External Constraints on Monetary Policy and The Financial Accelerator*

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Abstract

This paper incorporates a financial accelerator mechanism in a small open economy macro model with money and nominal price rigidities. Our goal is to explore the connection between financial distress that feeds into the real economy and the exchange rate regime. Our principle finding is that financial accelerator effects are much stronger under fixed rates than under flexible rates (with a suitably managed monetary policy). Roughly speaking, an exchange rate peg forces the central bank to adjust the interest rate in a manner that enhances the financial distress. This occurs even when debt is denominated in units of foreign currency. Finally, unexpectedly delaying the abandoment of an exchange rate peg several quarters after a shock can produce distress nearly as bad as occurs under a permanent peg, due to the unanticipated contractions in asset prices.

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1 Introduction

Over the past fifteen years there has been a dramatic rise in the frequency of financial crises that have apparently led to significant contractions in economic activity. One feature of these crises, that pertains in particular to open economies, is the strong connection with a fixed exchange rate regime. In a study covering the 1970s through the 1990s, Kaminsky and Reinhart [18] document the strong correlation between domestic financial strains and currency crises. Put differently, countries in the position of having to defend an exchange rate peg were more likely to have suffered severe financial distress. The likely reason is straightforward: defending an exchange rate peg generally requires a central bank to adjust interest rates in a direction that reinforces the crisis. Moreover, this connection between external constraints on monetary policy and financial crises is not simply a post war phenomenon: During the Great Depression, as Eichengreen [13] and others have shown, countries that stayed on the gold standard suffered far more severe financial and economic distress than countries that left early.

In this paper we develop a small open economy macroeconomic model where financial conditions influence aggregate behavior. Our goal is to explore the connection between the exchange rate regime and financial distress. Specifically, we extend to the open economy the financial accelerator framework developed in Bernanke, Gertler and Gilchrist [4] (hereafter BGG). We then consider the behavior of the economy under fixed versus flexible exchange rates and, in the process, isolate the role of the financial accelerator.

Section 2 develops the model. The core is a new open economy macro model with money and nominal price rigidities (as in, e.g., Obstfeld and Rogoff [24]). The financial accelerator mechanism links the condition of borrower balance sheets to the terms of credit, and hence to the demand for capital. Via the impact on borrower balance sheets, the financial accelerator magnifies the effects of shocks to the economy. As in Kiyotaki and Moore [19] and BGG, unanticipated movements in asset prices provide the main source of variation in borrower balance sheets. As in BGG, a countercyclical monetary policy can potentially mitigate a financial crisis: easing of rates during a contraction, for example, helps stabilize asset price movements, and hence borrower balance sheets. External constraints on monetary policy, however, limit this stabilizing option.

Section 3 presents a number of quantitative policy experiments. Specifically we explore the response of the economy to several shocks under fixed versus floating exchange rate regimes. Under the former, the central bank adjusts the short term rate to satisfy the peg. Under the latter, it adjusts the short rate according to an open economy variant of a Taylor rule. We find that financial accelerator effects are much stronger under fixed exchange rates than under flexible rates. The exchange rate peg forces the central bank to adjust the interest rate in a way that magnifies the financial accelerator effect. Indeed, a significant fraction of the enhanced volatility of output under fixed rates is due to the financial accelerator.

A number of authors have recently stressed that if private debts are denominated in foreign currency units - as it was recently the case for many emerging market economies

- a fixed rate regime may be desirable: In this environment devaluations weaken borrower balance sheets.[1] We accordingly consider the impact of having foreign indexed debt. As expected, this modificaton does raise output volatility under flexibile rates. Consistent with Cespedes, Chang and Velasco [10] (CCV), we find that volatility remains greater under fixed rates. However, we obtain this result for somewhat different reasons, however. In CCV, domestic assets do not serve as collateral but certain restrictions on the physical environment (specifically the assumption that capital is fully depreciable) ensure that flexible rates dominate. In our framework, flexible rates with foreign indexed debt dominate only because domestic assets do serve as collateral and monetary policy is able to move asset prices in a way that stabilizes balance sheets. Under fixed rates, adverse domestic asset price movements more than offset any gain from insulating balance sheets from exchange rate movements. In the absence of this domestic asset price channel, fixed rates could in fact dominate when there is foreign indexed debt.[2]

Finally, we consider a hybrid scenario that often occurs in practice: The exchange rate is initially fixed, but then the central bank eventually abandons the peg. Here we show that if the central bank unexpectedly delays the abandonment (in the wake of an adverse shock), then the contraction in output can be nearly as bad as under a pure peg. The unexpected delay produces unanticipated contractions in asset prices, which significantly weaken borrower balance sheets.

Section 4 provides concluding remarks.

2 The Model

We consider a small open economy framework with money and nominal price rigidities, along the lines of Obstfeld and Rogoff [24], Svensson [28], Gali and Monacelli [16], and others. The key modification is the inclusion of a financial accelerator mechanism, as developed in BGG. Within the model there exist both households and firms. There is also a foreign sector and a government sector. Households work, save and consume tradable goods that are produced both at home (H) and abroad (F). Domestically and foreign made goods are imperfect substitutes.

Within the home country, there are three types of producers: (i) entrepreneurs; (ii) capital producers; and (iii) retailers. Entrepreneurs manage the production of wholesale goods. They borrow from households to finance the acquisition of capital used in the production process. Due to imperfections in the capital market, entrepreneurs' demand for capital depends on their respective financial positions - this is the key aspect of the financial accelerator. In turn, in response to entrepreneurial demand, capital producers within each sector build new capital. Finally, retailers package together wholesale goods to make final output. They are

[1] See, for example, Aghion, Bacchetta and Banerjee [2].

[2] Caballero and Krishnamurthy [7] and Schneider and Tornell [27] also emphasize the importance of the asset price channel in analyzing emerging market crises.

monopolistically competitive and set nominal prices on a staggered basis. The role of the retail sector in our model is simply to provide the source of nominal price stickiness.

We now proceed to describe the behavior of the different sectors of the economy, along with the key resource constraints.

2.1 Households

2.1.1 Consumption Composites

Let C_t be a composite of household tradable consumption goods. Then the following CES index defines household preferences over home (H) consumption, C_t^H, and foreign (F) consumption, C_t^F:

$$C_t = \left[(\gamma)^{\frac{1}{\rho}} \left(C_t^H \right)^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} \left(C_t^F \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \tag{1}$$

The corresponding consumer price index, P_t is given by

$$P_t = \left[(\gamma) \left(P_t^H \right)^{1-\rho} + (1-\gamma) \left(P_t^F \right)^{1-\rho} \right]^{\frac{1}{1-\rho}} \tag{2}$$

Domestic consumption good C_t^H is a composite of differentiated products sold by domestic monopolistically competitive retailers. However, since we can describe household behavior in terms of the composite good C_t^H, we defer discussion of the retail sector until section (2.3.3) below.

2.1.2 The Household's Decision Problem

Household preferences are given by

$$E_t \sum_{i=0}^{\infty} \beta^i [\log (C_{t+i} - bC_{t+i-1}) + \chi \log \left(\frac{M_{t+i}}{P_{t+i}} \right) - \kappa \log (1 - L_{t+i})] \tag{3}$$

with $b > 0$. Note that this formulation incorporates habit formation over C_t, following Boldrin, Christiano, and Fisher [5]. Including habit formation improves the empirical performance of the model. Without habit formation, the interest sensitivity of consumption is counterfactually high and consumption dynamics fail to exhibit the hump-shaped pattern that is present in the data for most countries.

Let W_t denote the nominal wage, Π_t real dividend payments (from ownership of retail firms); T_t lump sum real tax payments; M_t nominal money balances; S_t the nominal exchange rate; B_{t+1} and B_{t+1}^* nominal bonds denominated in domestic and foreign currency, respectively; and $(1 + i_t)$ and $(1 + i_t^*)$ the domestic and foreign gross nominal interest rate, respectively. The household's budget constraint is then given by

$$C_t = \frac{W_t}{P_t} L_t + \Pi_t - T_t - \frac{M_t - M_{t-1}}{P_t} - \frac{B_{t+1} - (1 + i_{t-1}) B_t}{P_t} - \frac{S_t B_{t+1}^* - S_t \left(1 + i_{t-1}^*\right) B_t^*}{P_t} \tag{4}$$

The household maximizes (3) subject to (4) and (1).

2.1.3 Consumption Allocation, Labor Supply and Saving

The optimality conditions for consumption, labor supply, and saving are reasonably conventional:

consumption allocation;

$$\frac{C_t^H}{C_t^F} = \frac{\gamma}{1-\gamma}\left(\frac{P_t^H}{P_t^F}\right)^{-\rho} \tag{5}$$

labor allocation;

$$\lambda_t \frac{W_t}{P_t} = \kappa \frac{1}{1-L_t} \tag{6}$$

consumption/saving;

$$\lambda_t = \beta E_t \left\{ \lambda_{t+1}(1+i_t)\frac{P_t}{P_{t+1}} \right\} \tag{7}$$

where λ_t is the marginal utility of the consumption index C_t and is given by:

$$\lambda_t = \frac{1}{C_t - bC_{t-1}} - \beta \frac{b}{C_{t+1} - bC_t}, \tag{8}$$

and where $(1+i_t)\frac{P_t}{P_{t+1}}$ is the gross real interest rate.

The household also decides money holdings. However, we do not report this relation in the model. Because we restrict attention to monetary regimes where either the nominal exchange or the nominal interest rate is the policy instrument, money demand plays no role other than to pin down the nominal money stock (see, e.g., Clarida, Gali and Gertler [11])

2.1.4 International Arbitrage

Given frictionless international trade in bonds, the uncovered interest parity condition holds, as follows:[3]

$$E_t \left\{ \lambda_{t+1} \frac{P_t}{P_{t+1}} \left[(1+i_t) - (1+i_t^*)\frac{S_{t+1}}{S_t} \right] \right\} = 0. \tag{9}$$

We also assume frictionless trade in goods, implying that the law of one price must hold both for domestic and foreign produced tradables:

$$P_t^H = S_t P_t^{H*} \tag{10}$$

[3]The arbitrage equation for the foreign denominated bond is $\lambda_t = \beta E_t \left\{ \lambda_{t+1}(1+i_t^*)\frac{S_{t+1}}{S_t}\frac{P_t}{P_{t+1}} \right\}$. Combining this relation with the consumption euler equation then yields the uncovered interest parity condition.

$$P_t^F = S_t P_t^{F*} \tag{11}$$

where $P_t^{F*} = 1 \ \forall t$ and the terms of trade, $\frac{P_t^F}{P_t^H}$, are normalized to one in steady state.

2.2 Foreign Behavior

We take as exogenous both the gross foreign nominal interest rate[4] $(1 + i_t^*)$ and the nominal price (in units of foreign currency) of the foreign tradable, P_t^{F*}. Finally, we also assume that foreign demand for the home tradable, $C_t^{H^*}$, is given by

$$C_t^{H^*} = \left(\frac{P_t^{H*}}{P_t^*} \right)^{-\xi} Y_t^* \tag{12}$$

where Y_t^* is real foreign output, which we take as given.

2.3 Firms

We consider in turn: entrepreneurs, capital producers, and retailers.

2.3.1 Entrepreneurs, Finance and Wholesale Production

Entrepreneurs manage production and obtain financing for the capital employed in the process. Entrepreneurs are risk neutral. To ensure that they never accumulate enough funds to fully self-finance their capital acquisitions, we assume they have a finite expected horizon. Each survives until the next period with probability ϕ. The expected horizon is accordingly $\frac{1}{1-\phi}$. New entrepreneurs enter the market each period equal to the amount that exit, implying a stationary population. To get started, new entrepreneurs receive a small transfer of funds from exiting entrepreneurs.

Let Y_t, L_t and K_t be domestic output, labor and capital. Then the production technology is given by

$$Y_t = A_t (K_t)^{\alpha} (L_t)^{1-\alpha}. \tag{13}$$

At the end of each period t, entrepreneurs purchase capital which they use in combination with hired labor in the subsequent period $t+1$ to produce output at that time. They finance the acquisition of capital partly with their own net worth available at the end of period t,

[4] Because we do not assume complete international markets for sharing of consumption risk, the stock of net foreign indebtedness may be nonstationary. To address this issue, we follow Schmitt-Grohe and Uribe **??** by introducing a (very) small friction in the home countries' ability to obtain funds on the world capital market. In particular, we assume that the home country borrows in the international capital markets at the world interest rate plus a premium that is an increasing function of the stock of debt held by the country. As in Schmidt-Grohe and Uribe, we set the elasticity of the interest rate with respect to the debt is very close to zero so that the high frequency dynamics are unaffected by this friction. At the same time, the friction is sufficient to ensure that the stock of net foreign indebtedness reverts to a unique steady state.

N_{t+1}, and partly by issuing nominal bonds, B_{t+1}. Let Q_t be the nominal price of capital in domestic currency. Then the finance of capital is divided between net worth and debt, as follows:

$$\frac{Q_t}{P_t}K_{t+1} = N_{t+1} + \frac{B_{t+1}}{P_t}. \tag{14}$$

Observe that the entrepreneur's net worth is essentially the equity of the firm; i.e., the gross value of capital net of debt, $\frac{Q_t}{P_t}K_{t+1} - \frac{B_{t+1}}{P_t}$. The entrepreneur accumulates net worth through past earnings, including capital gains. We assume that new equity issues are prohibitively expensive, so that all marginal finance is done with debt.[5] Finally, for the time being we assume that debt is denominated in units of domestic currency. Later we consider the case where debt is issued in foreign currency units.

The entrepreneur's demand for capital, of course, depends on the expected marginal return and the expected marginal financing cost. Given the production technology, a unit of capital acquired at t and used at $t+1$ yields the expected gross return $E_t\left\{1 + r_{t+1}^k\right\}$, where

$$E_t\left\{1 + r_{t+1}^k\right\} = E_t\left\{\frac{\frac{P_{t+1}^w}{P_{t+1}}\alpha\frac{Y_{t+1}}{K_{t+1}} + (1-\delta)\frac{Q_{t+1}}{P_{t+1}}}{\frac{Q_t}{P_t}}\right\} \tag{15}$$

and P_t^w is the nominal price of domestic wholesale output, $\alpha\frac{Y_t}{K_t}$ is the marginal product of capital, $\frac{Q_t}{P_t}$ is the relative price of capital at time t, and δ is the rate of depreciation of capital.

The marginal cost of funds to the entrepreneur depends on financial conditions. Following BGG, we assume the existence of an agency problem that makes uncollateralized external finance more expensive than the internal finance. This external finance premium affects the overall cost of finance and, therefore, the entrepreneur's demand for capital. In general, the external finance premium varies inversely with the entreprenuer's net worth; the greater the share of capital that the entrepreneur can either self-finance or finance with collateralized debt, the smaller the agency costs and, hence, the smaller the external finance premium.

By definition, the entrepreneur's overall marginal cost of funds in this environment is the product of the gross premium for external funds and the gross real opportunity cost of funds that would arise in the absence of capital market frictions. Rather than present the details of the agency problem here, we simply observe, following BGG, that the external finance premium, χ_t, may be expressed as an increasing function of the leverage ratio, $\frac{\frac{B_{t+1}}{P_t}}{N_{t+1}}$. Accordingly, the entrepreneur's demand for capital satisfies the following optimality condition:

[5] To be clear, being an equity holder in this context means being privy to the firm's private information, as well as having a claim on the earnings stream. Thus, we are assuming that the firm cannot attract new wealthy investors that costlessly absorb all firm-specific information.

$$E_t\left\{1+r_{t+1}^k\right\}=(1+\chi_t(\cdot))E_t\left\{(1+i_t)\frac{P_t}{P_{t+1}}\right\} \tag{16}$$

with

$$\chi_t(\cdot)=\chi\left(\frac{\frac{B_{t+1}}{P_t}}{N_{t+1}}\right) \tag{17}$$

and

$$\chi'(\cdot)>0,\ \chi(0)=0,\ \chi(\infty)=\infty$$

where $E_t\{(1+i_t)\frac{P_t}{P_{t+1}}\}$ is the gross cost of funds absent capital market frictions.[6]

We intrepret equation (16) as follows: At the margin, the entrepreneur is considering acquiring a unit of capital financed by debt. The additional debt, however, raises the leverage ratio, increasing the external finance premium and the overall marginal cost of finance. Relative to perfect capital markets, accordingly, the demand for capital is lower, the exact amount depending on χ_t. Here we emphasize that the agency problem defines the precise form of the function $\chi(\cdot)$ (see BGG).[7] We note, however, that the general form relating external finance costs to financial positions arises across a broad class of agency problems.

Equation (16) provides the foundation for the financial accelerator. It links movements in the borrower's financial positions to the marginal cost of funds and, hence, to the demand for capital. Note in particular that fluctuations in the price of capital, Q_t, may have significant effects on the leverage ratio, $\frac{\frac{B_{t+1}}{P_t}}{N_{t+1}}=\frac{\frac{B_{t+1}}{P_t}}{\frac{Q_t}{P_t}K_{t+1}-\frac{B_{t+1}}{P_t}}$. In this way the model captures the link between asset price movements and collateral stressed in the Kiyotaki and Moore [19] theory of credit cycles. We add that though we have described equation (16) in terms of the behavior of an individual entrepreneur, we appeal to the assumptions in BGG that permit writing it as an aggregate condition. The key implication is that $\chi(\cdot)$ may be expressed as a function of the aggregate leverage ratio, i.e., $\chi(\cdot)$ is not entrepreneur specific.[8]

The other key aspect of the financial accelerator is the relation that describes the evolution of entrepreneurial net worth, N_{t+1}. Let V_t denote the value of entrepreneurial firm capital

[6] We do not allow the debt contract to be conditioned on aggregate risk. If entrepreneurs and households had indentical risk preferences then it would be optimal for households to provide some insurance to entrepreneurs against fluctuations in their collateral. However, because households in our model are considerably more risk adverse than entrepreneurs, quantitative experiments suggest that hosueholds would be unwilling to provide this insurance in equilbrium.

[7] To paramterize $\chi(\cdot)$ in the simulation exercises that follow, we assume a costly state verification problem of the type analyzed by Townsend [30], where lenders must pay a fixed auditing cost to observe the ex post realization of an entrepreneurs' output. See BGG for details.

[8] Following Carlstrom and Fuerst [9], BGG assume an agency problem that is essentially proportionate to the scale of the firm. This assumption, combined with a constant returns to scale production function implies that all entrepreneurs choose the same leverage ratio, which permits expressing $\chi(\cdot)$ in terms of the aggregate leverage ratio.

net of borrowing costs carried over from the previous period, and D_t the transfer that newly entering entrepreneurs receive from exiting entrepreneurs. Then we can express N_{t+1} as a convex combination of V_t and D_t, where the weights reflect the fractions of surviving (ϕ) and newly entering $(1-\phi)$ entrepreneurs, respectively

$$N_{t+1} = \phi V_t + (1-\phi) D_t \tag{18}$$

where

$$V_t = \left(1 + r_t^k\right) \frac{Q_{t-1}}{P_{t-1}} K_t - \left[(1 + \chi(\cdot)) (1 + i_{t-1}) \frac{P_{t-1}}{P_t} \right] \frac{B_t}{P_{t-1}} \tag{19}$$

and $(1 + r_t^k)$ is the ex-post real return on capital and $(1 + \chi(\cdot))(1 + i_{t-1})\frac{P_{t-1}}{P_t}$ is the ex post cost of borrowing.

As equations (18) and (19) suggest, the principle source of movements in net worth stems from unanticipated movements in returns and borrowing costs. In this regard, unforecastable variations in the asset price Q_t likely provide the principle source of fluctuation in $(1 + r_t^k)$. It is for this reason that unpredicable asset price movements play a key role in the financial accelerator. On the liability side, unexpected movements in the price level affect ex post borrowing costs. An unexpected deflation, for example, reduces entrepreneurial net worth. If debt were instead denominated in foreign currency, then unexpected movements in the nominal exchange rate will similarly shift net worth. (Later we explore this possibility.)

Entrepreneurs going out of business at time t consume and transfer some funds to new entrepreneurs out of the residual equity $(1-\phi)V_t$. For simplicity, we assume they only purchase domestic final goods, i.e.

$$C_t^e = (1-\phi)(V_t - D_t) \frac{P_t}{P_t^H} \tag{20}$$

Since the costs of pure debt finance are infinite (see equation 17), we include the transfer D_t to ensure that new entrepreneurs can operate. We take D_t as given, but observe that in our quantitative exercises it is of negligible size.

Finally, as we noted earlier, after securing capital entrepreneurs hire labor to produce output. The demand for household labor is given by:

$$(1-\alpha) \frac{Y_t}{L_t} = \frac{W_t}{P_t^w} \tag{21}$$

2.3.2 Capital Producers

After production of output at time t, competitive capital producers make capital goods. Specifically, they purchase final goods from retailers and then use these goods to produce new capital. Investment of I_t units of output yields $\Phi(\frac{I_t}{K_t})K_t$ units of new capital goods. We assume that $\Phi(\frac{I_t}{K_t})$ is increasing and concave. The assumption of concavity captures convex adjustment costs. We also assume, following BGG, that capital producers make their production plans one period in advance. The idea is to capture the delayed response of investment observed in the data. It is straightforward to show that capital producers plan investments to satisfy

$$E_{t-1}\left\{\frac{Q_t}{P_t^H}-\left[\Phi'\left(\frac{I_t}{K_t}\right)^{-1}\right]\right\}=0. \tag{22}$$

Equation (22) is a standard "Q-investment" relation, modified to allow for the investment delay. The variable price of capital, though, plays an additional role in this framework: As we have discussed, variation in asset prices will affect entrepreneurial balance sheets, and hence, the cost of capital.

2.3.3 Retailers, Price Setting and Inflation

We assume there is a continuum of monopolistically competitive retailers of measure unity. Retailers buy wholesale goods from entrepreneur/producers in a competitive manner and then differentiate the product slightly (e.g., by painting it or adding a brand name) at no resource cost. Let $Y_t^H(z)$ be the good sold by retailer z. Final good domestic output is the CES composite of individual retail goods:

$$Y_t^H=\left[\int_0^1 Y_t^H(z)^{\frac{\vartheta-1}{\vartheta}}dz\right]^{\frac{\vartheta}{\vartheta-1}}. \tag{23}$$

The corresponding price of the composite consumption good, P_t^H, is given by

$$P_t^H=\left[\int_0^1 P_t^H(z)^{1-\vartheta}dz\right]^{\frac{1}{1-\vartheta}}. \tag{24}$$

Domestic households, capital producers, and government, and the foreign country buy final goods from retailers. Cost minimization implies that each retailer faces an isoelastic demand for his product, given by $Y_t^H(z)=\left(\frac{P_t^H(z)}{P_t^H}\right)^{-\vartheta}Y_t^H$. Since retailers simply repackage wholesale goods, the marginal cost to the retailer of producing a unit of output is simply the relative wholesale price, $\frac{P_t^w}{P_t^H}$.

As we have noted, the retail sector provides the source of nominal stickiness in the economy. We assume retailers set nominal prices on a staggered basis, following the approach in Calvo [8]: Each retailer resets his price with probability $1-\theta$, independently of the time elapsed since the last adjustment. Thus, each period a measure $1-\theta$ of producers reset their prices, while a fraction θ keeps their prices unchanged. Accordingly, the expected time a price remains fixed is $\frac{1}{1-\theta}$. Thus, for example, if $\theta=.75$ per quarter, prices are fixed on average for a year.

Since there are no firm-specific state variables, all retailers setting price at t will choose the same optimal value P_t^{*H}. It can be shown that, in the neighborhood of the steady state, the domestic price index evolves according to

$$P_t^H = (P_{t-1}^H)^{\theta}(P_t^{*H})^{1-\theta}. \tag{25}$$

Retailers free to adjust choose prices to maximize expected discounted profits, subject to the constraint on the frequency of price adjustment[9]. Here we simply observe that within a local neighborhood of the steady state, the optimal price is

$$P_t^{*H} = \mu \prod_{i=0}^{\infty} (P_{t+i}^w)^{(1-\beta\theta)(\beta\theta)^i} \tag{26}$$

where $\mu = \frac{1}{1-1/\vartheta}$ is the retailers' desired gross mark-up over wholesale prices. In particular, note that if retail prices were perfectly flexible, equation (26) simply implied $P_t^{*H} = \mu P_t^w$, i.e., the retail price would simply be a proportionate markup over the wholesale price. However, because their price may be fixed for some time, retailers set prices based on the expected future path of marginal cost, and not simply on current marginal cost.

Combining equations (25) and (26) yields an expression for the gross domestic inflation rate (within the neighborhood of a zero-inflation steady state)

$$\frac{P_t^H}{P_{t-1}^H} = \left(\mu \frac{P_t^w}{P_t^H}\right)^{\lambda} E_t \left\{\frac{P_{t+1}^H}{P_t^H}\right\}^{\beta} \tag{27}$$

where the parameter $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$ is decreasing in θ, the measure of price rigidity. Equation (27) is the canonical form of the new optimization-based Phillips curve that arises from an environment of time-dependent staggered price setting (see, e.g., Gali and Gertler [15]). The curve relates inflation to movements in real marginal cost and expected inflation.

Economy-wide inflation is a composite of inflation in domestic and foreign good prices. Within a local region of the steady state, economy-wide inflation may be expressed as

$$\frac{P_t}{P_{t-1}} = \left(\frac{P_t^H}{P_{t-1}^H}\right)^{\gamma} \left(\frac{S_t}{S_{t-1}}\right)^{(1-\gamma)} \tag{28}$$

2.4 Resource Constraints

The resource constraint for the domestic traded good sector is

$$Y_t^H = C_t^H + C_t^{eH} + C_t^{H*} + I_t^H + G_t^H$$

where G_t^H is government consumption. The only difference from the norm is the inclusion of sectoral entrepreneurial consumption C_t^{eH}. The aggregate capital stock evolves according to

$$K_{t+1} = \Phi\left(\frac{I_t}{K_t}\right) K_t + (1-\delta)K_t. \tag{29}$$

[9]Since it is standard in the literature, we do not report the maximization problem here.

2.5 Government Budget Constraint

We assume that government expenditures are financed by lump-sum taxes and money creation as follows

$$\frac{P_t^H}{P_t} G_t^H = \frac{M_t - M_{t-1}}{P_t} + T_t. \tag{30}$$

Government expenditures are exogenous. Lump sum taxes adjust to satisfy the government budget constraint. Finally, the money stock depends on monetary policy, which we specify in the next section.

Except for the description of monetary policy, we have completed the specification of the model. The distinctive aspect of the model is the financial accelerator, characterized by just two equations: (16) and (18). The former characterizes how net worth influences capital demand. The latter describes the evolution of net worth. If we restrict the external finance premium $\chi(\cdot)$ to zero in equation (16), we effectively shut off the financial accelerator, and the model reverts to a reasonably conventional new open economy macroeconomic framework. In what follows we will explore the performance of the model under alternative exchange rate regimes, with and without an operative financial accelerator.

3 Exchange Rate Regimes and the Financial Accelerator

In this section we expose our model economy to a variety of disturbances and consider the response under a fixed versus a floating exchange rate regime. Our particular interest is to illustrate how financial accelerator effects exacerbate the performance of the fixed exchange rate regime.

3.1 Fixed versus Flexible Exchange Rate Regimes

We consider various shocks to the economy under three different scenarios: (i) a pure fixed exchange rate regime; (ii) a floating exchange rate regime where the central bank manages the nominal interest rate according to an open economy variant of the Taylor rule; and (iii) a hybrid case where the central banks initially fixes the exchange rate, but then eventually abandons the peg in favor of the floating exchange rate regime.

Under the fixed exchange rate regime, the central bank keeps the nominal exchange rate pegged at a predetermined level, i.e.

$$S_t = S_{t-1}, \ \forall t \tag{31}$$

To do so, it sets the nominal interest rate to satisfy the uncovered interest parity condition, given by equation (9).

Under the flexible exchange rate regime, the policy instrument becomes the nominal interest rate. The central bank adopts a feedback rule that has the nominal rate adjust to deviations of economy-wide inflation and domestic output from their respective target values. In addition, we allow for partial adjustment to capture the interest rate smoothing that seems apparent in the data (see, e.g., Clarida, Gali, and Gertler [11]) . Let Y_t^H denote domestic real output and Y_t^0 the target level, which we take to be the level that would arise if prices were perfectly flexible. The feedback rule, accordingly, is given by:

$$(1+i_t) = \left[(1+rr^{ss})(\frac{P_t}{P_{t-1}})^{\gamma_\pi}(\frac{Y_t^H}{Y_t^0})^{\gamma_y}\right]^{1-\tau}(1+i_{t-1})^{\tau} \tag{32}$$

with $\gamma_\pi > 1$, $\gamma_y > 0$, and $0 \leq \tau < 1$, where the parameter τ captures interesting rate smoothing, and where rr^{ss} is the steady state real interest rate. For simplicity, we take the target gross inflation rate to be unity. Equation (32), of course, is simply a Taylor rule with partial adjustment[10]. We interpret this rule as being a form of flexible inflation targeting, in the sense of Bernanke and Mishkin (1999). The central bank adjusts the interest rate to ensure that over time the economy meets the inflation target, but with flexibility in the short term so as to meet stabilization objectives. Importantly, we assume the central bank is able to credibly commit to the Taylor rule.

In the hybrid regime, as a shock hits the economy, the central bank intially maintains the exchange rate peg. Conditional on being on the peg in the current period, it abandons the peg with probability Π in the subsequent period, where Π is independent of time. Once off the peg, the cental bank reverts to the interest rate feedback rule given by equation (32).

3.2 Model Parametrization

Our quantitative analysis is meant to be suggestive. We assume the capital market is somewhat less developed relative to the U.S., in the respect that we fix parameters to generate a steady state external finance premium that is roughly one hundred basis points higher than what the U.S. data suggest. Conservatively, we also set the debt-equity ratio at unity, a number that is roughly twenty percent higher than the historical U.S. average. We set the export share of domestic output at twenty percent, a compromise between a protype emerging market economy (e.g., Korea) and a developed economy (e.g. Italy.). For the remaining parameters, we use reasonably standard parameters.

3.2.1 Preferences

We set the quarterly discount factor β to 0.99. The habit formation parameter, b, is assumed to be 0.6, based on estimates in Boldrin, Christiano and Fisher **??**. For given steady state

[10] The results are robust to allowing for a managed float, where the Tayor rule is appended with a term that allows for a modest adjustment of the nominal interest to deviations of the nominal exchange rate from target.

share of export demand and unitary terms of trade, the share parameter γ is choosen such that the economy is in a balanced-trade steady state. Following the international RBC literature, we fix the elasticity of substitution between home and foreign goods, ρ, equal to 1.5. These parameters implies a domestic consumption share of 0.33. We set the parameter κ in the utility function to have a labor supply elasticity of 2 and average hours worked relative to total hours available equal to $\frac{1}{3}$.

3.2.2 Technology

The capital share, α, is 0.35. The quarterly depreciation rate for capital, δ, is assigned the conventional value of 0.025. The steady state mark-up value, μ, is set at 1.2. The elasticity of the price of capital with respect to investment-capital ratio is taken to be 0.75. As it is common in the literature on the Calvo [8] pricing technology, we assume the probability of the price not adjusting, θ, to be 0.75. These parameters give an investment-output ratio, $\frac{I^H}{Y^H}$, of about 0.17.

3.2.3 External Finance Premium

The non-standard parameters of the model affect the relation between real and financial variables. We choose the entrepreneurs' death rate, $(1-\phi)$, to be 0.0272. We set the idiosyncratic productivity variable to be log-normally distributed with variance equal to 0.28. Finally, we fix the fraction of realized payoffs lost in bankruptcy to 0.12. These parameters imply the following steady state outcomes: (i) a risk spread (external finance premium), $\frac{r^k}{r}$, of about 320 annual basis points; (ii) an annualized business failure rate of 5.3 percent; and (iii) a leverage ratio roughly equal to 1.

3.2.4 Government Policy

In the open economy version of the Taylor rule, we set the coefficients on inflation, γ_π, and on domestic output gap, γ_y, equal to 2, and 0.5, respectively. We fix the autoregressive parameter in the policy rule τ, to 0.9. We also take the steady state government expenditure ratio, $\frac{G^H}{Y^H}$, to be 0.2.

3.3 Policy Experiments

We first consider the effect of an unanticipated rise in the foreign nominal interest rate under the fixed and the floating exchange rate regimes. We next consider the impact of a drop in domestic demand, induced by an unanticipated rise in the discount factor β. For robustness, we explore how the results are affected when debt is denominated in units of foreign currency. Finally, we consider a shock to the foreign interest rate in the hybrid regime, where the central bank abandons the peg over time probabilistically.

3.3.1 Foreign Interest Rate Shock

We consider an unanticipated one hundred basis point increase in the foreign nominal interest rate. We assume further that the shock obeys a first order correlation process that persists at the rate of 0.95 per quarter. Figures 1a and 1b plot the response of eight key variables under fixed versus floating rates.

Under the fixed exchange rate regime, the domestic nominal interest rate rises to match the foreign rate. Due to the nominal price rigidities, there is also a significant rise in the real interest which, in turn, induces a contraction in output. The financial accelerator magnifies the output drop. The rise in the real rate, in fact, induces a contraction in asset prices, which raise the leverage ratio and the external finance premium. The increase in the latter further dampens investment and output.

Under flexible exchange rates, the domestic nominal rate is no longer tied to the foreign rate, and is instead governed by the feedback rule, equation (32). As a consequence, the rise in the foreign rate produces immediate depreciation of the domestic currency, which in turn prompts an increase in both export demand and domestic inflation. The central bank raises the nominal rate to fight inflation, according to the feedback rule, causing a moderate drop in investment. Output, however, rises slightly on net due to the surge in export demand. Overall, except for the transitory higher inflation due to the currency depreciation, output and inflation are significantly more stable under the floating rate regime.[11]

That output should decline more under fixed rates in this scenario is of course a feature of the standard model absent a financial accelerator. What we wish to stress here is that the financial accelerator greatly magnifies the difference. Figure 2 makes this point directly. The figure plots the response of output and investment across the two different exchange rate regimes, with and without an operative financial accelerator. Under fixed exchanges, the financial accelerator nearly doubles the contraction in investment (lower left panel) and, as a consequence, nearly doubles also the contraction in output (upper left panel) at the trough. Under flexible rates, the effect of the financial accelerator is far more modest, producing a roughly fifty percent greater drop in investment.

3.3.2 Domestic Demand Shock

We next consider an unanticipated drop in domestic demand. Specifically, we consider an unanticipated one percentage point increase in the discount factor β that persists with a decay rate of 0.95 per quarter. Effectively, we are temporarily reducing the household's desire to consume today relative to tomorrow.

The rise in the discount factor requires a drop in the real interest rate to offset the impact on demand. Under fixed rates, the exchange rate constraint ties the hand of monetary policy. Under flexible rates, the central bank is free to respond, though reducing rates produces a

[11] Our assumption of perfect exchange rate pass through does give an edge to the floating rate regime for output stabilization. However, even with imperfect pass through, floating rates will dominate here due the moderation in domestic interest rate adjustment that they afford.

currency depreciation. Figure 3 shows the response of output and investment under the two different exchange rate regimes, again with and without the financial accelerator.

Overall, the results are broadly similar to the previous case. Output and investment drop considerably more under fixed rates. The financial accelerator mechanism plays a key role and has a quantitative effect roughly as large as before. One interesting additional result is that nearly all of the drop in investment under fixed exchange rates is due to the financial accelerator.

3.3.3 Unconditional Moments

To obtain a more precise measure of the interaction between the exchange rate regime and the financial accelerator, we compute the standard deviations of the ouput gap and inflation under the alternative scenarios, assuming that the shocks to the economy are random draws from a standard normal distribution. We consider both the foreign interest rate shock and the domestic demand shock, though one at a time. Each, further, is a first order univariate process, as described above.

Table 1 reports the results for the different cases (fixed versus flexible / with versus without financial accelerator). In each instance, the standard deviation is normalized by the standard deviation of output under a flexible exchange rate regime, absent the financial accelerator. Under either shock process, both output and inflation volatilily is highest in the fixed exchange rate regime. The difference in volatility across regimes, further, is significantly enhanced by the financial accelerator.

3.3.4 Foreign Denominated Debt

As we noted in the introduction, a number of authors have stressed the significance of having debt denominated in foreign currency[12]. Accordingly, we reconsider the shock to foreign interest rate, this time having foreign currency indexed debt. Figure 4 plots the response of output and investment under three different scenarios: flexible exchange rates with foreign currency denominated debt; flexible exchange rates with domestic currency denominated debt; and fixed exchange rates.

[12] In the presence of loans denominated in foreign currency, the entrepreneurial net wealth and the external finance premium equations are modified as follows:

$$V_t = \left(1 + r_t^k\right) \frac{Q_{t-1}}{P_{t-1}} K_t - \left[(1 + \chi(\cdot)) \left(1 + i_{t-1}^*\right) \frac{S_t}{S_{t-1}} \frac{P_{t-1}}{P_t} \right] \frac{B_{t-1}}{P_{t-1}}$$

and

$$E_t \left\{1 + r_{t+1}^k\right\} = (1 + \chi_t) E_t \left\{ (1 + i_t) \frac{P_t}{P_{t+1}} \right\}$$

since, ex-ante,

$$(1 + i_t) = (1 + i_t^*) \frac{S_{t+1}}{S_t}.$$

As one would expect, foreign currency debt makes the flexible exchange rate regime less attractive. Allowing for foreign currency debt nearly doubles the contraction in investment relative to the case of domestic currency debt. With foreign currency debt, the decline in the exchange rate reduces entrepreneurial net worth, thus enhancing the financial accelerator mechanism. Nonetheless, even in this instance, output volatility remains significantly lower under flexible rates than under fixed rates. Put differently, the impact of exchange rates on the balance sheets under flexible rates is less damaging than the contraction in asset prices under fixed rates.

As we noted, CCV obtain a similar result, but for different reasons. In CCV, because capital is fully depreciable, there is no fixed debt overhang. This mitigates the impact of a depreciation in the exchange rate on the domestic balance sheets. The impact of the depreciation on net export demand and firm cash flows more than offsets the effect on real indebtedness. Flexible rates dominate even though an asset price channel is not present. In our framework, however, the asset price channel is key. Since capital is non-depreciable, in the short term there is a non-variable component to borrowing needs. This raises firms' exposure to currency depreciations. In the absence of the asset price channel, flexible rates no longer clearly dominate fixed rates. To analyize this case, we consider the same experiment as before, but this time we shut off the impact of unanticipated shifts in the price of capital on the borrower net worth (see Figure 5). In this instance, there is a greater contraction in investment under flexible rates. The currency depreciation still produces a transitory rise in output under flexible rates due to the impact on export demand.[13] Over time, however, output contracts below its fixed rates path, owing to the relatively larger contraction in investment.

Accordingly, to the extent that market-based domestic asset values play a significant role in collateralizing lending, our analysis suggest that the flexible rate regime is less volatile, even if debts are denominated in foreign currency. For countries with capital markets that are not sufficiently developed to incorporate market value-based accounting and collateral, it might be possible to make a case for fixed rates. This scenario is unlikely to be relevant for most developed economies, but could be pertinent to some emerging market countries.

3.3.5 Uncertain Duration of the Fixed Exchange Rate Regimes

Finally, we turn to the hybrid case, where the exchange rate is initially fixed, but then abandoned probabilistically. We set the abandonment probability at $\Pi = 0.75$. Accordingly, conditional on being on the peg, the expected duration is $1/\Pi = 1/(0.75) = 1.25$ quarters. We then consider the response of the economy to a foreign interest rate shock under two different scenarios: "timely switch" where the central bank reverts to the flexible rate regime after one quarter; versus "late switch", where it does not shift until after three quarters

Figure 6 plots the response of output, investment, inflation and the external finance

[13]With imperfect exchange rate pass through, further, this transitory sharp rise in output under flexible rates would likely not arise.

premium. Even in the case of a timely switch after one quarter, there is a significant drop in output and investment. The reason is that the sharp rise in rates that occurs during the initial period (when the exchange rate is fixed) produces a sharp increase in the external finance premium (via the contraction in asset values.)

When the switch is delayed another two quarters, the drop in output and investment is greatly enhanced. The overall contraction is nearly as large as under fixed exchange rates (see Figure 1a) When the fixed exchange rate is abandoned after only one quarter, the economy experiences "good news" and asset values rise. The premium on external finance immediately drops and both investment and output recover rapidly. With the maintenance of the peg an additional two quarters, however, the economy effectively experiences a series of negative shocks to monetary policy, producing a sequence of unanticipated declines in asset values. The contraction in asset values, in turn, keeps the premium on external funds elevated. As a consequence, investment remain substantially below trend.

4 Concluding Remarks

Our principle finding is that financial accelerator effects are stronger under a fixed exchange rate regime than under a flexible exchange rate regime with a suitably managed monetary policy. Indeed, under fixed exchange rates, the interest rate adjusts in a way that magnifies the financial effects. Accordingly, from the standpoint of domestic stabilization, an operative financial accelerator raises the attractiveness of flexible exchange rates. The conclusion appears to hold even if debt is denominated in units of foreign currency, to the extent the market value of domestic assets plays an important role in collateralizing lending.

Could there be benefits to fixed exchange rates that offset the stabilization costs? The main rationale for fixed exchange rates is to provide a credible nominal anchor in the fight against inflation. As Obsteld and Rogoff [23] note, however, given that fixed exchange rate regimes never seem to last, it is not clear they can offer this credibility. Considerable recent research (e.g. Svensson [28], Mishkin [20]) suggests, further, that flexible inflation targeting under floating rates may provide a practical way to solve the credibility problem without having to suffer the bad side effects of domestic financial crises. As we noted, the Taylor rule 32 that generated superior performance under flexible rates is perfectly consistent with flexible inflation targeting. It is true that successful implementation of the Taylor rule requires that the overall economic infrastructure be sound, e.g. the domestic budget cannot be out of control, etc. These kinds of considerations, though, pose a dilemma for the adoption of any kind of monetary regime. Nonethess, we concede that a better understanding of how credibility considerations factor into the choice of monetary regimes is an important topic for future research.

How do these results apply to currency unions? If integration of monetary policy implies economic (and financial) integration, then a currency union may dominate a fixed exchange rate regime in terms of safeguarding financial stability. By economic integration in this context, we have in mind borrowers within the union hedging their financial positions against member country-specific risks. With borrowers hedged against regional risks, country-specific financial crises within the union may be less likely to occur.

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Table 1

Unconditional Standard Deviation of Output and Inflation

(normalized by output under Taylor rule with no fin. acc.)

		Taylor Rule		Fixed Exchange Rate	
		No FA	*With FA*	*No FA*	*With FA*
Shock:					
Foreign	σ_y	1.00	0.83	1.82	4.02
Interest Rate	σ_π	0.81	0.85	0.94	1.14
Domestic	σ_y	1.00	0.80	1.32	1.47
Interes rate	σ_π	0.66	0.55	0.83	0.97

FIGURE 1 A: FOREIGN INTEREST RATE SHOCK

FIXED VS. FLEXIBLE EXCHANGE RATE

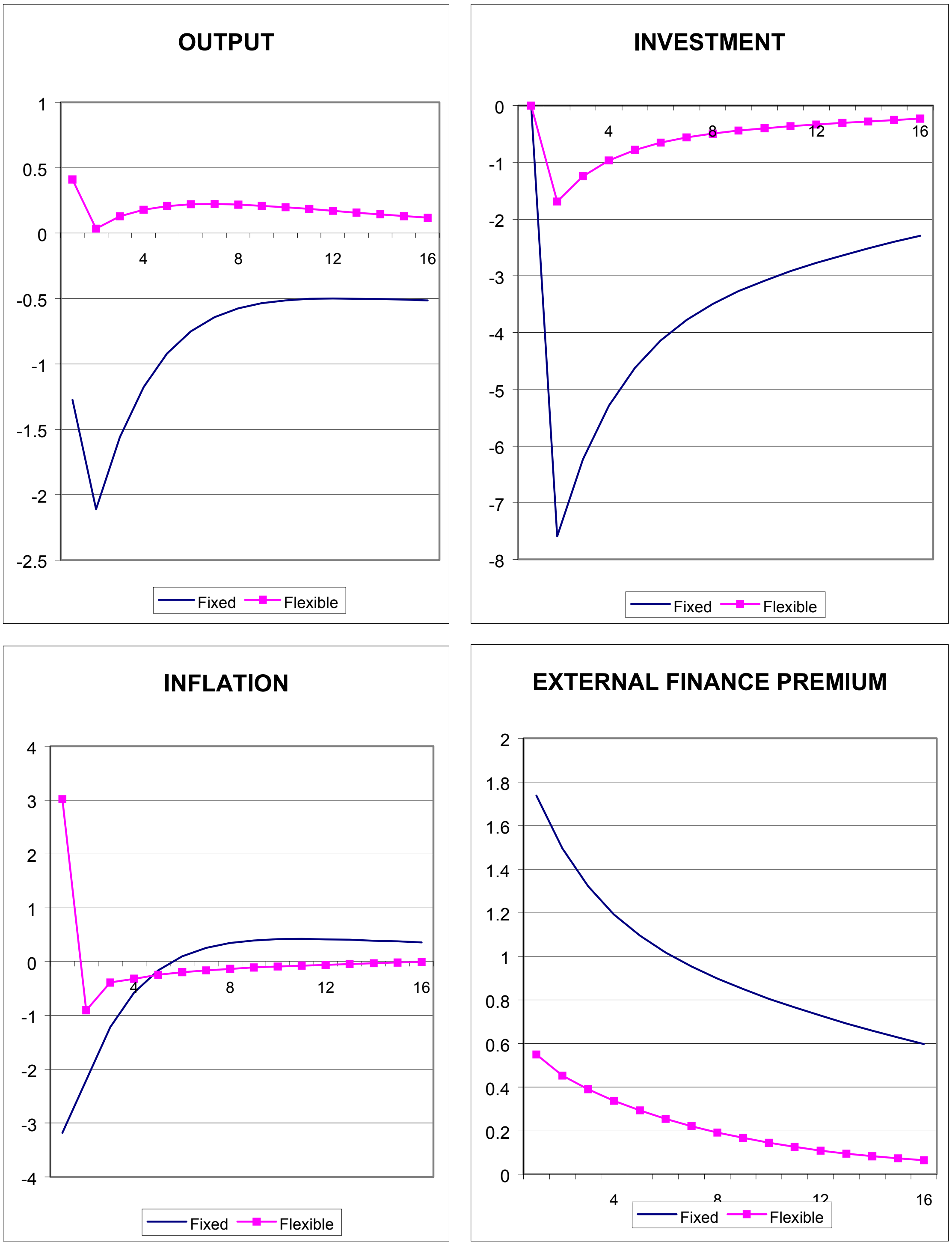


FIGURE 1 B: FOREIGN INTEREST RATE SHOCK

FIXED VS. FLEXIBLE EXCHANGE RATE (cont'd)

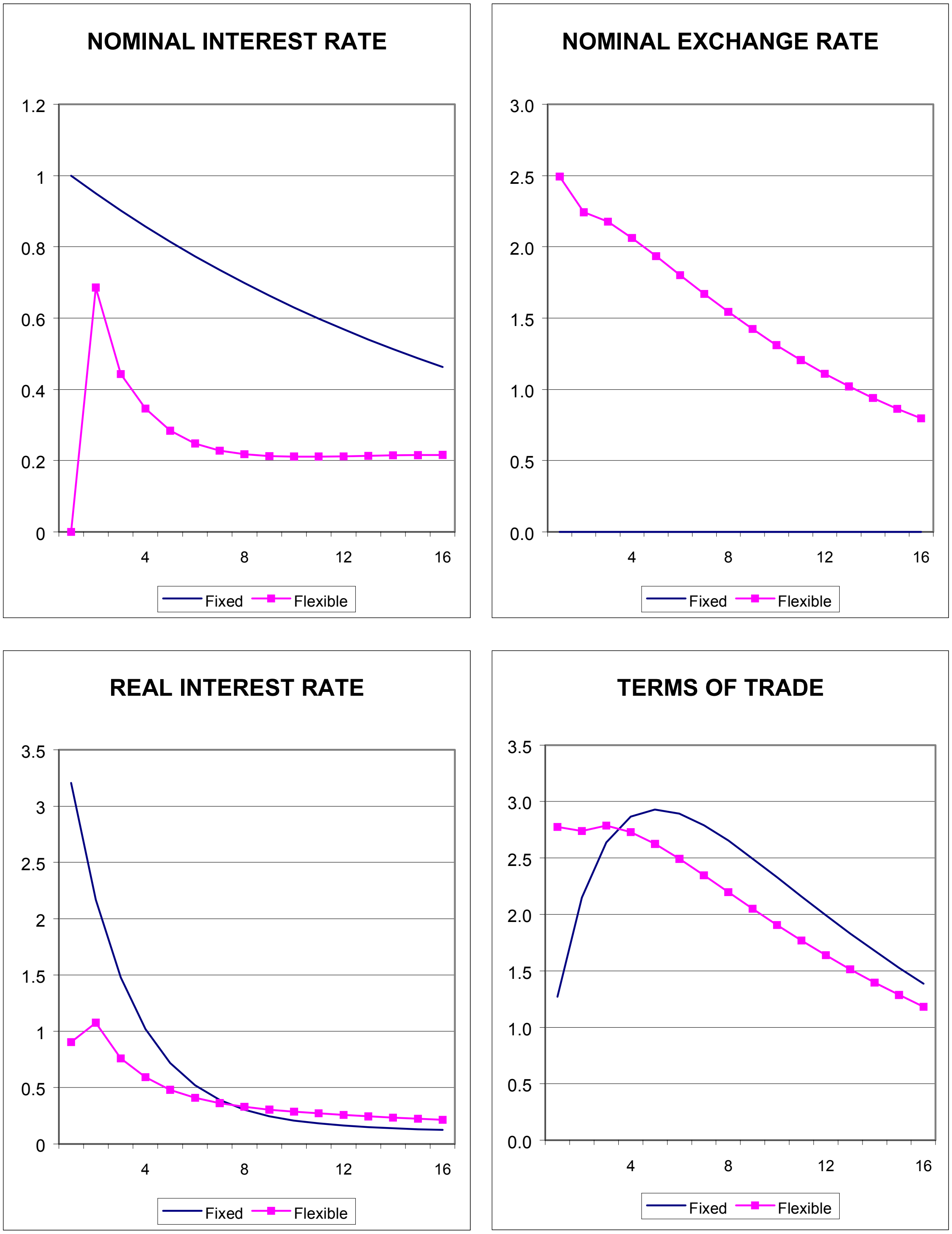


FIGURE 2: <u>FOREIGN INTEREST RATE SHOCK</u>

WITH VS. WITHOUT FINANCIAL ACCELERATOR

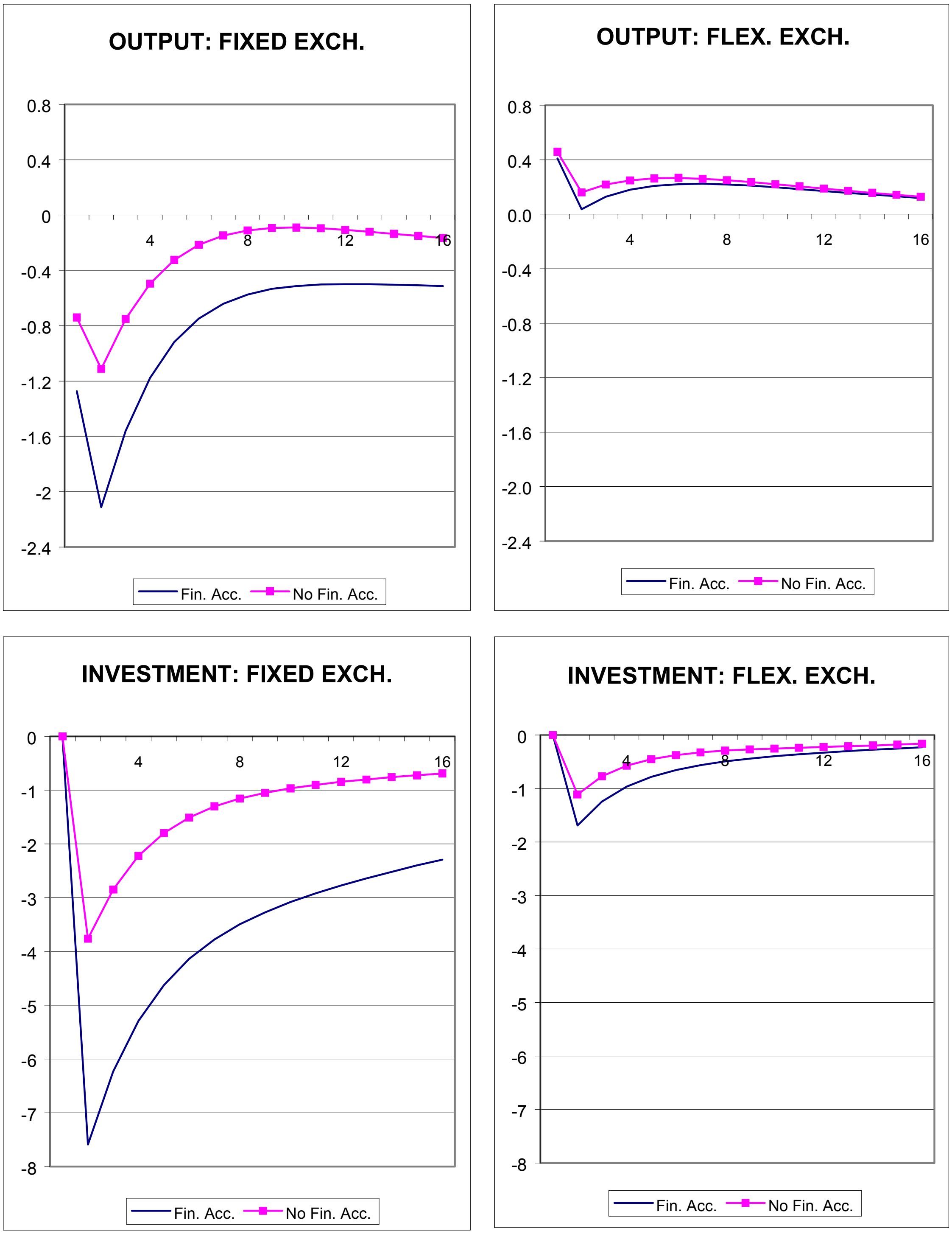


FIGURE 3: <u>DOMESTIC TASTE SHOCK</u>

FIXED VS. FLEXIBLE EXCHANGE RATE

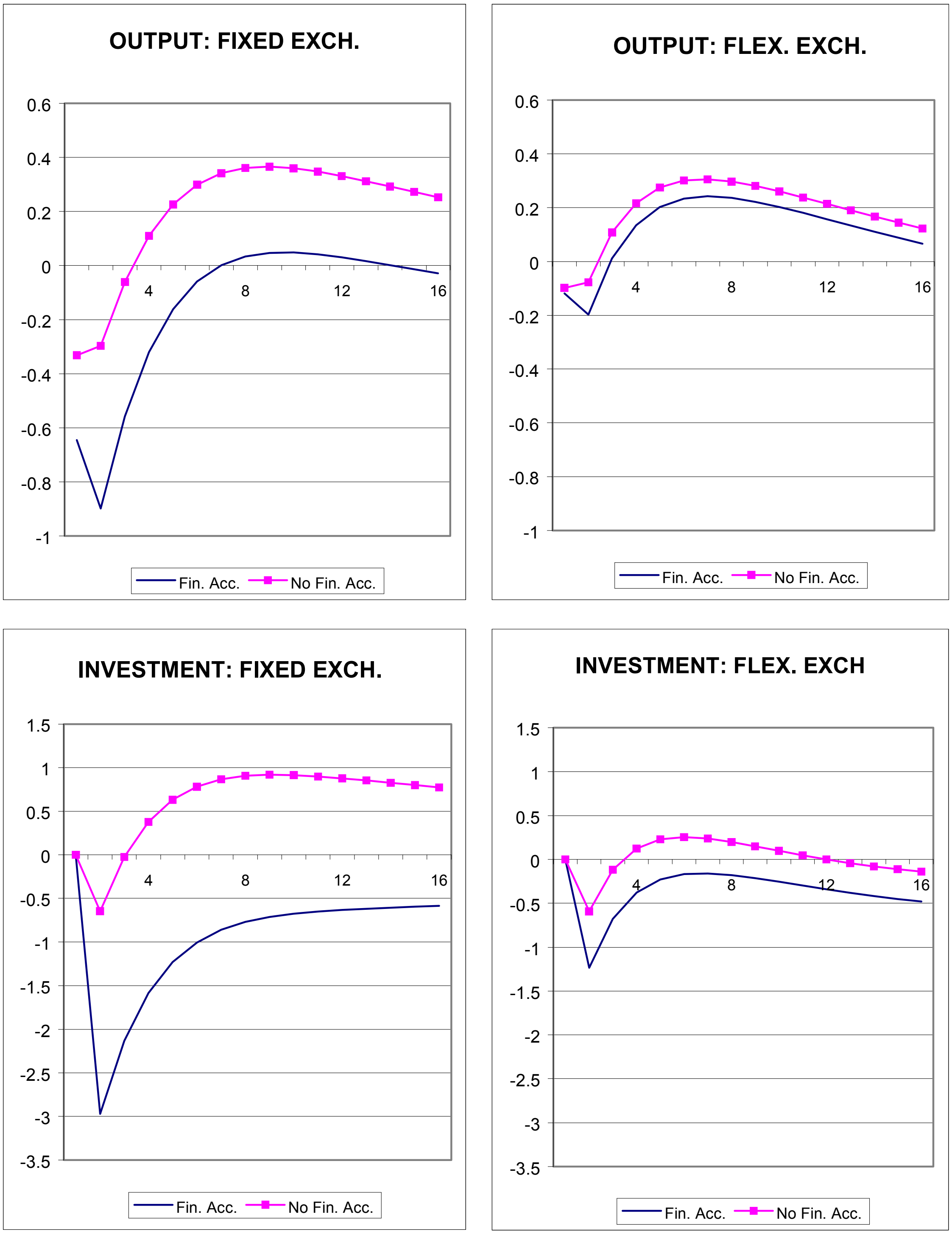
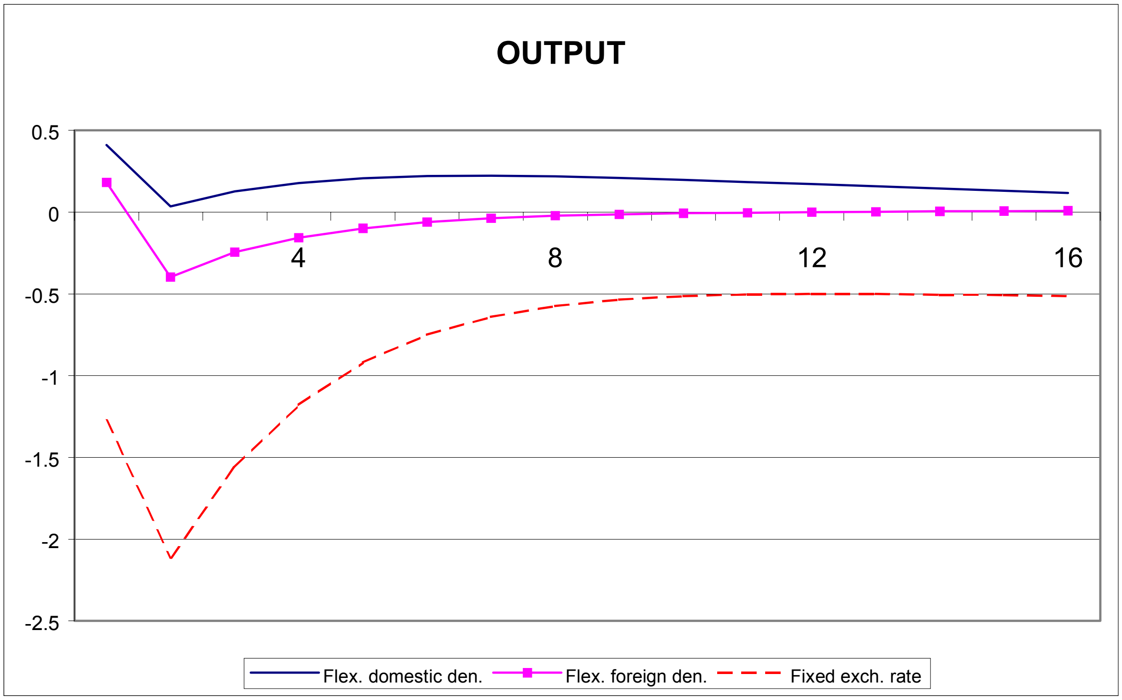


FIGURE 4: <u>FOREIGN INTEREST RATE SHOCK</u>

FLEXIBLE DOMESTIC VS. FLEXIBLE FOREIGN DENOMINATED VS. FIXED EXCHANGE RATE



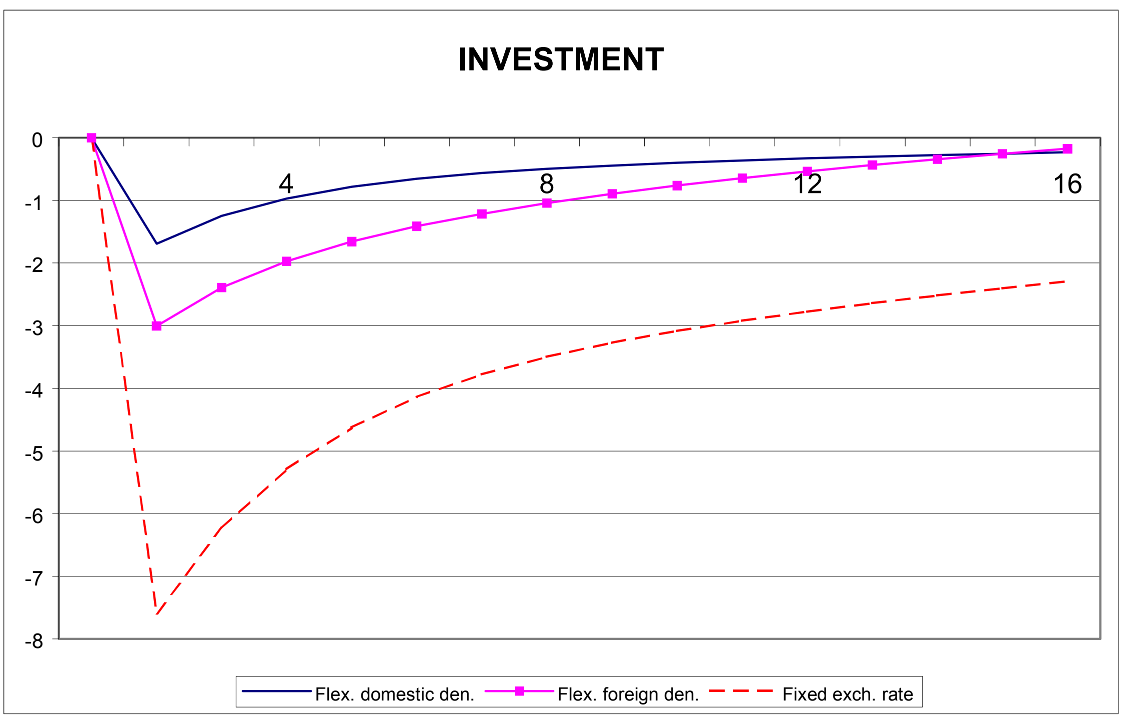
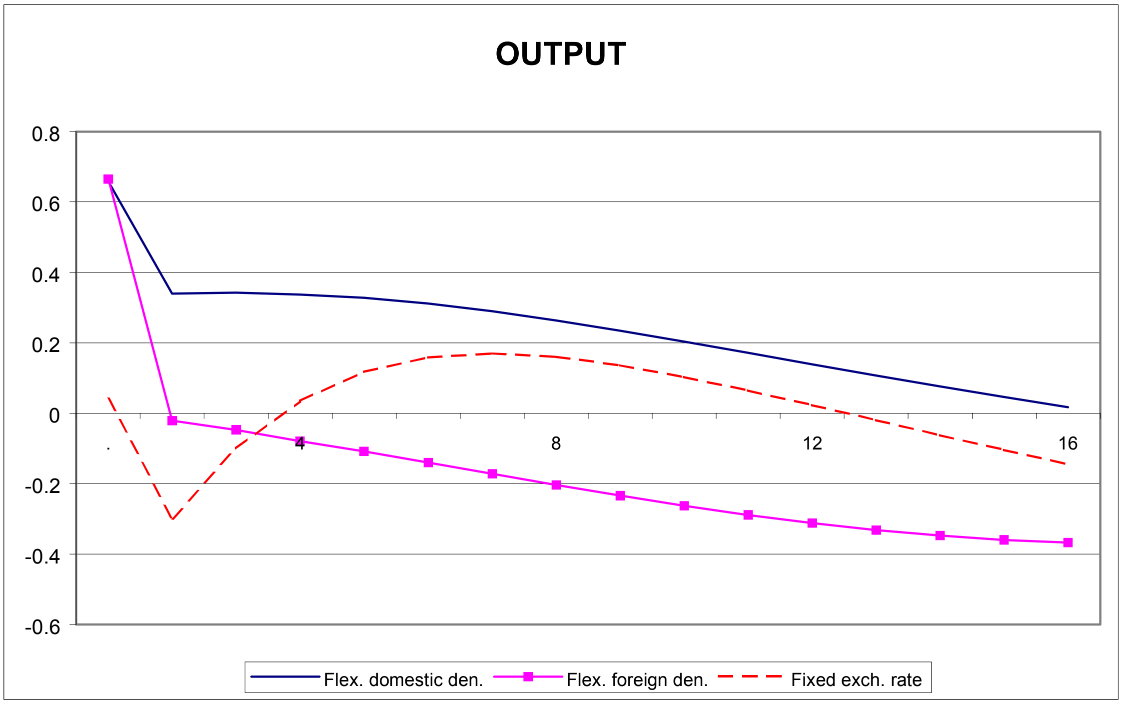


FIGURE 5: FOREIGN INTEREST RATE SHOCK

SHUTTING OFF THE ASSET PRICE CHANNEL



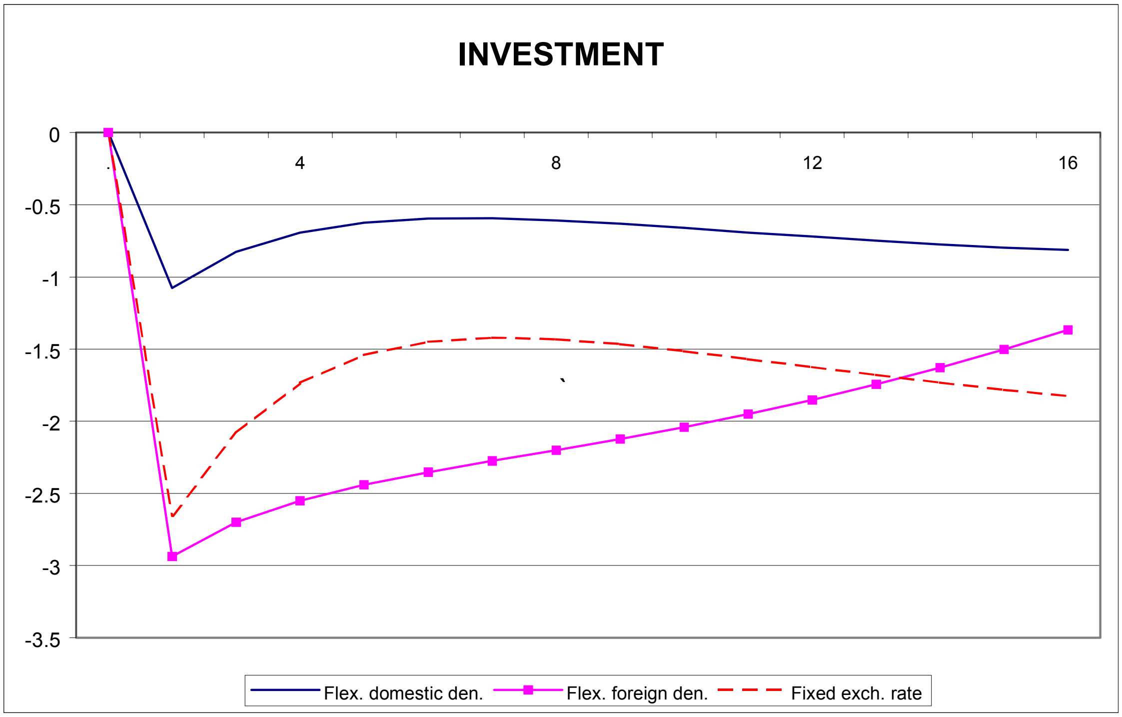


FIGURE 6: FOREIGN INTEREST RATE SHOCK

UNCERTAIN DURATION OF THE FIXED EXCHANGE RATE REGIME