})e^{\theta t} + \left[(f_0 - \bar{f}) - \frac{\Omega}{\theta - r}(S_0 - \bar{S})\right]e^{rt}. \tag{21}$$

Therefore, for f_t to converge to its steady state level, we need

$$(f_0 - \bar{f}) - \frac{\Omega}{\theta - r}(S_0 - \bar{S}) = 0. \tag{22}$$

This condition shows how $\bar{f}$ and $\bar{S}$ must be related for saddle point stability, given f_0 and S_0. Equations (16), (17), and (21), with condition (22), give us the perfect foresight path.

2.3. The Effects of an Increase in the Inflation Rate

Now consider the effects of an increase in the inflation rate. To this end, first consider the steady state effects. The steady state equilibrium is characterized by equations (3), (12), (14), and (19) with $\dot{S} = \dot{f} = \dot{\lambda} = 0$. These, however, are four equations in five unknowns: $\bar{S}$, $\bar{Z}$, $\bar{f}$, $\bar{\lambda}$, and $\bar{\mu}$. The fifth equation is (22). Differentiating these equations, we obtain

$$\frac{d\bar{S}}{d\varepsilon} = \frac{2(r+\varepsilon)\dfrac{\bar{Z}V'^2}{V^2} - (r+\varepsilon)\dfrac{\bar{Z}V''}{V}}{\dfrac{1}{V}\left[1+(r+\varepsilon)\dfrac{V'}{V}\right] - \dfrac{r\Omega}{\theta - r}} < 0, \quad \text{if } (r+\varepsilon) > 0,^{10} \tag{23}$$

and

$$\frac{d\bar{f}}{d\varepsilon} = \frac{\Omega}{\theta - r}\frac{d\bar{S}}{d\varepsilon} >, =, < 0, \text{ as } \rho <, =, > -\theta. \tag{24}$$

Thus, an increase in the inflation rate will lead to a fall in the steady state habitual standard of living, if the nominal interest rate is initially positive. The reason is that with CIA constraint on consumption, nominal interest rates represent a distortion. If nominal interest rates are initially positive, an increase in them will increase the size of the distortion, requiring a fall in the steady state habitual standards of living.

From (24) it is clear that the effect of the increase in ε on the country's net foreign asset position depends on the value of ρ relative to $|\theta|$. Solving for θ, we see that $-\theta < \rho$ only if

$$U_{\omega S} > \frac{-U_{SS}}{r/\rho + 2}. \tag{25}$$

If this condition is satisfied, then preferences exhibit adjacent complementarity, in which case an increase in current full consumption will increase the marginal utility from full consumption in the near future relative to the distant future. As it is adjacent complementarity that has made the habit persistence model popular in the asset pricing literature, we will confine the analysis to this case. It can easily be shown that with adjacent complementarity the agent tries to maintain the habitual standard of living at time 0, and therefore ω_0 falls by a smaller amount than its steady state level. The country starts running a current account deficit, and ω falls along the adjustment path to the steady state.

One can readily derive the adjustments of consumption and employment. The increase in the inflation rate ε increases the cost of consumption relative to leisure. As a result, the representative agent substitutes leisure for consumption. On impact, then, consumption, employment, and output will fall. If preferences exhibit adjacent complementarity (condition (25) is satisfied), c will fall on impact by a

https://doi.org/10.1017/S1365100509090336 Published online by Cambridge University Press

smaller amount than in the new steady state, as the representative agent tries to maintain his or her habitual standard of living. Hence, the country starts running a current account deficit.

Consumption will then be falling along the adjustment path to the steady state. By the homotheticity of preferences, it is clear that labor supply must be rising along the adjustment path. Hence, on impact, employment falls by a large amount, and then it increases along the adjustment path. Surprisingly, employment in the new steady state could be higher or lower than it was before the increase in ε.[11]

3. THE MODEL WITH CAPITAL

3.1. The Model

In this section we introduce capital into the model. Now output is produced with a neoclassical, constant returns to scale production function $Y_t = F(K_t, L_t)$, where K is the capital stock and L is employment.[12] Of course, in equilibrium $L = 1–l$.

The dividend payment (D_t), or profits net of investment expenditures, is

$$D_t = F(K_t, L_t) - w_t L_t - \Phi(I_t), \tag{26}$$

where w is the wage rate, and $\Phi(I)$ denotes total costs associated with investment I_t: $\Phi(I) = I + \Psi(I)$. Note that $\Psi(I)$ is the adjustment costs, assumed to be a non-negative convex function of investment. This convexity implies that $\Phi' \geq 0$ and $\Phi'' \geq 0$ By the choice of units we may set $\Psi(0) = 0$ and $\Psi'(0) = 0$, which implies that $\Phi(0) = 0$ and $\Phi'(0) = 1$

The firm's problem is to maximize the present value of its dividend payments,

$$Max \int_0^\infty D_t e^{-rt} dt = \int_0^\infty [F(K_t, L_t) - w_t L_t - \Phi(I_t)]\, e^{-rt} dt, \tag{27}$$

subject to $\dot{K}_t = I_t$ and the initial condition K_0.The optimality conditions for this problem are

$$F_L(K, L) = w, \tag{28}$$

$$\Phi'(I) = q, \tag{29}$$

$$\dot{q} = qr - F_K(K, L), \tag{30}$$

and the standard transversality condition, where q is the shadow price of capital (Tobin's "q").

As is standard in the literature, the representative household holds all the titles to domestic capital; see,. for example, Sen and Turnovsky (1989a, 1989b). Its total assets are, therefore, $a_t = m_t + b_t + k_t$. The only other change in the problem faced by the household is in its flow budget constraint (7). Now the wage rate is variable, and the household receives the dividends D_t from the firms.[13] Hence, its flow budget constraint is

$$\dot{a}_t = D_t + w_t(1 - l_t) + r a_t + \tau_t - c_t - (r + \varepsilon_t) m_t. \tag{31}$$

The optimality conditions for the household's problem are as before, except that now with variable wage rate, condition (11) is replaced by[14]

$$H_l \equiv U_\omega \omega_l + \rho\lambda\omega_l - \mu w = 0. \qquad (32)$$

Also, now, to determine the dynamics of the current account, first combine the household's and government's budget constraints [(9) and (31)] and use the definition of dividend payments given in equation (26) to obtain the current account balance of the economy,

$$\dot{f}_t = F(K_t, L_t) + rf_t - c_t - \Phi(I_t), \qquad (33)$$

according to which changes in the country's net foreign assets are equal to total income minus absorption. One can then derive the saddlepath of the model along the lines of the version of the model without capital.[15]

3.2. Numerical Simulation of the Model

In this section we provide a numerical evaluation of the model. Briefly, following the real business cycle and the consumption-based asset pricing literature, we assume that $U(\omega, S) = \frac{(\omega S^{-\nu})^{1-\sigma}}{1-\sigma}$, $\omega(c, l) = c^{1-\alpha} l^\alpha$, $F(K, L) = K^\theta L^{1-\theta}$, and $\Psi(I_t) = 0.5 I_t^2$. Following Carroll, Overland, and Weil (2000, p. 345), Cooley (1995, pp. 20–22), and Mendoza (1991, p. 804), we set $\sigma = 1.1$, $\nu = 0.2$, $\alpha = 0.64$, $\theta = 0.32$, $r = \delta = 0.04$, and $\rho = 0.3$. Owing to hysteresis in the model,[16] we also need to specify the initial value for net foreign assets. We determine this value from the data for the eight Latin American countries that we consider in the next section. For these countries the average value of net foreign assets as a percentage of GDP ranges from −20% to +15%. Thus, we choose the initial net foreign asset position as −10% of GDP. Focusing on high-inflation countries, we assume that the initial inflation rate is relatively high, at 20%.

Given these functional forms and parameter values, we simulate the effects of a permanent increase in the inflation rate from 20% to 30% on consumption, employment, capital, net foreign assets, and total household assets. The numerical results are summarized in Table 1, where we report the initial and final steady state values c, L, K, f, and a, as well as their values immediately after the shock. The adjustment paths of c, L, K, f, and a are shown in Figures 1 to 5, respectively.

TABLE 1. The impact and steady state effects

Variables	Initial SS	After impact	Impact eff. %	Final SS	SS effect %
c	0.626642	0.581851	−7.1477	0.580095	−7.4279
L	0.236470	0.206496	−12.6753	0.219112	−7.3407
K	5.033266	5.033266	0.0000	4.663788	−7.3407
f	−0.062916	−0.062916	0.0000	−0.071962	−14.3789
a	4.970351	4.970351	0.0000	4.591826	−7.6156

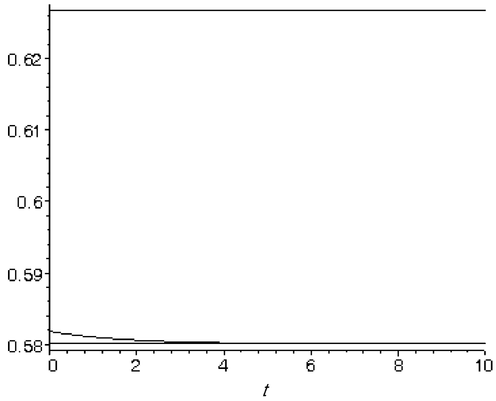

FIGURE 1. The adjustment of *c*.

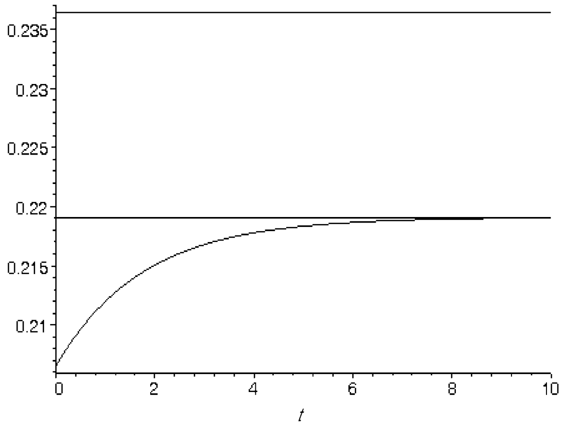

FIGURE 2. The adjustment of *L*.

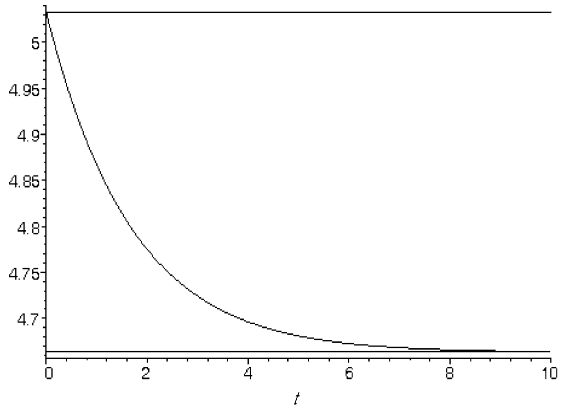

FIGURE 3. The adjustment of *K*.

https://doi.org/10.1017/S1365100509090336 Published online by Cambridge University Press

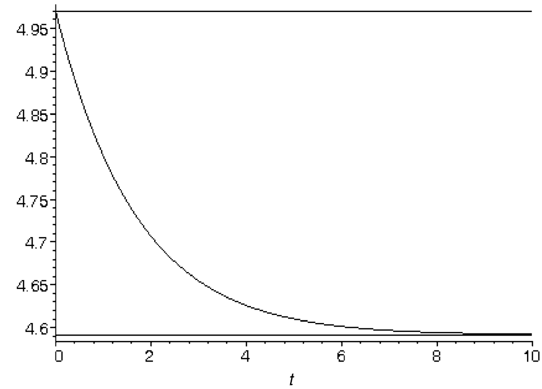

FIGURE 4. The adjustment of *a.*

As shown in Table 1, *c* and *L* fall on impact, with *L* falling more than *c* (−7.1477% versus −12.6753%), whereas *K, f*, and *a*, being state variables, do not jump on impact following the inflation shock. Along the adjustment path *c* falls further to its new steady state (Figure 1), and *L* recovers relative to its initial drop and settles down to a new lower steady state (Figure 2), whereas the state variables *K*, *a*, and *f* adjust smoothly to their lower steady state values (Figures 3, 4, and 5 respectively). In the new steady state *c* has fallen by 7.4279%, *L* and *K* by 7.3407%,[17] *f* by 14.3789%, and *a* by 7.6156%.

It is not difficult to explain these results in terms of the behavior of the model. From the theoretical results of the model without capital, one can readily infer the adjustments in the complete model. An increase in the inflation rate raises the price of consumption relative to leisure, leading the representative household

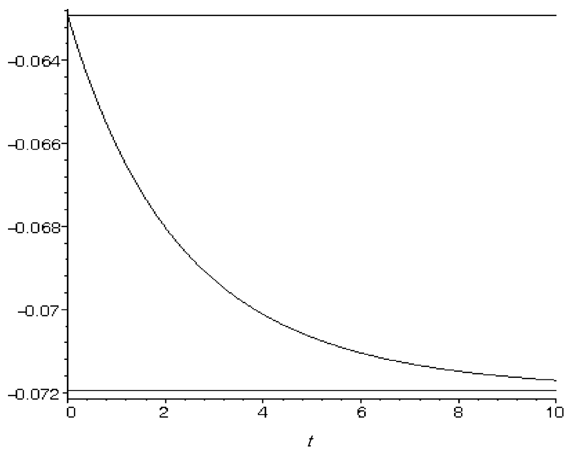

FIGURE 5. The adjustment of *f.*

https://doi.org/10.1017/S1365100509090336 Published online by Cambridge University Press

to substitute leisure for consumption. Furthermore, the increase in the inflation rate also requires a fall in the steady state habitual standards of living, if the nominal interest rate is initially positive. Assuming adjacent complementarity in preferences, then immediately after the increase in the inflation rate the household tries to maintain the habitual standards of living. Thus, on impact, savings falls (a will be falling), and there is a large substitution of leisure for consumption; leisure increases by more than in the steady state and consumption falls by less than in the steady state. Hence, there will be a large decline in labor supply (larger than in the steady state), which will reduce the marginal productivity of capital, leading to a fall in investment. In fact, the fall in investment is smaller than the fall in savings, and the country's net foreign asset position starts to deteriorate.[18] As the economy adjusts towards its steady state level, consumption and the capital stock will be falling over time, whereas employment will be rising.

Now we turn to a quantitative comparison of the predictions of the model with those from the Mansoorian and Mohsin model without habits. We simulated the latter model using the same parameter values given above, except for the habits parameter v, which we set equal to zero. Consider a high-inflation country that experiences an increase in the inflation rate from 20% to 30%. Because with habit formation the representative household attempts to maintain the relatively high standards of living it has inherited from the past, the steady state level of net foreign assets is smaller, which implies a larger steady state fall in consumption, a smaller steady state increase in leisure, and a correspondingly larger fall in welfare. With smaller leisure effects, there are correspondingly smaller effects on steady state employment, capital, and output.[19] Whereas with time-separable preferences steady state consumption falls by 5.168%, with habits steady state consumption falls by 7.428%. Whereas with time-separable preferences steady state employment, capital, and output fall by 8.006%, with habits steady state employment, capital, and output fall by 7.340%. Finally, whereas with time-separable preferences the steady state net foreign asset position of the country improves by 714.74%, the net foreign asset position deteriorates by 14.38% with habits.

This large difference in the steady state response of net foreign assets between the model with habits and the model without habits implies a substantially larger fall in the steady state purchasing power of the household with habits, which now has to pay the interest on the larger accumulated debt, which reduces its consumption possibilities and welfare.

4. SOME EMPIRICAL EVIDENCE

In this section we provide some illustrative empirical evidence for the effects of a permanent inflation shock on output, gross investment, and net foreign assets, from a sample of eight Latin America countries that have traditionally experienced high average inflation rates: Argentina, Brazil, Chile, Costa Rica, Mexico, Peru, Uruguay, and Venezuela. For each of these countries we computed an impulse response function (IRF) for each of the three variables following a permanent shift in the rate of inflation. The empirical IRFs were computed using annual data from the World Bank world development indicators (WDI), over the period 1961–2006. All series were in real 2000 prices and in millions of the local currency. Output and investment were measured as the natural logs of real GDP and gross fixed capital formation, respectively; net foreign assets (NFA) were measured in their natural units; and the CPI was used to compute the rate of inflation.

Because the theoretical analysis is in terms of the effects of a permanent inflation shock on these variables, we first tested for the presence of permanent changes in inflation and the other three variables over the sample period. Formally, we tested each time series for the presence of unit roots, using recently developed unit root tests that also account for structural breaks in the data. Accounting for possible structural breaks in the data is an important issue in the present analysis, because almost all countries in our sample have experienced economic setbacks and have undertaken monetary policy reforms in order to reduce their inflation rates and stabilize their exchange rates. For instance, in 1991 Argentina adopted a currency board regime with one-to-one parity of the peso to the U.S. dollar, which was subsequently abandoned in 2002 following the country's mounting deficits and debts. Brazil experienced economic stagnation following the 1982 debt crisis, pegged its currency to the U.S. dollar in 1994, and adopted an inflation-targeting policy and floating exchange rates in 1999.

Specifically, we performed the unit root tests proposed by Saikkonen and Lütkepohl (SL, 2002) using critical values from Lanne et al. (2002). These tests determine the timing of the break endogenously and are more powerful than standard unit root tests, such as the ADF, which ignore structural breaks and may thus lead to misleading inferences. SL assume that the data-generating process for the random variable y_t takes the form

$$y_t = \alpha + \beta t + f_t(\theta)'\gamma + u_t, \tag{34}$$

where α, β, θ, and γ are unknown parameters (with θ and γ possibly vector-valued) and the error term u_t is an AR(p) process with possible unit root. Thus the SL unit root tests allow for a deterministic time trend βt and account for a break in the data using the shift function $f_t(\theta)$, which includes the following: a simple dummy, an impulse dummy that adjusts a series at the point of the break and then returns its value to its prebreak level, and smooth transition functions based on two specific exponential and rational functions.

Applying the SL unit root tests to the data, we obtained the following results:[20] the real GDPs and inflation rates of all eight countries have unit roots at the 1%, 5%, or 10% level of significance, and thus have had permanent shifts over the sample period, even in the presence of structural breaks in the data. Similarly, the investment series of seven countries have unit roots—all except for Peru. Last, the NFA series of only four countries have unit roots: Brazil, Costa Rica, Mexico, and Venezuela. Further, the first differences of the series with unit roots turn out to be stationary and thus these series are integrated of order one, or $I(1)$ processes, each possessing a single unit root, at the same levels of significance. All the remaining series turn out to be stationary in their levels, or are $I(0)$ processes.

On the basis of these results, we then computed the IRFs of a permanent increase in inflation on output, investment, and NFA after eliminating all the $I(0)$ series from the sample, as in this case we have the direct implication that a permanent inflation shock did not have a permanent effect on these series. To this end, we fitted the data to three bivariate time series models, each consisting of the change in the rate of inflation, $\Delta\pi_t$, and the change in each of the other three variables, represented generically by Δx_t.

Let $\Delta Y_t = [\Delta\pi_t, \Delta x_t]'$, $\theta(L) = [(\theta_{11}(L), \theta_{21}(L))', (\theta_{12}(L), \theta_{22}(L))']$, and $U_t = [U_{\pi t}, U_{xt}]'$. Then the moving average representation (MAR) of the model can be written $\Delta Y_t = \theta(L)U_t$, where $\theta_{ij}(L) = \sum_{k=0}^{\infty} \theta_{ijk} L^k$, $i, j = 1, 2$, are polynomials in the lag operator L, and $U_{\pi t}, U_{xt}$ are random disturbances to inflation and the generic variable, respectively. Following Bullard and Keating (1995), we identify the disturbances by assuming that (a) they are uncorrelated and (b) $\theta_{12}(1) = \sum_{k=0}^{\infty} \theta_{12k} = 0$. The latter condition restricts the U_{xt} shocks to have only a transitory effect on the inflation rate, but no long-run effect. On the other hand, the inflation shocks $U_{\pi t}$ can have a permanent effect on the inflation rate. This is in line with Milton Friedman's view on the trend behavior of inflation that "inflation is everywhere and always a monetary phenomenon." Further, a permanent inflation shock can have a positive, zero, or negative effect on output, investment, or NFA.

Given this identification scheme, we estimated several VAR models, using the software package JMulti, available at www.jmulti.de. All the VAR estimations were performed for each pair of variables using different combinations of a constant, a trend, and up to four lags, with the reported IRFs based on the VAR estimations with the lowest values of the Akaike and Schwarz information criteria. Table 2 reports the specific VAR model used for each country.

Figures 6, 7, and 8 show, respectively, the IRFs for output, investment, and NFA with permanent shifts or $I(1)$ components in our sample. In each plot, the

TABLE 2. VAR model used for each country

Country	Inflation and output	Inflation and investment	Inflation and NFA
Argentina	1 lag	1 lag	NA
Brazil	1 lag	1 lag	1 lag
Chile	2 lags	2 lags	NA
Costa Rica	1 lag	1 lag	1 lag
Mexico	2 lags, detrended	1 lag	2 lags
Peru	1 lag	NA	NA
Uruguay	1 lag	1 lag	NA
Venezuela	1 lag	1 lag	1 lag, detrended

Note: NA, not applicable.

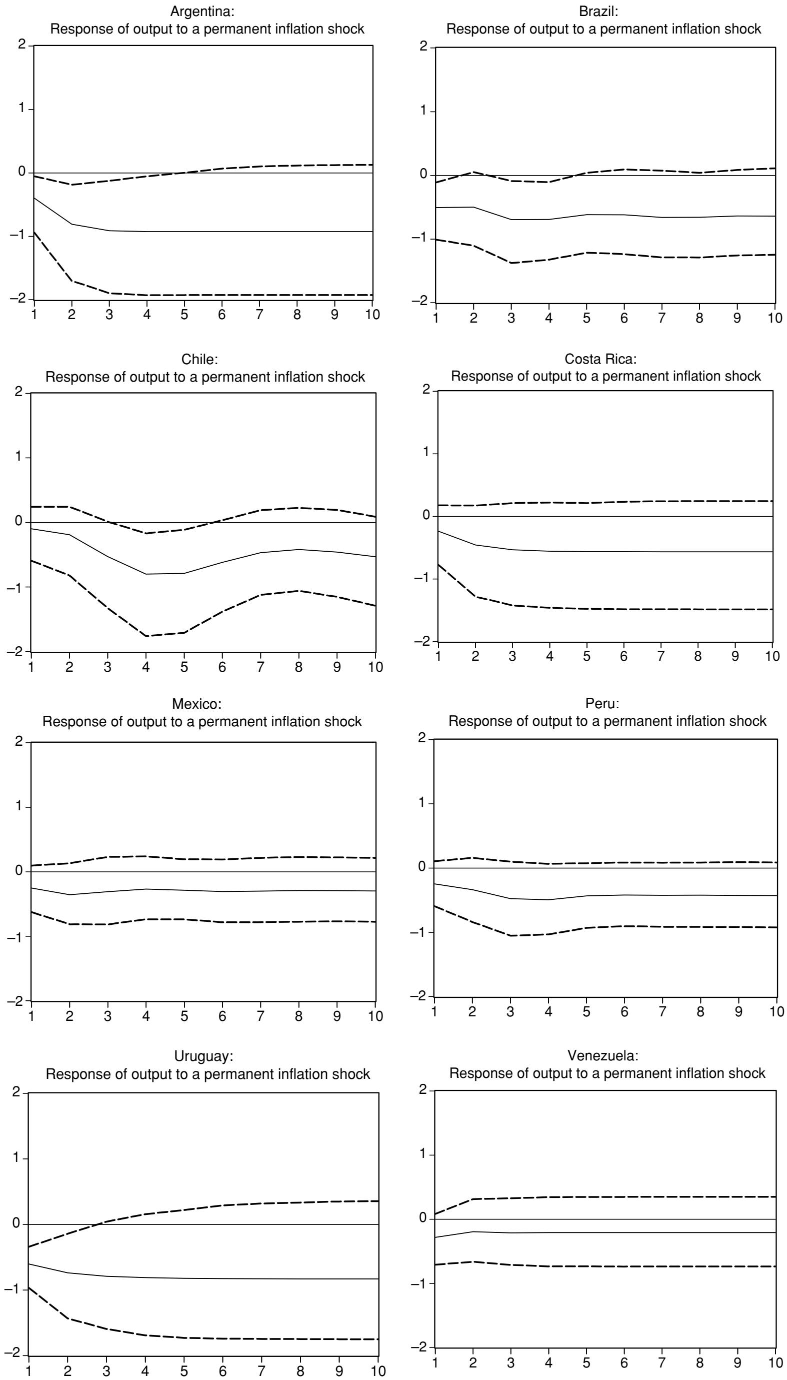

FIGURE 6. Impulse response functions for output.

https://doi.org/10.1017/S1365100509090336 Published online by Cambridge University Press

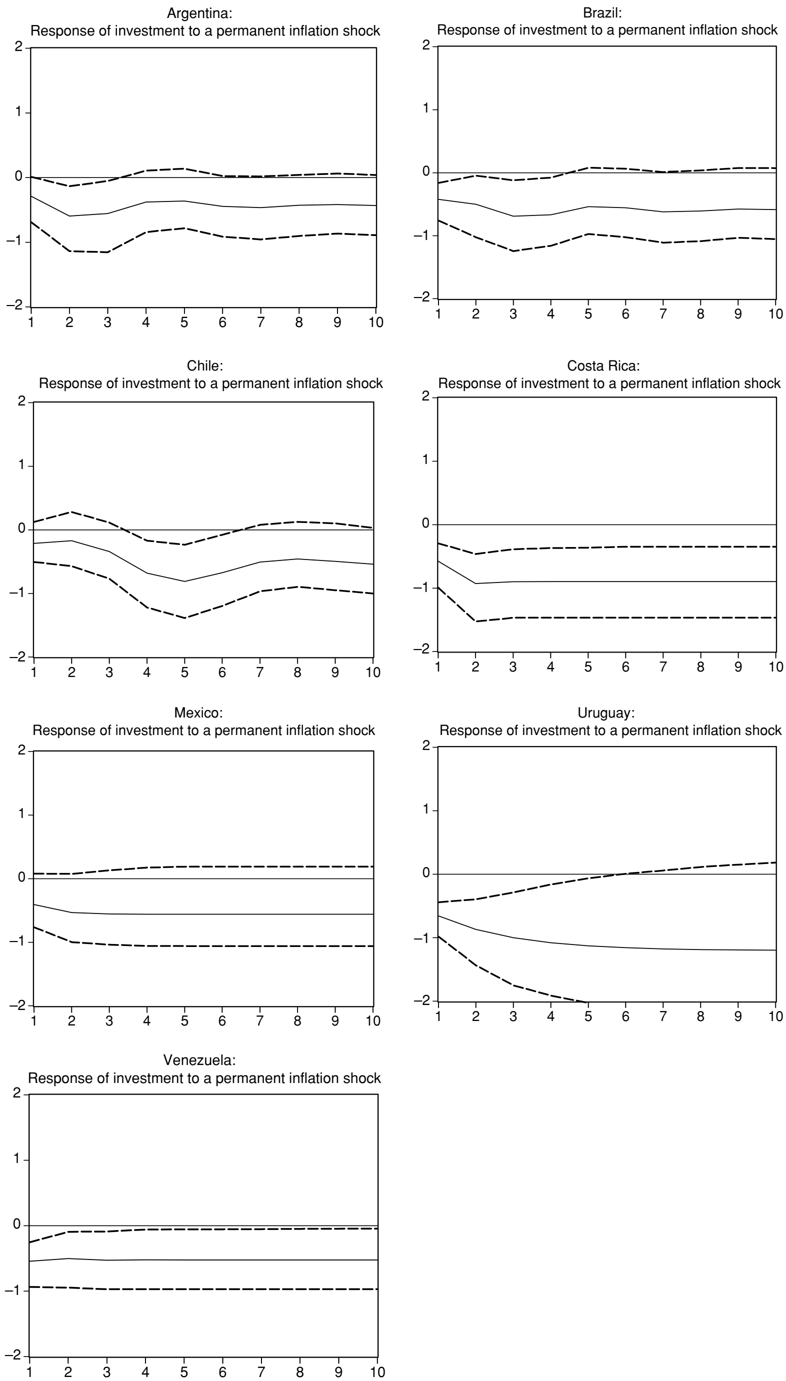

FIGURE 7. Impulse response functions for investment.

https://doi.org/10.1017/S1365100509090336 Published online by Cambridge University Press

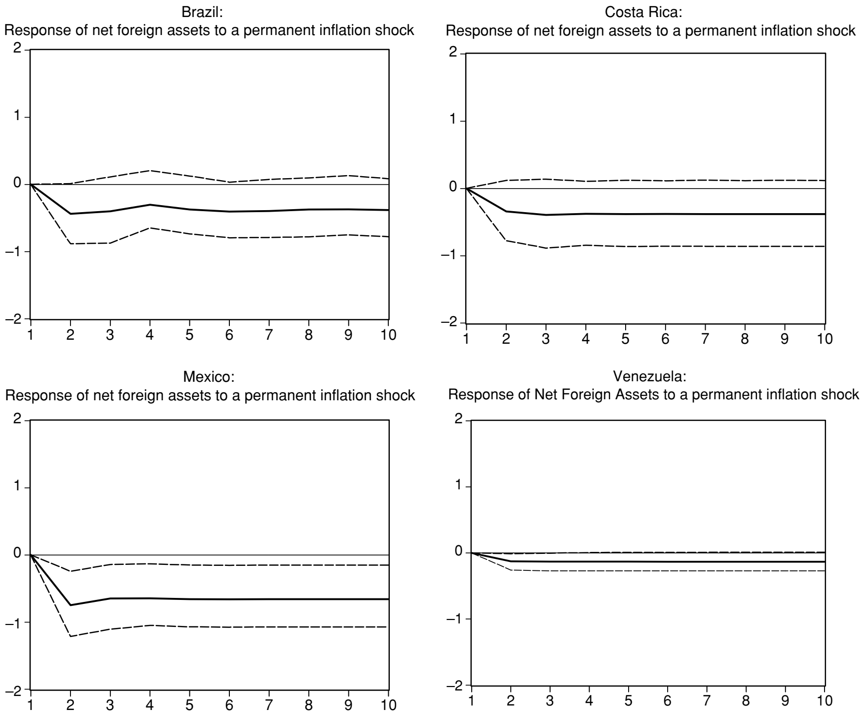

FIGURE 8. Impulse response functions for net foreign assets.

solid line represents the accumulated response of output, investment, and NFA, respectively, following a permanent one–percentage point increase in the rate of inflation. Each IRF was standardized by dividing each differenced series by the standard deviation of that series. The dashed lines represent 90% confidence intervals calculated using the Efron bootstrap method with 499 replications.

As predicted by our theory, the empirical results show that a permanent inflation shock tends to negatively affect output, investment, and net foreign assets. The impact effects of inflation are uniformly negative for output and investment. For output they are significant for three of the eight countries (Argentina, Brazil, and Uruguay) and nearly significant for the remaining five countries. For investment they are significant for five of the seven counties, and nearly significant for the remaining two countries (Chile and Mexico). NFA, being a state variable, does not adjust on impact following the permanent inflation increase.

The short-run and long-run effects of inflation on the three variables are shown by the empirical IRFs over the 10-year horizon. The negative effects of inflation on output persist over time and are statistically significant or nearly significant for five (Argentina, Brazil, Chile, Costa Rica, Peru) of the eight countries. There is even stronger evidence for investment. The negative effects of inflation on investment are significant or nearly significant in all seven countries. This evidence is also consistent with the cross-sectional regression results of the empirical growth literature; see, for example, Fischer (1993, Table 5) and Barro (1996, Table 6).

In the case of net foreign assets, there are four countries that have experienced permanent shifts in the two variables over the sample period. For Brazil, Mexico, and Venezuela the short-run and long-run effects of inflation on NFA are negative and statistically significant, and for Costa Rica nearly significant, as shown by the 90% confidence bands. Further, as shown by the shape of the IRFs, following the inflation increase, the NFAs start falling, or equivalently the current accounts (CAs) of these countries are deteriorating, thus implying a negative correlation between the NFA (or the CA) and the rate of inflation, as predicted by our theoretical results.

Figure 9 provides additional evidence of the negative long-run correlation between NFA and inflation, from the cross-sectional plot of the NFA and inflation for all eight countries.[21] To adjust for country size, each country's NFA is a GDP-weighted average over the sample period 1961–2006, with weights equal to its annual GDP-shares relative to all eight countries. Then it is converted to 2000 U.S. dollars by multiplying it by the country's U.S. exchange rate in the year 2000. The estimated regression line is NFA $= 1.63–0.034$INFL with the t-statistic for the inflation coefficient equal to -2.76. This is clear evidence of a significant negative long-run relationship between the two variables, which complements the results of the empirical IRFs shown in Figure 8 for the four countries with permanent shifts in both NFA and inflation.

Overall, the empirical results provide evidence in support of the theoretical results of our model. Although the empirical results of the effects of inflation on

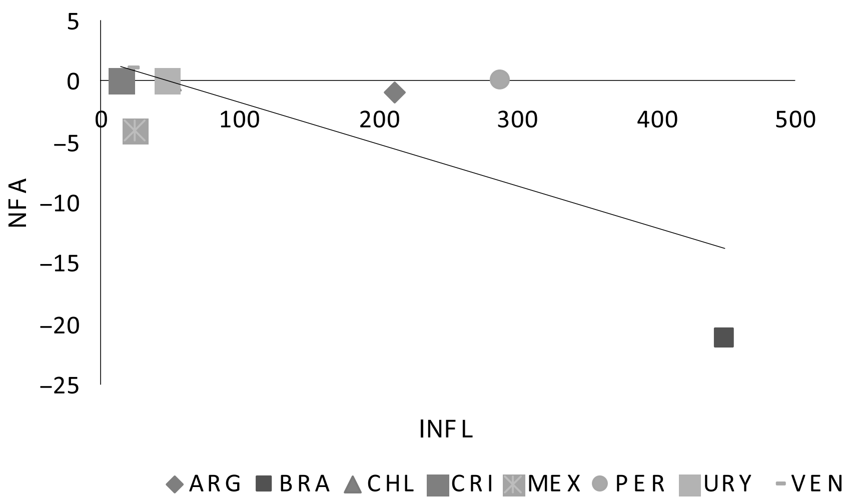

FIGURE 9. Cross-section plot of NFA and inflation and the fitted regression line. *Note*: NFA are measured in billions of 2000 U.S. dollars.

https://doi.org/10.1017/S1365100509090336 Published online by Cambridge University Press

investment are known in the literature for high-inflation countries, the evidence on the negative effects of inflation on net foreign assets is new.

5. CONCLUSIONS

In this paper we studied the effects of monetary shocks on a small open economy in which preferences exhibit habit persistence, the representative agent has labor–leisure choice, and firms make investment decisions subject to adjustment costs. Money is introduced into the model through a CIA constraint on consumption expenditures, and monetary policy involves targeting the inflation rate, rather than the rate of growth of money per se.

The model enables us to work out the effects of persistent monetary shocks on important macroeconomic variables. In particular, it is shown that an increase in the inflation rate will require a fall in the steady state habitual standards of living as long as initially the nominal interest rate is positive. With CIA constraints on consumption expenditures, a permanent increase in the domestic inflation rate will increase the cost of consumption relative to leisure, resulting in a substitution of leisure for consumption. If preferences exhibit adjacent complementarity, then the representative agent will try to maintain his habitual standards of living by reducing his savings and making a substantial substitution of leisure for consumption. The resulting fall in labor supply will reduce the marginal productivity of capital and investment.

The effects of inflation on steady state consumption are more pronounced with habits than with time-separable preferences, whereas the effects on employment, output, and capital are more pronounced with time-separable preferences. Our empirical impulse response functions from a sample of eight high-inflation countries provide some illustrative evidence in support of the theoretical predictions of the model. In particular, our new empirical evidence finds a negative correlation between net foreign assets or the current account and the rate of inflation across these countries.

Our empirical investigation is illustrative and limited to eight Latin American countries with traditionally high inflation rates. More empirical work with a larger sample of countries is needed to establish the robustness of our theoretical results and the related issue of the Feldstein–Horioka puzzle. This is an important area that is left for future research.

NOTES

1. For example, Mendoza (1991) uses Uzawa (1968) preferences in a real–business cycle setting to explain the high correlation between savings and investment through productivity shocks. Ikeda and Gombi (1998) use the habit formation model of Ryder and Heal (1973) in a small open economy setting without money or labor–leisure choice to explain the puzzle through temporary productivity shocks. Other references include Backus, Kehoe, and Kydland (1995), Baxter and Crucini (1993), and Finn (1990). A thorough quantitative analysis of the present model for the Feldstein–Horioka puzzle is left for future research.

2. Mansoorian (1996) uses the habit persistence model with money-in-utility to examine the effects of exchange rate policies in an endowment model with no labor–leisure choice or investment.

3. The assumption is also consistent with the assumptions in the literature concerned with the time consistency of monetary policy [e.g., Backus and Drifill (1985), Kydland and Prescott (1977), and Walsh (1995)], where it is also assumed that the central bank targets the inflation rate (not the rate of growth of money per se). Recently, Mishkin (2000) also argued that the central banks of most developed as well as emerging countries do indeed target the inflation rate rather than the rate of growth of money.

4. The reason is that with a CIA constraint on consumption, nominal interest rates represent a distortion. If nominal interest rates are initially positive, an increase in them will increase the size of the distortion, requiring a fall in the steady state habitual standards of living.

5. Ryder and Heal provide a complete description of adjacent complementarity and adjacent substitutability.

6. To appreciate the role played by habits in the adjustment process, notice that with time-separable preferences and no investment after a change in the inflation rate, consumption and employment would jump to their new levels without any dynamics. Hence, savings would play essentially no role in the adjustment process, and all the dynamics of the complete model would be driven by the dynamics of investment.

7. Cardia (1991) uses a real–business cycle type model with CIA on consumption, labor–leisure choice, and capital in Blanchard's (1985) overlapping-generations framework and concludes that monetary and fiscal policies play a minor role in producing the empirical regularities. However, as stated by Ikeda and Gombi (p. 364), the Blanchard overlapping-generations model is rather controversial in describing savings behavior. In Haug (1996) it is strongly rejected by quarterly Canadian data. On the other hand, the habit formation model has been supported empirically and has been used by several authors in accounting for empirical phenomena. It is, crucial, therefore, to work out its full potential.

8. CIA constraints are usually expressed in a discrete-time setting, where money is held at the beginning of each period in order to finance purchases at the end of the period. The continuous-time setting is a limiting case of this setup, where periods have lengths that are infinitely small. The continuous-time assumption does not change any of the results. This assumption is made for tractability.

9. Clearly, "expenditures" on leisure are the wage income foregone, whereas "expenditures" on consumption are the actual expenditures c plus the cost of holding money in order to finance these expenditures $(r+\varepsilon)c$.

10. If $E(r+\varepsilon, \bar{S})$ is the expenditure function corresponding to $\omega(c, l)$ at the initial steady state, where $\omega = \bar{S}$, then

$$E_{11} = \frac{-\bar{S}V''}{V^2} + 2\frac{\bar{S}V'^2}{V^3} = \frac{-\bar{Z}V''}{V} + 2\frac{\bar{Z}V'^2}{V^2}.$$

Thus, the numerator of the right-hand side of (23) is $(r+\varepsilon)E_{11}$, which is negative for $(r+\varepsilon) > 0$, as $E_{11} < 0$. The denominator of the right-hand side of (23) is positive by the definition of Ω.

11. If preferences exhibit adjacent substitutability (the case in which condition (25) is not satisfied), then the fall in full consumption ω immediately after the increase in ε will be larger than in the steady state, and there will be a current account improvement. Then, along the adjustment path, ω will be increasing over time. In this case, on impact consumption c will fall by a larger amount than in the steady state; and then it will be rising along the adjustment path. Again, by the homotheticity of preferences, it follows that in this case labor supply will be rising along the adjustment path. Hence, after the increase in ε the representative agent substitutes leisure for consumption, resulting in a fall in employment. On impact, employment falls by less than in the steady state, and then it will be falling further over time along the adjustment path.

12. Of course, with constant returns to scale $F_K > 0$, $F_L > 0$, $F_{KK} < 0$, $F_{LL} < 0$, and $F_{KK}F_{LL} - F_{KL}^2 = 0$.

13. Note that D_t is taken as given by the household.

14. As before, we will have to assume that the rate of time preference is equal to the rate of interest in order to have a well-defined steady state. Hence, we will have that $\dot{\mu} = 0$ and that μ is always at its steady state level.

15. The derivations are available from the authors upon request.

16. The reason for this is that in small open economy models that set the rate of time preference equal to the world rate of interest, we have hysteresis, and the initial value of one of the steady state variables can be chosen.

17. Notice that because the small open economy takes the world interest rate as given, and because the production function exhibits constant returns to scale, the steady state levels of employment, capital, and output fall by the same percentage.

18. Recall from the national income identity [equation (33)] that changes in net foreign assets are equal to savings minus investment.

19. Notice that, because the small open economy takes the world rate of interest as given, and because the production function displays constant returns to scale, steady state employment, capital, and output increase in the same proportion.

20. The detailed results are in an earlier version of the paper and are available from the authors upon request.

21. We are indebted to an anonymous referee for suggesting this figure.

REFERENCES

Backus, David K. and John Driffill (1985) Inflation and reputation. *American Economic Review* 75(June), 530–538.

Backus, David K., Allen W. Gregory, and Chris I. Telmer (1993) Accounting for forward rates in markets for foreign currency. *Journal of Finance* 48, 1887–1908.

Backus, David K., Patrick J. Kehoe, and Finn E. Kydland (1994) Dynamics of the trade balance and the terms of trade: The J-curve? *American Economic Review* 84, 84–103.

Barro, Robert (1996) Inflation and growth. *Federal Reserve Bank of St. Louis Review* 78(3)(May/June), 153–169.

Baxter, Marianne and Mario J. Crucini (1993) Explaining savings–investment correlations. *American Economic Review* 83, 416–436.

Blanchard, Olivier (1985) Debts, deficits, and finite horizons. *Journal of Political Economy* 93, 223–247.

Bullard, James and John W. Keating (1995) The long-run relationship between inflation and output in postwar economies. *Journal of Monetary Economics* 36, 477–496.

Cardia, Emanuela (1991) The dynamics of a small open economy in response to monetary, fiscal, and productivity shocks. *Journal of Monetary Economics* 28, 411–434.

Carroll, Christopher D., Jody Overland, and David N. Weil (2000) Saving and growth with habit formation. *American Economic Review* 90, 341–355.

Constantinides, George M. (1990) Habit formation: A resolution of the equity premium puzzle. *Journal of Political Economy* 98(3), 519–543.

Cooley, Thomas F. (1995) *Frontiers of Business Cycle Research*. Princeton, NJ: Princeton University Press.

Cooley, Thomas F. and Gary D. Hansen (1989) The inflation tax in a real business cycle model. *American Economic Review* 79(4), 733–748.

Feldstein, Martin, and Charles Horioka (1980) Domestic saving and international capital flows. *Economic Journal* 90, 314–329.

Ferson, Wayne E. and George M. Constantinides (1991) Habit persistence and durability in aggregate consumption: Empirical tests. *Journal of Financial Economics* 29, 199–240.

Finn, Mary (1990) On savings and investment dynamics in a small open economy. *Journal of International Economics* 29, 1–21.

Fischer, Stanley (1979) Capital accumulation on the transition path in a monetary optimizing model. *Econometrica* 47, 1433–1439.

Fischer, Stanley (1993) The role of macroeconomic factors in growth. *Journal of Monetary Economics* 32(3), 485–512.

Fuhrer, Jeffrey C. and Michael Klein (1998) Risky Habits: On Risk Sharing, Habit Formation, and the Interpretation of International Consumption Correlations. Working paper 6735, National Bureau of Economic Research.

Haug, Alfred (1996) Blanchard's model of consumption: An empirical study. *Journal of Business and Economics Statistics* 14, 169–177.

Heaton, John (1993) The interaction between time non-separable preferences and time aggregation. *Econometrica* 61, 353–385.

Ikeda, Shinsuke and Ichiro Gombi (1998) Habits, costly investment, and current account dynamics. *Journal of International Economics* 49, 363–384.

Kydland, Finn and Edward Prescott (1977) Rules rather than discretion: The inconsistency of optimal plans. *Journal of Political Economy* 85, 473–492.

Lanne, Markku, Helmut Lütkepohl, and Pentti Saikkonen (2002) Comparison of unit root tests for time series with level shifts. *Journal of Time Series Analysis* 21(6), 667–685.

Mansoorian, Arman (1996) On the macroeconomic policy implications of habit persistence. *Journal of Money, Credit, and Banking* 28, 119–129.

Mansoorian, Arman and Mohammed Mohsin (2006) On the employment, investment and current account effects of inflation in a cash-in-advance economy. *Journal of International Economics* 70, 296–313.

Mehra, Rajnish and Edward C. Prescott (1985) The equity premium: A puzzle. *Journal of Monetary Economics* 15, 145–161.

Mendoza, Enrique (1991) Real business cycles in a small open economy. *American Economic Review* 82, 797–818.

Mishkin, Frederic S. (2000) Inflation targeting in emerging-market countries. *American Economic Review Papers and Proceedings* 90, 105–109.

Naik, Narayan and Michael Moore (1996) Habit formation and intertemporal substitution in individual food consumption. *Review of Economics and Statistics* 78, 321–328.

Ryder, Harl E. and Geoffrey M. Heal (1973) Optimal growth with intertemporally dependent preferences. *Review of Economic Studies* 40, 1–31.

Saikkonen, Pentti and Helmut Lütkepohl (2002) Testing for a unit root in a time series with a level shift at unknown time. *Econometric Theory* 18, 313–348.

Sen, Partha and Stephen J. Turnovsky (1989a) Deterioration of the terms of trade and capital accumulation: A re-examination of the Laursen–Metzler effect. *Journal of International Economics* 26, 227–250.

Sen, Partha and Stephen J. Turnovsky (1989b) Tariffs, capital accumulation and the current account in a small open economy. *International Economic Review* 30, 811–831.

Stockman, Alan C. (1981) Anticipated unflation and the capital stock in a cash-in-advance economy. *Journal of Monetary Economics* 8, 387–393.

Uzawa, Hirofumi (1968) Time preference, the consumption function, and optimal asset holdings. In J.N. Wolfe (ed.), *Value, Capital and Growth: Papers in Honour of Sir John Hicks*. Chicago: Aldine.

Walsh, Carl E. (1995) Optimal contracts for central bankers. *American Economic Review* 85, 150–167.