External Constraints on Monetary Policy and the Financial Accelerator[1]

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Abstract

We develop a small open economy macroeconomic model where financial conditions influence aggregate behavior. We use this model to explore the connection between the exchange rate regime and financial distress. Fixed exchange rates are shown to exacerbate financial crises. Quantitative exercises calibrated to match the Korean experience during the recent Asian crisis are able to replicate key macroeconomic outcomes including the sharp increase in lending rates and the observed drop in output, investment and productivity during the 1997-1998 episode. These exercises imply that welfare losses following a financial crisis are significantly larger under fixed exchange rates relative to flexible exchange rates.

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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 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 [27] 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 the 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 [22] 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 [7] (hereafter BGG). We then consider the role of fixed versus flexible exchange rates in exacerbating a financial crisis. In the process, we quantify the role of the financial accelerator in explaining economic downturns during crisis episodes.

The core model is a new open economy macro model with money and nominal price rigidities (as in, e.g., Obstfeld and Rogoff [34]). 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 [28] 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, instead, limit this stabilizing option.

To understand the empirical relevance of the financial accelerator in crisis episodes, we use this model to conduct a quantitative exercise aimed at replicating the key features of the Korean experience during the Asian financial crisis of 1997-1998. We think the Korean episode is interesting because it is symptomatic of many financial crises that have occurred over time: the country experienced a sharp contraction in both output and productivity, along with a sharp deterioration in credit conditions, including falling asset prices and increasing credit spreads.[2] As well, in the process the country was attempting to defend a fixed exchange rate regime.

We model the financial crisis as the endogenous response to a large unanticipated increase in the country risk premium. With flexible exchange rates, the increase in the risk premium would be offset by a devaluation of the domestic currency. Such a devaluation would mitigate the effect on domestic interest rates, largely avoiding the contraction in asset values and investment spending that appears to drive the downturn during such episodes. With fixed exchange rates, the increase in the country risk premium causes an immediate rise in domestic interest rates which generates the financial collapse. As a consequence, asset prices plummet, external finance premia rise sharply and investment spending collapses.

Our quantitative exercise indicates that the financial accelerator in conjunction with fixed exchange rates can account for the 14 percent drop in economic activity experienced by Korea during the 1997-1998 episode. In contrast, in the absence of the financial accelerator mechanism, this same exercise accounts for only half of the measured drop in Korean output during this time period. Our model also captures the sharp rise in borrowing rates experienced by the private sector, and the collapse in Korean investment spending that ensued. By endogenizing capital utilization decisions, we are also able to capture the slowdown in measured labor-productivity experienced by the Korean economy during this period. Our demand-driven explanation for endogenous movements in labor productivity suggests that it is unlikely that supply-side technology stories play a strong role in explaining the economy's response to the financial crises.

Following the financial collapse, the Korean authorities abandoned the fixed exchange rate and let the currency devalue. We consider the potential benefits to such a policy by developing a hybrid model whereby the monetary authority is initially following a fixed exchange rate but abandons the peg with some positive probability following the external shock. Our modeling exercise indicates that a policy of an initial peg followed by abandon-

[2] Both Cole and Ohanian [20] and Chari, Kehoe and McGrattan [16] have emphasized declines in measured productivity as a robust feature of crisis episodes.

ment produces an initial contraction that is nearly as severe as the fixed-exchange rate policy itself. Abandoning the peg and allowing real interest rates to fall produces a rapid recovery however. Consistent with the Korean experience, in our model experiment, the primary channel through which the recover occurs is an increase in domestic investment owing to the positive effects that reduced real interest rates have on asset values and net worth, rather than an increase in exports owing to increased competitiveness following the devaluation.

The rest of the paper is organized as follows. Section 2 presents macroeconomic evidence on the Korean experience. Section 3 presents the model. In section 4 we conduct various policy experiments, including the exercise designed to capture key macroeconomic features of the Korean financial crisis. Section 5 provides concluding remarks.

2 The Korean Financial Crisis

The financial crisis that hit the Asian economies began in the summer of 1997. However, according to Krueger and Yoo [29], there was no evidence of a crisis in Korea until the final quarter of 1997, despite the fact that the Thai crisis started in June 1997, and the Indonesian crisis unfolded during the summer of that year. Although Korean off-shore banks held substantial quantities of dollar-denominated foreign loans from countries such as Indonesia and Russia, this was not widely understood, and it was not until October 1997 that S&P downgraded Korea's sovereign risk status. Capital flight began early in the fourth quarter of 1997, and reserves were depleted rapidly as Korea sought to defend its currency. Overnight call rates rose from 12 percent in July to 14 percent in November, and then jumped to 25 percent after Korea approached the IMF for assistance. The evidence suggests that capital outflows and the subsequent collapse in bank lending occurred for reasons that were largely exogenous to Korea's economic situation at the time. Nonetheless, the financial crisis had important effects on both real interest rates and real outcomes.

Figure 1 plots the real-side behavior of the Korean economy during this time period. Real GDP had been consistently above trend for several years before the crisis and showed no weakness until the fourth quarter of 1997. During the first quarter of 1998, real GDP fell 8 percent and subsequently contracted by another 6 percent, implying an overall contraction in real GDP of 14 percent from peak to trough during the crisis period. Real gross capital formation had been gradually weakening since the beginning of 1997 and then experienced a 40 percent contraction in the first quarter of 1998. Real gross capital formation fell another

10 percent in the subsequent two quarters. Real consumption spending tracked GDP during the downturn, falling by 14% in the first quarter of 1998 and 18 percent overall during the crisis period. Employment fell by somewhat less than GDP – 8 percent from peak to trough, implying a 6 percent reduction in labor productivity, as measured by GDP per worker. Using electricity consumption as a proxy for capital services, the drop in labor productivity is associated with a sharp reduction in capital utilization over this time period.[3]

Figure 2 plots the behavior of various financial variables, including the call rate, the exchange rate, the corporate-treasury spread and the EMBI spread which may be viewed as a measure of the country risk premium. The country risk premium as measured by the EMBI jumped from 100 basis points to 600 basis points in a two month period following the onset of the crisis.[4] The corporate-treasury bond spread rose nine percentage points in response. Monetary policy was conducted in such a way as to first defend the exchange rate, and later abandon the peg in favor of flexible rates. This policy led to a 12 percentage point rise in the overnight call rate in the final quarter of 1997, followed by a gradual reduction in interest rates throughout the next year. It is reasonable to believe that prior expectations regarding the probability that Korea would abandon the fixed exchange rate were low. Once the Bank of Korea failed in its attempt to defend the won, the currency depreciated by 40 percent. Inflation, which was averageing 4 percent before the crisis, increased 5 percentage points in the first quarter of 1998 as import prices rose sharply following the devaluation. The overall reductioin in economic activity led to a sharp contraction in inflation however. By the first quarter of 1999, inflation had fallen to 0.5 percent, well below its pre-crisis level. The stock market, which had been trending downward prior to the crisis, lost 200 points, or a third of its value, in the immediate aftermath of the crisis. Following a brief rally, stock prices lost another 100 points before beginning a recovery in the second quarter of 1998.

Figure 3 plots the foreign sector of the Korean economy. The 40 percent decline in the real exchange rate led to a 15 percent increase in net exports. Nearly all of this increase in net exports is attributable to the 40 percent decline in imports rather than an expansion in exports however. Thus it appears that the competitiveness effect of the devaluation had at

[3]If energy and capital services enter the production function as perfect complements owing to a Leontief technology, electricity is a perfect measure for capital utilization. Econometric estimates imply a very low degree of substitutability between capital and energy especially in the short-run, making electricty a very good proxy even in the absence of perfect complementarity.

[4]The country risk spread also rose sharply following the Russian crisis. This had very little effect on the Korean economy however. By this time, the Korean monetary authority had abandoned the fixed exchange rate.

best, only a modest expansionary effect on the economy. This in part reflects the fact that many of Korean's Asian trading partners were also suffering from the crisis environment. It also reflects the fact that the Korean economy was unable to grow its way out of the recession by exporting more goods to economically stable trading partners such as the U.S and Europe.

For modeling purposes, we take away the following implications from the Korean experience: the 5 percent rise in the country risk premium that occurred in the fourth quarter of 1997 arguably occurred for reasons that were exogenous to the existing macroeconomic conditions in Korea; the Bank of Korea initially followed a fixed exchange rate policy (with some drift) and then abandoned the policy after the crisis had begun to unfold; the sharp rise in domestic interest rates led to an immediate and large contraction in real GDP, investment spending, and labor productivity, and a sharp increase in loan rate spreads. The subsequent devaluation led to a rise in inflation and a significant reduction in imports but only a modest expansion in exports.

Explaining the measured contraction in Korean real GDP as the endogenous response to an increase in the country risk premium requires a substantial amplification mechanism relative to the standard open economy New Keynesian model. In the next section, we outline the open economy version of the BGG model, which naturally provides such an amplification device. We then consider the ability of this model to quantitatively account for various features of the 1997-1998 Korean crisis.

3 The Model

We consider a small open economy framework with money and nominal price rigidities, along the lines of Obstfeld and Rogoff [34], Svensson [38], Gali and Monacelli [25], Chari, Kehoe and McGrattan [15], 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 build new capital. Finally, retailers package together wholesale goods to produce final output. They are 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.

3.1 Households

3.1.1 Consumption Composites

Let C_t be a composite of household tradable consumption goods. Then the following CES index defines household preferences over home consumption, C_t^H, and foreign 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 (CPI), P_t is given by

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

The 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 (3.3.3) below.

3.1.2 The Household's Decision Problem

Household preferences are given by

$$E_0 \sum_{t=0}^{\infty} \beta^t U \left(C_t, L_t, \frac{M_t}{P_t} \right) \tag{3}$$

with

$$\begin{aligned} U \left(C_t, L_t, \frac{M_t}{P_t} \right) &= \frac{\left[(C_t)^{1-\varsigma} (1-L_t)^{\varsigma} \right]^{1-\sigma}}{1-\sigma} + \log \left(\frac{M_t}{P_t} \right) \\ \sigma &\geq 0, \ \varsigma \in (0,1) . \end{aligned} \tag{4}$$

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

$$C_t = \frac{W_t}{P_t} L_t + \Pi_t - T_t - \frac{M_t - M_{t-1}}{P_t} - \frac{B_{t+1} - (1+i_{t-1}) B_t}{P_t} - \frac{S_t B^*_{t+1} - S_t \left(1+i^*_{t-1}\right) B^*_t}{P_t} \quad (5)$$

The household maximizes (3) subject to (5).

3.1.3 Consumption Allocation, Labor Supply, and Saving

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

consumption allocation

$$\frac{C^H_t}{C^F_t} = \frac{\gamma}{1-\gamma} \left(\frac{P^H_t}{P^F_t}\right)^{-\rho}; \quad (6)$$

labor allocation

$$(1-\varsigma) \frac{1}{C_t} \frac{W_t}{P_t} = \varsigma \frac{1}{1-L_t}; \quad (7)$$

consumption/saving

$$\lambda_t = \beta E_t \left\{ \lambda_{t+1} (1+i_t) \frac{P_t}{P_{t+1}} \right\}; \quad (8)$$

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

$$\lambda_t = (1-\varsigma) \left(C_t\right)^{(\sigma-1)(\varsigma-1)-1} \left(1-L_t\right)^{\varsigma(1-\sigma)} \quad (9)$$

and $(1+i_t)\frac{P_t}{P_{t+1}}$ denotes 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 [17])

3.1.4 International Arbitage

Given frictionless international trade in bonds, the uncovered interest parity condition holds as follows:[5]

$$E_t\left\{\lambda_{t+1}\frac{P_t}{P_{t+1}}\left[(1+i_t)-(1+i_t^*)\frac{S_{t+1}}{S_t}\right]\right\}=0 \tag{10}$$

We distinguish between the wholesale (import) price of foreign goods and their retail price in the domestic market by allowing for imperfect competition and pricing to market in the local economy (see section 3.3.3). At the wholesale level, before pricing to market considerations, the law of one price holds. Let $P_{W,t}^F$ denote the wholesale price of foreign goods in domestic currency, and P_t^{F*} the foreign currency price of such goods, which is taken as exogenous. The law of one price then implies:

$$P_{W,t}^F = S_t P_t^{F*} \tag{11}$$

3.2 Foreign Behavior

We take as exogenous both the gross foreign nominal interest rate[6] $(1+i_t^*)$ 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

$$C_t^{H^*}=\left[\left(\frac{P_t^{H*}}{P_t^*}\right)^{-\varkappa}Y_t^*\right]^{\omega}\left(C_{t-1}^{H^*}\right)^{1-\omega},\ 0\leq\omega\leq 1 \tag{12}$$

where Y_t^* is real foreign output, which we take as given. The term $\left(C_{t-1}^{H^*}\right)^{(1-\omega)}$ represents inertia in foreign demand for domestic products.

3.3 Firms

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

[5] 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.

[6] Because we do not assume complete international markets for sharing of consumption risk, the stock of net foreign indebtedness may be non-stationary. To address this issue, we follow Schmitt-Grohe and Uribe [36] 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 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.

3.3.1 Entrepreneurs, Finance, and Wholesale Production

Entrepreneurs manage production and obtain financing for the capital employed in the production 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. Accordingly, the expected horizon is $\frac{1}{1-\phi}$. The entrepreneurs' population is stationary, with new entrepreneurs entering to replace those who exit. 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. To provide endogenous movements in measured total factor productivity, we introduce variable capital utilization. Let u_t denote the utilization rate of capital and $(u_t K_t)$ denote capital services. Then the production technology is given by

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

Given the capital stock K_t, which is pre-determined within the period, entrepreneurs hire labor and decide on the optimal utilization rate u_t to maximize profits. Labor demand satisfies

$$(1-\alpha)\frac{Y_t}{L_t} = \frac{W_t}{P_{W,t}} \tag{14}$$

where $P_{W,t}$ is the nominal price of domestic wholesale output. We endogenize the utilization decision by assuming that increases in the utilization rate of capital are costly owing to faster depreciation rates (Greenwood, Hercowitz and Huffman [26]). We adopt the formulation of Baxter and Farr [5] and assume the following convex cost function for depreciation:

$$\delta\left(u_t\right) = \delta + \frac{b}{1+\xi}\left(u_t\right)^{1+\xi} \quad \text{with} \quad \delta, b, \xi > 0. \tag{15}$$

The optimality condition for capital utilization is

$$\alpha\frac{Y_t}{u_t} = \delta'\left(u_t\right) K_t \frac{P_{I,t}}{P_{W,t}} \tag{16}$$

where $P_{I,t}$ denotes the price of new investment goods, defined below. Equation (16) equates the marginal value of the output gain from a higher rate of utilization with its marginal cost owing to a higher rate of capital depreciation.

At the end of each period t, entrepreneurs purchase capital which can be used in the subsequent period $t+1$ to produce output at that time. Entrepreneurs finance the acquisition of capital partly with their own net worth available at the end of period t, 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 capital financing is divided between net worth and debt, as follows:

$$\frac{Q_t}{P_t}K_{t+1} = N_{t+1} + \frac{B_{t+1}}{P_t}. \tag{17}$$

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.[7] Finally, we assume for the time being that debt is denominated in units of domestic currency. Later we will consider the case where debt is issued in foreign currency units.

The entrepreneur's demand for capital depends on the expected marginal return and the expected marginal financing cost. As specified below, we assume that the price of capital reflects aggregate adjustment costs born by the capital-producing sector. We assume, however, that such adjustment costs apply to net rather than gross capital. To formulate such a specification, we therefore assume that entrepreneurs pay the "wear and tear" costs associated with capital use, before selling it on the market.

Accordingly, given the production technology, a unit of capital acquired at t and used at $t+1$ yields the expected gross return

$$E_t\left\{1 + r^k_{t+1}\right\} = E_t\left\{\frac{\frac{P_{W,t+1}}{P_{t+1}}\left(\alpha\frac{Y_{t+1}}{K_{t+1}}\right) + \frac{Q_{t+1}}{P_{t+1}} - \delta(u_{t+1})\frac{P_{I,t+1}}{P_{t+1}}}{\frac{Q_t}{P_t}}\right\} \tag{18}$$

where $\left(\alpha\frac{Y_{t+1}}{K_{t+1}}\right)$ is the marginal product of capital, $\frac{Q_t}{P_t}$ is the relative price of capital, and $\delta(u_{t+1})$ is the depreciation rate 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 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

[7] 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.

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, $\chi_t(\cdot)$, 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 optimality condition

$$E_t\left\{1+r_{t+1}^k\right\} = (1+\chi_t(\cdot))E_t\left\{(1+i_t)\frac{P_t}{P_{t+1}}\right\} \tag{19}$$

with

$$\begin{aligned} \chi_t(\cdot) &= \chi\left(\frac{\frac{B_{t+1}}{P_t}}{N_{t+1}}\right) \\ \chi'(\cdot) &> 0,\ \chi(0)=0,\ \chi(\infty)=\infty \end{aligned} \tag{20}$$

and where $E_t\{(1+i_t)\frac{P_t}{P_{t+1}}\}$ is the gross cost of funds absent capital market frictions.[8]

We interpret equation (19) 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).[9] We note, however, that the general form relating external finance costs to financial positions arises across a broad class of agency problems.

Equation (19) provides the foundation for the financial accelerator. It links movements in the borrower's financial position 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

[8] We do not allow the debt contract to be conditioned on aggregate risk. If entrepreneurs and households had identical 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.

[9] To parametrize $\chi(\cdot)$ in the simulation exercises that follow, we assume a costly state verification problem of the type analyzed by Townsend [40], where lenders must pay a fixed auditing cost to observe the ex-post realization of entrepreneurs' output. See BGG for details.

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 [28] theory of credit cycles. We add that though we have described equation (19) 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.[10]

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 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:

$$N_{t+1} = \phi V_t + (1-\phi) D_t \tag{21}$$

where V_t is given by

$$V_t = \left(1 + r_t^k\right) \frac{Q_{t-1}}{P_{t-1}} K_t - \left[\left(1 + \chi(\cdot)\right)\left(1 + i_{t-1}\right) \frac{P_{t-1}}{P_t}\right] \frac{B_t}{P_{t-1}} \tag{22}$$

$(1 + r_t^k)$ 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 (21) and (22) 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 unpredictable 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 - we explore this possibility later.

Entrepreneurs going out of business at time t consume and transfer some funds to new entrepreneurs out of the residual equity, $(1-\phi)V_t$. We assume that entrepreneurs have

[10]Following Carlstrom and Fuerst [13], 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. This allows to express $\chi(\cdot)$ in terms of the aggregate leverage ratio.

preferences over domestic and foreign goods that are identical to the households' preferences specified in equation (1). Let C_t^e denote the amount of the consumption composite consumed by the entrepreneurial sector. The optimal mix of foreign and domestic tradable goods for entrepreneurial consumption satisfies an equation analagous to equation (6). Let D_t denote the transfer to new entrepreneurs. Since the costs of pure debt finance are infinite (see equation (20)), 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. Under these assumptions, entrepreneurial consumption satisifies

$$C_t^e = (1-\phi)(V_t - D_t) \tag{23}$$

3.3.2 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 replace depreciated capital and produce new capital. Investment is assumed to be a composite of domestic and foreign final goods:

$$I_t = \left[(\gamma_i)^{\frac{1}{\rho_i}} \left(I_t^H \right)^{\frac{\rho_i - 1}{\rho_i}} + (1-\gamma_i)^{\frac{1}{\rho_i}} \left(I_t^F \right)^{\frac{\rho_i - 1}{\rho_i}} \right]^{\frac{\rho_i}{\rho_i - 1}} \tag{24}$$

The production parameter γ_i measures the relative weight that domestic and foreign inputs receive in the investment composite. Capital producers choose the optimal mix of foreign and domestic inputs according to the intra-temporal first-order-condition

$$\frac{I_t^H}{I_t^F} = \frac{\gamma_i}{1-\gamma_i} \left(\frac{P_t^H}{P_t^F} \right)^{-\rho_i} \tag{25}$$

Owing to adjustment costs, I_t units of the investment composite yields $\Phi(\frac{I_t}{K_t} - \delta(u_t))K_t$ units of new capital goods (net investment). We assume that $\Phi(\frac{I_t}{K_t} - \delta(u_t))$ is increasing and concave.[11] 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. Since adjustment costs only apply to the net increase in the capital stock, capital accumulation satisfies

$$K_{t+1} = K_t + \Phi(\frac{I_t}{K_t} - \delta(u_t))K_t \tag{26}$$

[11] By assuming adjustment costs to new capital goods, our model may be viewed as a two-sector model whose endogenous movements in capital good prices may have important implications for the one-sector business cycle accounting frameworks employed by Chari, Kehoe and McGrattan [16] and Cole and Ohanian [20] to explain the Great Depression.

where gross investment is defined as $\Phi(\frac{I_t}{K_t} - \delta(u_t))K_t + \delta(u_t)K_t$.

Let

$$P_{I,t} = \left[(\gamma_i)\left(P_t^H\right)^{1-\rho_i} + (1-\gamma_i)\left(P_t^F\right)^{1-\rho_i}\right]^{\frac{1}{1-\rho_i}} \tag{27}$$

denote the investment good price index. It is straightforward to show that capital producers plan net investments to satisfy

$$E_{t-1}\left\{\frac{Q_t}{P_{I,t}} - \left[\Phi'\left(\frac{I_t}{K_t} - \delta(u_t)\right)^{-1}\right]\right\} = 0. \tag{28}$$

Equation (28) 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, variations in asset prices will affect entrepreneurial balance sheets, and hence, the cost of capital.

3.3.3 Retailers, Price Setting, and Inflation

We assume there is a continuum of monopolistically competitive retailers of measure unity. Retailers buy wholesale goods from entrepreneurs/producers in a competitive manner and then differentiate the product slightly (e.g., by painting it or adding a brand name) at a fixed resource cost. We model the fixed (from the retailer's point of view) resource cost, κ. We assume that the fixed cost κ represents distribution and selling costs that are assumed to be proportional to the steady-state value of wholesale output. We choose the level of the fixed costs so that profits to the wholesale sector are zero in steady-state.

Let $Y_t^H(z)$ be the good sold by retailer z. Final domestic output is a CES composite of individual retail goods:

$$Y_t^H = \left[\int_0^1 Y_t^H(z)^{\frac{\vartheta-1}{\vartheta}} dz\right]^{\frac{\vartheta}{\vartheta-1}} - \kappa \tag{29}$$

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

$$P_t^H = \left[\int_0^1 P_t^H(z)^{1-\vartheta} dz\right]^{\frac{1}{1-\vartheta}} \tag{30}$$

Domestic households, capital producers, the 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, $\frac{P_{W,t}}{P_t^H}$.

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 [12]: 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 $\overline{P}_t^H$. It can be shown that, in the neighborhood of the steady state, the domestic price index evolves according to

$$P_t^H = (P_{t-1}^H)^{\theta}(\overline{P}_t^H)^{1-\theta}. \tag{31}$$

Retailers free to adjust choose prices to maximize expected discounted profits, subject to the constraint on the frequency of price adjustments.[12] Here we simply observe that, within a local neighborhood of the steady state, the optimal price is

$$\overline{P}_t^H = \mu \prod_{i=0}^{\infty} (P_{W,t+i})^{(1-\beta\theta)(\beta\theta)^i} \tag{32}$$

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 (32) would simply imply $\overline{P}_t^H = \mu P_{W,t}$, i.e., the retail price would simply be a proportionate markup over the wholesale price. However, because their prices 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 (31) and (32) yields an expression for the gross domestic inflation rate (within the neighborhood of a zero-inflation steady state):

$$\frac{P_t^H}{P_{t-1}^H} = \left(\mu \frac{P_{W,t}}{P_t^H}\right)^{\lambda} E_t \left\{ \frac{P_{t+1}^H}{P_t^H} \right\}^{\beta} \tag{33}$$

where the parameter $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$ is decreasing in θ, the measure of price rigidity. Equation (33) is the canonical form of the new optimization-based Phillips curve that arises from an

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

environment of time-dependent staggered price setting (see, e.g., Gali and Gertler [24]). The curve relates inflation to movements in real marginal cost and expected inflation.

Similarly, foreign goods sold in the local economy are subject to an analogous mark-up over the wholesale price owing to imperfect competition. We assume that retailers of foreign goods face the marginal cost $P^F_{W,t}$ - see equation 11 - and set prices according to a Calvo-style price setting equation. Let $1-\theta^f$ denote the probability that a retailer of foreign goods resets its price in any given period. The inflation rate for foreign goods satisfies

$$\frac{P^F_t}{P^F_{t-1}} = \left(\mu^f \frac{S_t P^{F*}_t}{P^F_t}\right)^{\lambda_f} E_t \left\{ \frac{P^F_{t+1}}{P^F_t} \right\}^{\beta} \tag{34}$$

where $\lambda_f = \frac{(1-\theta^f)(1-\beta\theta^f)}{\theta^f}$. This specification of the pricing process for domestically-sold foreign goods implies temporary deviations from the law of one price owing to delay in the exchange-rate pass through mechanism.[13] The coefficient θ^f captures the degree of this delay. When calibrating the model, we assume that retailers of domestic and foreign goods face the same degree of price rigidity, so that $\theta^f = \theta$.[14]

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

$$\frac{P_t}{P_{t-1}} = \left(\frac{P^H_t}{P^H_{t-1}}\right)^{\gamma} \left(\frac{P^F_t}{P^F_{t-1}}\right)^{(1-\gamma)}. \tag{35}$$

3.4 Resource Constraints

The resource constraint for the domestic traded good sector is

$$Y^H_t = C^H_t + C^{eH}_t + C^{H*}_t + I^H_t + G^H_t \tag{36}$$

where G^H_t is government consumption and C^{eH}_t is entrepreneurial consumption of the domestic good.

[13] Chari, Kehoe and McGrattan [15] also consider pricing-to-market specifications to explore the role of nominal rigidities in explaining exchange rate dynamics.

[14] Since foreign prices are exogenous, we can assume, without loss of generality, that the steady-state markup $\mu^f = \mu$.

3.5 Government Budget Constraint

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

$$\frac{P_t^H}{P_t}G_t^H = \frac{M_t - M_{t-1}}{P_t} + T_t. \tag{37}$$

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

Except for the description of monetary policy, we have completed the specification of the model. The distinctive aspect is the financial accelerator, characterized by just two equations: (19) and (21). 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 (19), 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.

3.6 Fixed versus Flexible Exchange Rate Regimes

In the quantitative analysis discussed in the next section, we consider 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.

$$S_t = \overline{S}, \ \forall t \tag{38}$$

To do so, the central bank sets the nominal interest rate to satisfy the uncovered interest parity condition, given by equation (10).

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 interest rate adjust to deviations of CPI inflation and domestic output from their respective target values.

Let Y_t^0 denote the output target level, which we take to be the level that would arise if prices were perfectly flexible. The feedback rule, accordingly, is given by

$$(1+i_t) = (1+rr^{ss}) \left(\frac{P_t}{P_{t-1}} \right)^{\gamma_\pi} \left(\frac{Y_t^H}{Y_t^0} \right)^{\gamma_y} \tag{39}$$

with $\gamma_\pi > 1$ and $\gamma_y > 0$, and where rr^{ss} is the steady state real interest rate. For simplicity, we take the target gross inflation rate to be unity.[15] We interpret this rule as being a form of flexible inflation targeting, in the sense of Bernanke et al. [8]. 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 (39).

3.7 Model Parametrization

Our quantitative analysis is meant to capture the broad features of an emerging market economy such as South Korea for which financial frictions and financial crises seem most relevant. We assume that capital markets are somewhat less developed relative to the U.S.; in this respect, we fix parameters to generate a steady state external finance premium that is about 3.5 percent, a number that is roughly 150 basis points higher than what U.S. data suggest. Also in line with the Korean experience relative to the U.S., we set the leverage ratio 50 percent higher than the historical U.S. average.

In addition to having less-developed financial markets, the Korean economy has a much higher capital share than the U.S economy, and is considerably more open. To match these characteristics, we set the capital share, α, at 0.5, and the steady state ratio of exports to domestic output at 0.4. For the remaining parameters, we use reasonably standard values.

[15] 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.

3.7.1 Preferences

We set the quarterly discount factor β equal to 0.99. We set the elasticity of intertemporal substitution $\frac{1}{\sigma}$ equal to $\frac{1}{5}$. Intra-temporal elasticities of substitutions are $\rho_h = \rho_e = 1$ and $\rho_i = 0.25$. These parameters imply unit elasticity of substitution between domestic and foreign consumption goods and a substantially lower elastisicity of substitution for investment goods. We assume that the share of foreign goods in the consumption and investment composites is 0.5. Finally, we set the elasticity of labor supply equal to 2 and average hours worked relative to total hours available equal to $\frac{1}{3}$.

With regard to the parameters of the export demand 12, we set the elasticity $\varkappa$ equal to 1 and the share parameter ω equal to 0.25. This implies a relatively high degree of inertia in export demand, in line with the response of Korean exports during the 1997-1998 crisis.

3.7.2 Technology

Steady-state utilization rate is set to unity and steady-state quarterly depreciation, $\delta(u_{ss})$, is assigned the conventional value of 0.025. The elasticity of marginal depreciation $\delta'(u)$ with respect to utilization rate is set at 1, consistent with Baxter and Farr [5] who rely on estimates provided by Basu and Kimball [3]. The steady state mark-up value, μ, is set at 1.2. Consistent with the retail sector earning zero profits in steady-state, fixed costs in the retail sector are assumed to be 20 percent of wholesale output. The elasticity of the price of capital with respect to the investment-capital ratio is taken to be 2. As it is common in the literature on the Calvo [12] pricing technology, we assume the probability of the price not adjusting, θ, to be 0.75.

3.7.3 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) of about 350 annual basis points; (ii) an annualized business failure rate of around 6 percent; and (iii) a leverage ratio roughly equal to 1.2.

3.7.4 Government Policy

In the open economy version of the Taylor rule, we set the coefficients on inflation, γ_π, and domestic output gap, γ_y, equal to 2, and 0.75, respectively. These coefficients provide a reasonable approximation to the real interest rate response of the Korean economy following abandonment of the real exchange rate. We also take the steady state government expenditure ratio, $\frac{G^H}{Y^H}$, to be 0.2.

4 External Shocks and Financial Crises: a Quantitative Assessment.

In this section we consider the response of the model to external shocks. We begin by displaying the response to a persistent one percentage point rise in foreign interest rates. In order to highlight the various model mechanisms, we consider the effect of this shock under alternative scenarios: fixed versus flexible exchange rates, and with versus without the financial accelerator. For robustness, we also explore how the results are affected when debt is denominated in units of foreign currency. We then turn to the quantitative exercise aimed at replicating the Korean experience during the 1997-1998 crisis period. This latter exercise considers two alternative policy scenarios: fixed exchange rates and a policy of abandoning the fixed exchange rate after the shock occurs.

4.1 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 auto-correlation process that persists at the rate of 0.95 per quarter. Figures 4A and 4B plot the response of twelve key variables under fixed versus floating rates.[16]

Under the fixed exchange rate regime, the domestic nominal interest rate rises to match the foreign rate. Due to 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 induces a contraction in asset prices, which raises

[16] We have also alternative experiments such as shocks to foreign demand. These experiments yield very similar conclusion regarding the effect of fixed versus flexible exchange rates in the presence of the financial accelerator.

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 interest rate is no longer tied to the foreign interest rate, and is instead governed by the feedback rule, equation (39). The rise in the foreign interest rate produces an immediate depreciation of the domestic currency, which in turn prompts an increase in exports and a sharp rise in CPI inflation. The central bank raises the nominal interest rate to fight inflation, according to the feedback rule. This monetary policy implies only a modest increase in the real interest rate however, and a moderate drop in investment. Because the rise in domestic inflation was due to a currency depreciation, it is short-lived. Nominal rates fall back to trend one period after the shock while real rates fall slightly below trend. Output falls slightly on net, due to offsetting effects of a reduction in investment demand and increasing exports. Overall, output is significantly more stable under the flexible exchange-rate regime.[17]

Figure 4A also shows the effect of the contraction in output on capital utilization and labor productivity. With either fixed or flexible exchange rates, the reduction in output implies a reduction in capital utilization of almost equal magnitude. As a consequence, labor productivity falls following a demand-driven slow-down, despite the fact that hours are contracting. The model implies a strongly pro-cyclical movement in measured TFP – under fixed exchange rates, measured TFP drops 1.5 percent in response to a 2 percent drop in utilization – despite the absence of any exogenous change in technology. These results suggest that the model is capable of producing quantitatively realistic productivity dynamics in response to demand rather than supply shocks.

The last two panels of Figure 4A show the effect of the rise in foreign interest rates on consumption and net exports. With flexible exchange rates, consumption falls more than output owing to the increased cost of imported consumer products following the depreciation. With fixed rates, this effect is muted and consumption falls by slightly less than output. As expected, with flexible exchange rates, net exports increase, albeit by a modest amount. Interestingly, net exports increase under fixed exchange rates as well. The rise in net exports is substantially larger under fixed exchange rates, despite the fact that the real exchange

[17]The monetary policy rule includes the output gap as well as inflation. In principal, output stability is influence by the combined effect from targeting inflation and the output gap. Using an interest rate that puts zero weight on the output gap produces very similar results however. With zero weight on the output gap, the contraction in output produces less inflationary pressure and hence less need to raise real rates to fight inflation.

rate depreciates more under the flexible exchange-rate regime.

The fact that net exports expand more under fixed exchange rates is primarily due to the financial accelerator mechanism. Under either exchange-rate regime, pricing-to-market and sluggish export demand imply only a modest increase in exports. The expansion in net exports is thus primarily due to a contraction in demand for imported capital goods. With flexible rates, the reduction in demand for imported capital goods occurs for two reasons: capital goods prices rise in domestic currency terms following the devaluation; and overall investment demand falls. The strength of the second mechanism is closely tied to the strength of the financial accelerator. With fixed exchange rates, the import price mechanism is not operative and the reduction in demand for imported capital goods is solely due to the collapse of domestic investment demand. Because the effect of the financial accelerator is more severe under fixed exchange rates however, imports contract more under fixed rates exchange rates relative to flexible exchange rates. As a result, the model implies that net exports are more likely to increase under fixed rather than flexible exchange rates following the rise in foreign interest rates.

Overall, these results imply a much larger drop in output, hours (not shown), and investment under a fixed exchange rate regime than under a flexible exchange rate regime in response to a rise in foreign interest rates. 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 5 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 exchange rates, the financial accelerator doubles the contraction in investment (lower left panel) and, as a consequence, doubles the contraction in output (upper left panel) at the trough. Under flexible rates, instead, the effect of the financial accelerator is far more modest.

4.2 Foreign-denominated Debt

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 exchange rate regime may in fact be more desirable than a flexible exchange rate regime, since devaluations weaken borrowers' balance sheets.[18] In assessing the Korean experience below,

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

we would like to make sure that our results are robust to such considerations. Accordingly, we briefly consider the effect of foreign-indexed debt for the response of the model to a rise in the foreign interest rate.[19]

Figure 6 plots the response of output and investment under three different scenarios: flexible exchange rates with foreign-denominated debt; flexible exchange rates with domestic-denominated debt; and fixed exchange rates. As one would expect, foreign currency debt makes the flexible exchange rate regime considerably less attractive. Allowing for foreign currency debt implies a contraction in investment that is twice as large as the contraction obtained in the case of domestic currency debt. With foreign currency debt, the depreciation of the exchange rate reduces entrepreneurial net worth, thus enhancing the financial accelerator mechanism. Nonetheless, even in this instance, the output drop remains smaller under flexible rates than under fixed rates. Put differently, the impact of the exchange rate on the balance sheets under flexible rates is less damaging than the contraction in asset prices under fixed rates.

Cespedes, Chang and Velasco [14] (CCV) also find that the output response remains greater under fixed rates but for different reasons.[20] In CCV, domestic assets do not serve as collateral but certain restrictions on the physical environment ensure that flexible rates dominate. In CCV, because capital is fully depreciable, there is no fixed debt overhang. This mitigates the impact of a depreciation of 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. Nonetheless, the contraction in asset values that occurs as interest rates rise under the fixed exchange rate regime more

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

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

and

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

[20] Caballero and Krishnamurthy [11] and Schneider and Tornell [37] also emphasize the importance of the asset price channel in analyzing emerging market crises.

than offsets the benefits to the balance sheets from avoiding the currency depreciation. As a result, the contraction in investment and output is invariably larger under the fixed exchange rate regime relative to the flexible exchange rate regime.

4.3 The Korean Experience

We now turn to a quantitative exercise that is intended to capture the macroeconomic consequences of the rise in the country risk premium that occurred in Korea during its recent financial crisis. Our goal is to analyze the quantitative response of our model under such a scenario and compare the model outcome with the actual Korean data. Within the context of our model, an exogenous rise in the country risk premium introduces a wedge between domestic and foreign interest rates in the uncovered interest parity condition. Formally, it is equivalent to a shock to the foreign interest rate. As discussed above, we believe that treating the rise in the country risk premium as exogenous is a reasonable approximation of the Korean situation.[21]

We consider a 5 percentage point rise in foreign interest rates, which is in line with the rise in the risk premium that occurred in Korea during the financial crisis. We assume that the shock persists as a first-order autoregressive process with a 0.95 coefficient.[22] We consider two alternative scenarios for monetary policy. The first scenario assumes a fixed exchange rate. The second scenario assumes that the monetary authority starts out under a fixed exchange rate but abandons the fixed rate two periods after the interest rate increase.[23] To make this realistic, we assume that private agents have some expectations that the monetary authority will abandon the peg, but the actual abandonment is still a positive surprise. Specifically, we consider a hybrid model where the exchange rate is initially fixed but where policy makers are expected to abandon the fixed exchange rate with a low probability. We set the abandonment probability at $\Pi = 0.1$. Accordingly, conditional on being on the peg, the expected duration is $1/\Pi = 1/(0.1) = 10$ quarters. Thus abandoning the fixed exchange-rate regime two periods after the shock represents a positive surprise to the economy.

Figure 7A and 7B plot the response of twelve key variables under the policy of fixed

[21] Cooper and Ejarque [21] provide a model with an endogenous collapse of the banking sector applied to the Great Depression. Their model, however, does not provide an endogenous amplification of the collapse through a financial accelerator mechanism.

[22] Even after controlling for the sharp spike in the EMBI+ following the Russian crisis in 1998, it appears that the increase in the Korean spread was persistently high after the Asian crisis.

[23] As a benchmark, we also include the flexible exchange rate regime case.

exchange rates and under the policy of probabilistic abandonment. For comparison purposes, we also plot the response under flexible exchange rates. With fixed exchange rates, the 5 percentage point rise in foreign interest rates leads to a 12 percent drop in output and a 35 percent drop in investment according to the model. As expected, the financial accelerator plays an important role in this exercise – the premium on external funds rises 9 percentage points on an annual basis. As a result, the financial accelerator accounts for 50 percent of the overall drop in investment and output in this exercise. The endogenous contraction in the rate of capital utilization implies a reduction in labor productivity despite the fact that hours are falling. We also obtain a quantitatively important reduction in measured total-factor productivity in this exercise (not shown). Under the fixed rate policy, consumption spending falls by 8 percent while net exports rise by 12 percent in the period following the shock.

In this experiment, abandoning the fixed exchange rate represents good news for the economy and hence asset values. Prior to abandonment, the response of the hybrid model is very similar to the response obtained under the model with fixed exchange rates.[24] Following abandonment, the nominal and real exchange rates depreciate by 10 percent. Under the now flexible monetary policy, the nominal interest rate falls 13 percentage points, while the real interest rate drops 17 percentage points. The sudden reduction in real rates leads to an increase in asset values and a reduction in the premium on external funds. As a result, investment and output recover to levels that are close to those that would be obtained under the flexible exchange rate regime. Overall, the hybrid model implies a deep but short-lived recession, which again suggest that there are substantial gains to be obtained from a flexible exchange rate policy even if it is enacted after the onset of the crisis.

The hybrid model does well at capturing the key outcomes of the Korean experience displayed in Figures 1-3 above. In the Korean data, the drop in real GDP is 14 percent whereas the model produces a 12 percent drop in real GDP. The reduction in gross capital formation for Korea is on the order of 45 percent, again in line with, albeit somewhat larger than, the model's 35 percent response. Net exports increase by 15 percent in the data, compared with 12 percent in the model. Notably, both the data and the model imply a large reduction in imports, especially capital goods, which drives the expansion in net exports. In the data, consumption falls by 18 percent which is somewhat more than the 8 percent

[24] Because agents expect the monetary authority to abandon eventually, expected future inflation is higher, and consequently, so is current inflation. As a result, both nominal and real interest rates rise by more under the hybrid policy, and the initial contraction is somewhat more severe.

implied by the model; because the data include durables as well as non-durables, we expect to find that the consumption data are more volatile than the model's response however.

The model also does well at capturing the productivity and utilization variables observed in Korea over this time period. The Korean data imply a 5 percent drop in labor productivity over the period December 1997 through September 1998 while the model implies a 3 percent drop in labor productivity. The magnitude of the decline in labor producivity observed in the data is probably exagerated, however, since it is based on output per worker not output per hour. As shown in figure 1, electricity consumption for the Korean economy falls 14 percent during the crisis period. In the model, capital utilization drops 11 percent. Given that oil is an imported good, we would expect some substitution away from energy towards other capital goods and inputs in the case where energy and capital show some degree of substitutability. Hence the 14 percent drop in energy is likely to overstate the decline in capital services owing to a drop in utilization rates. These results imply that variable capital utilization provides a reasonable explanation for the contraction in productivity that emerging market economies such as Korea experience in the wake of a financial crisis.

Finally, the model also does well at capturing various financial features of the Korean experience. The 9 percentage point rise in the corporate-treasury bond spread observed in the data is very close in magnitude to the response obtained by the model's external finance premium. Under fixed exchange rates, the external finance premium in the model is highly persistent. In contrast, the hybrid model does a good job of capturing the sudden reduction in the corporate-treasury bond spread following abandoment. The hybrid model also does well at mimicing both the nominal and real interest rate movements observed in the data. In particular, in the data, the (expost) real rate initially rises by 8 percentage points prior to abandonment, and then falls 16 percentage points following abandonment – a result that is similar to the real rate path generated by the model.[25] Consistent with this path, both the data and model exhibit a surge in inflation – on the order of 5 percentage points – following abandonment.

The financial variable that is difficult to match is the actual exchange rate movement when the monetary authority abandons the flexible exchange rate regime probabilistically.

[25] Although we don't have data on exante real rates it is useful to look at the expost real rate as a guide. The nominal interest rate rises from 13% to 25% on an annual basis in January, 1998, before falling to 5% by September 1998. The inflation rate rises from 5% to 9% from the third quarter of 1997 to the first quarter of 1998 before falling to 6% by September of 1998. Thus, the expost real rate is approximately 8% in October, 1998, 16% in January, 1998 and 0% in September 1998, indicating an initial 8 percentage point rise followed by a 16 percentage point fall in the real rate.

Table 1: Welfare Loss As a Percent of Steady-State Consumption

	No Financial Accelerator	With Financial Accelerator
Flexible Rates	23.4%	25.2%
Switching Re gime	25.1%	29.7%
Fixed Rates	27.5%	37.7%

The fact that quantitative macroeconomic models have difficutly matching exchange rate movements comes as no surprise however. Our model nonetheless produces a sizable depreciation in the real exchange rate – on the order of 10 percent. As is well known, movements in the nominal exchange rate dramatically over-state movements in real exchange rates and terms of trade.[26] To the extent that our model does well at capturing the dynamic response of net-exports, we are less concerned that it does not fully account for the volatility of exchange rates during this time period.

We now consider the welfare loss associated with the financial crisis. Specifically, we compute the amount of steady-state consumption that an appropriately weighted average of households and entrepreneurs would be willing to pay as a one-time payment to avoid the present-discounted loss in utility associated with the crisis -corresponding to 16 quarters in these calculations. The loss incorporates the current and future foregone consumption of households and entrepreneurs as well as the gain in current and future household leisure that accompanies the crisis. Details of these calculations are available in an accompanying appendix. These results are reported in table 1.Under flexible exchange rates and in the absence of the financial accelerator, the welfare loss associated with the crisis is a one-time drop in consumption equivalent to 23.4 percent of the economy's steady-state consumption on an annual basis. With flexible rates, the addition of the financial accelerator causes a modest increase in the welfare loss. Under fixed exchange rates, the losses are more severe. Without the financial accelerator, the loss is 27.5 percent of annual consumption. With the financial accelerator, the welfare loss is equivalent to a one-time loss on the order of 37.7 percent of annual consumption. In the presence of the financial accelerator, the reduction in welfare owing to fixed relative to flexible exchange rates appears to be sizeable. The welfare loss under the switching regime model, at 29.7 percent, is substantially less than the loss

[26] As emphasized by Burstein, Eichenbaum and Rebelo [9], in the absence of a substantial non-tradeable goods sector, it would likely be difficult to match movements in the nominal exchange rate. Barth and Dinmore [?] provide further discussion of the response of real exchange rates and the terms of trade for various Asian countries during the financial crisis.

obtained under a purely fixed rate regime. This result again highlights the benefits to flexible exchange rates in this environment.

5 Concluding Remarks

In this paper we use a small open-economy general equilibrium framework to assess the importance of financial factors in explaining the macroeconomic outcomes observed in Korea during the 1997-1998 Asian financial crisis. Our model experiments are able to match the observed drop in Korean output, investment and productivity during this time period. The financial accelerator mechanism is found to be quantitatively significant – accounting for about 50 percent of the total reduction in output. Our modeling exercises suggest that a policy of fixed exchange rates can lead to substantially higher welfare losses following a financial crisis. Abandoning the fixed exchange after the crisis has begun provides substantial gains in terms of output stabilization however. These findings suggest that a policy of flexible exchange rate targeting may provide major gains in terms of both welfare and output stabilization during crisis episodes.

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Appendix

Assuming real money balance effects are negligible, we can write the household utility function at time t as

$$U_t^h = \frac{\left[(C_t)^{1-\varsigma}(1-L_t)^{\varsigma}\right]^{1-\sigma}}{1-\sigma}$$

Since the entrepreneur utility function at time t is given by

$$U_t^e = C_t^e$$

then in steady state we have

$$U_{ss}^h = \frac{\left[(C_{ss})^{1-\varsigma}(1-L_{ss})^{\varsigma}\right]^{1-\sigma}}{1-\sigma}$$

and

$$U_{ss}^e = C_{ss}^e$$

From equation (9), the household marginal utility of consumption at time t is given by

$$\lambda_t^h = \frac{\partial U_t^h}{\partial C_t} = (1-\phi)(C_t)^{(\sigma-1)(\phi-1)-1}(1-L_t)^{\phi(1-\sigma)}$$

while the entrepreneur marginal utility of consumption is 1.

Define the present discounted value of the household and entrepreneur utility along the time path as

$$W_t^h = \sum_{t=1}^{k} \beta^{t-1} U_t^h$$

and

$$W_t^e = \sum_{t=1}^{k} \beta^{t-1} U_t^e$$

Finally, define the utility of the household and entrepreneur corresponding to a constant sequence of consumption and leisure as

$$W_{ss}^h = \frac{U_{ss}^h\left(1-\beta^k\right)}{1-\beta}$$

and

$$W_{ss}^e = \frac{U_{ss}^e\left(1-\beta^k\right)}{1-\beta}$$

Then the welfare cost of the business cycle is given by

$$\frac{\Delta C_{ss}^{tot}}{C_{ss}^{tot}} = \left[(\omega) \frac{W_t^h - W_{ss}^h}{\lambda_{ss}^h C_{ss}} + (1-\omega) \frac{W_t^e - W_{ss}^e}{C_{ss}^e} \right]$$

where ω is the household share of total steady state consumption:

$$\omega = \frac{C_{ss}}{C_{ss} + C_{ss}^e}$$

FIGURE 1

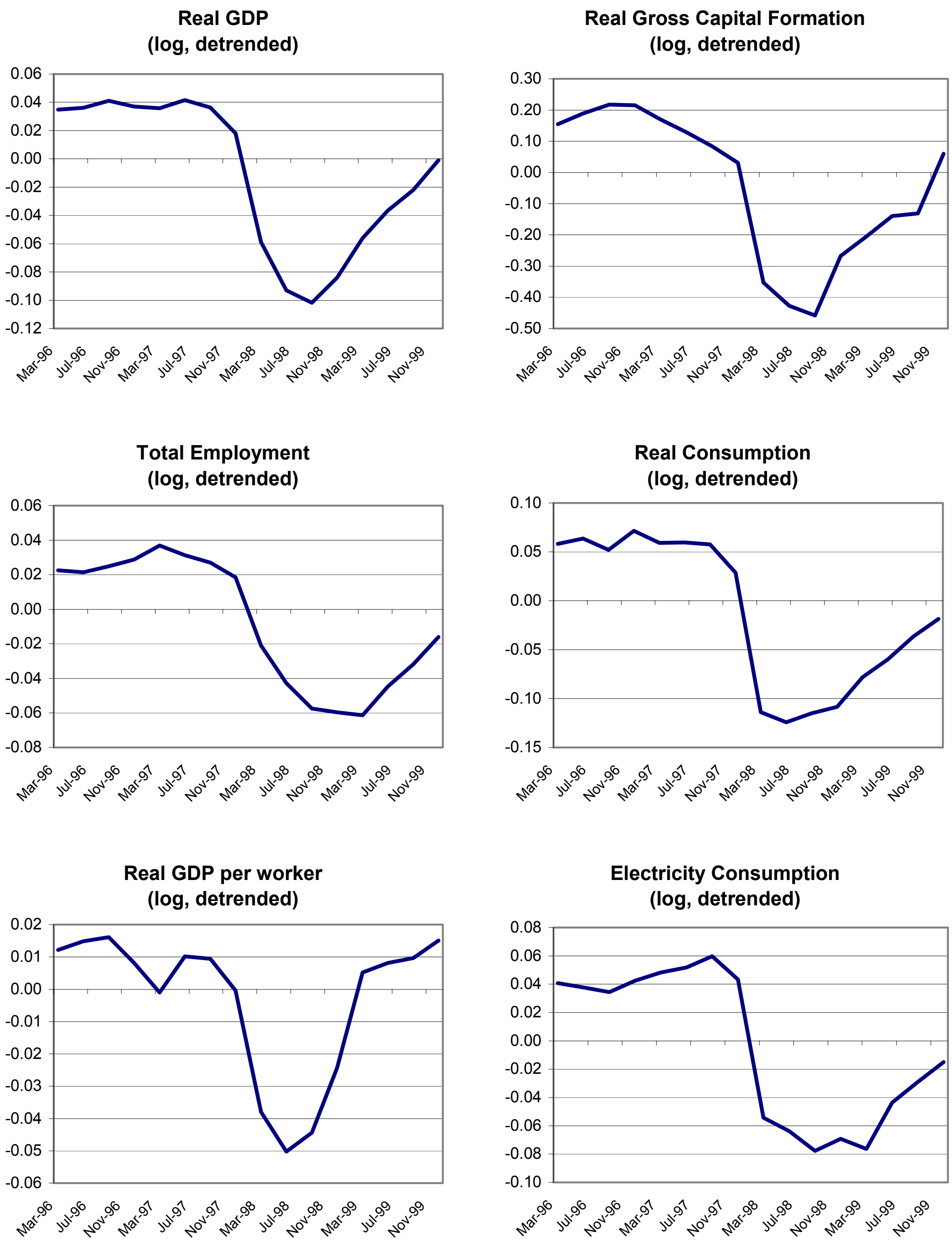

Real GDP
(log, detrended)
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
Mar-96
Jul-96
Nov-96
Mar-97
Jul-97
Nov-97
Mar-98
Jul-98
Nov-98
Mar-99
Jul-99
Nov-99
Real Gross Capital Formation
(log, detrended)
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
Total Employment
(log, detrended)
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
Real Consumption
(log, detrended)
0.10
0.05
0.00
-0.05
-0.10
-0.15
Real GDP per worker
(log, detrended)
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
Electricity Consumption
(log, detrended)
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10

FIGURE 2

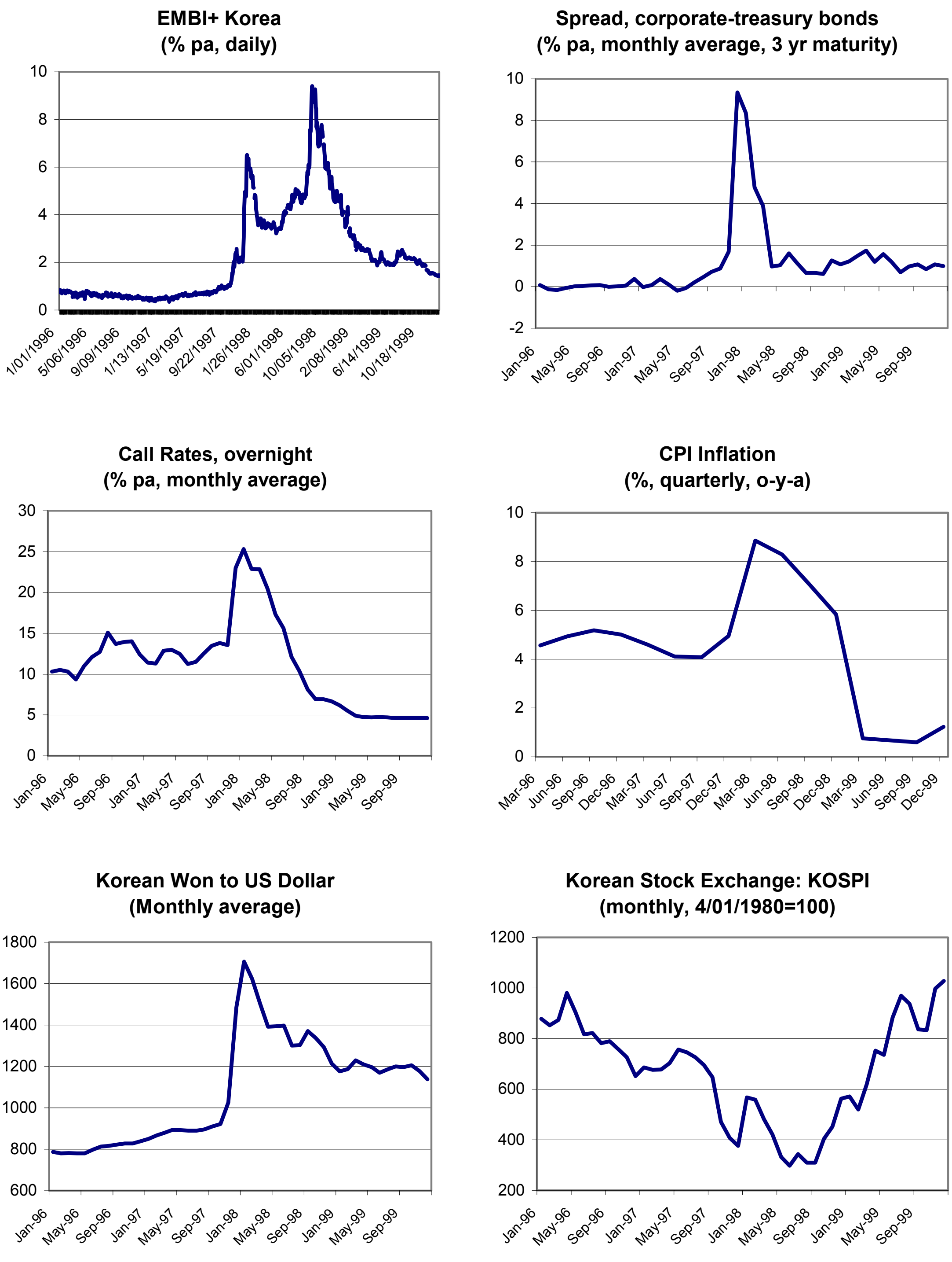

EMBI+ Korea
(% pa, daily)
0 2 4 6 8 10
1/01/1996 5/06/1996 9/09/1996 1/13/1997 5/19/1997 9/22/1997 1/26/1998 6/01/1998 10/05/1998 2/08/1999 6/14/1999 10/18/1999
Spread, corporate-treasury bonds
(% pa, monthly average, 3 yr maturity)
-2 0 2 4 6 8 10
Jan-96 May-96 Sep-96 Jan-97 May-97 Sep-97 Jan-98 May-98 Sep-98 Jan-99 May-99 Sep-99
Call Rates, overnight
(% pa, monthly average)
0 5 10 15 20 25 30
Jan-96 May-96 Sep-96 Jan-97 May-97 Sep-97 Jan-98 May-98 Sep-98 Jan-99 May-99 Sep-99
CPI Inflation
(%, quarterly, o-y-a)
0 2 4 6 8 10
Mar-96 Jun-96 Sep-96 Dec-96 Mar-97 Jun-97 Sep-97 Dec-97 Mar-98 Jun-98 Sep-98 Dec-98 Mar-99 Jun-99 Sep-99 Dec-99
Korean Won to US Dollar
(Monthly average)
600 800 1000 1200 1400 1600 1800
Jan-96 May-96 Sep-96 Jan-97 May-97 Sep-97 Jan-98 May-98 Sep-98 Jan-99 May-99 Sep-99
Korean Stock Exchange: KOSPI
(monthly, 4/01/1980=100)
200 400 600 800 1000 1200
Jan-96 May-96 Sep-96 Jan-97 May-97 Sep-97 Jan-98 May-98 Sep-98 Jan-99 May-99 Sep-99

FIGURE 3

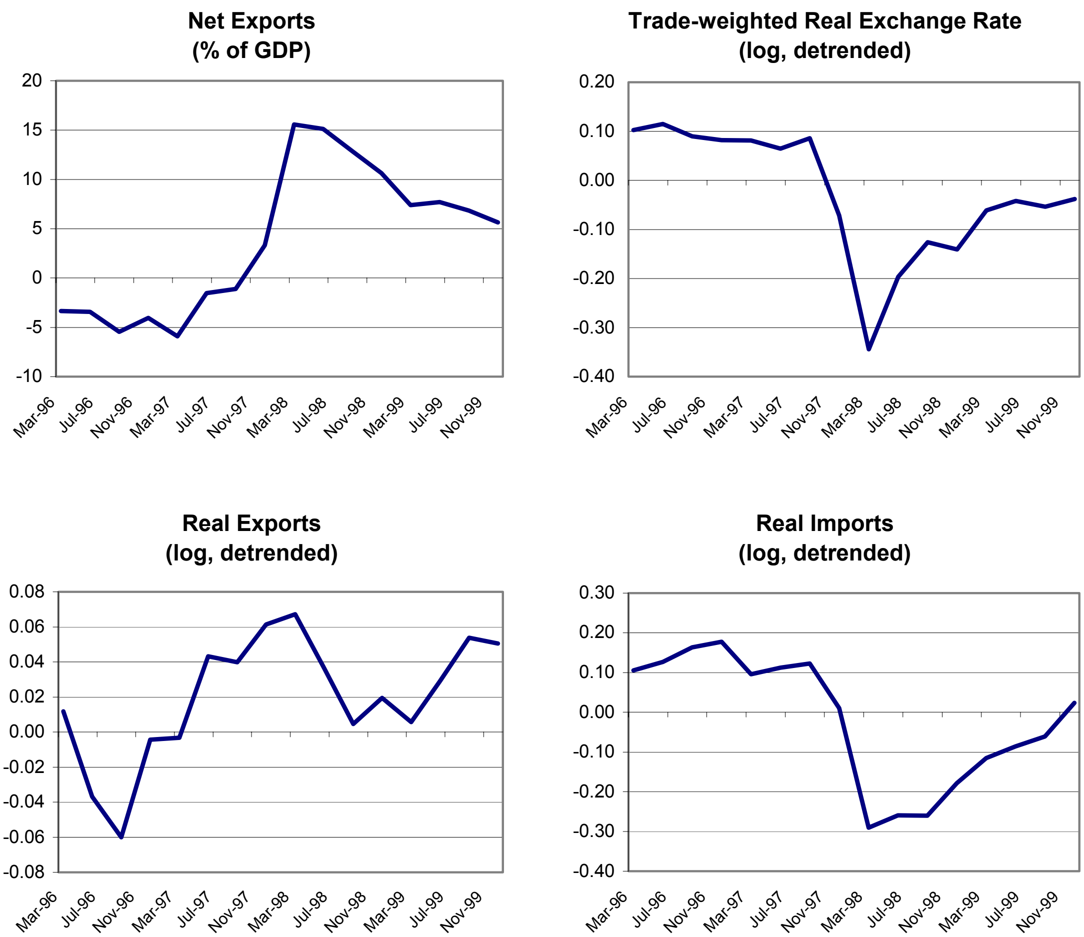

Net Exports
(% of GDP)
20
15
10
5
0
-5
-10
Mar-96
Jul-96
Nov-96
Mar-97
Jul-97
Nov-97
Mar-98
Jul-98
Nov-98
Mar-99
Jul-99
Nov-99
Trade-weighted Real Exchange Rate
(log, detrended)
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
Mar-96
Jul-96
Nov-96
Mar-97
Jul-97
Nov-97
Mar-98
Jul-98
Nov-98
Mar-99
Jul-99
Nov-99
Real Exports
(log, detrended)
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
Mar-96
Jul-96
Nov-96
Mar-97
Jul-97
Nov-97
Mar-98
Jul-98
Nov-98
Mar-99
Jul-99
Nov-99
Real Imports
(log, detrended)
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
Mar-96
Jul-96
Nov-96
Mar-97
Jul-97
Nov-97
Mar-98
Jul-98
Nov-98
Mar-99
Jul-99
Nov-99

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

FIXED VS. FLEXIBLE EXCHANGE RATE

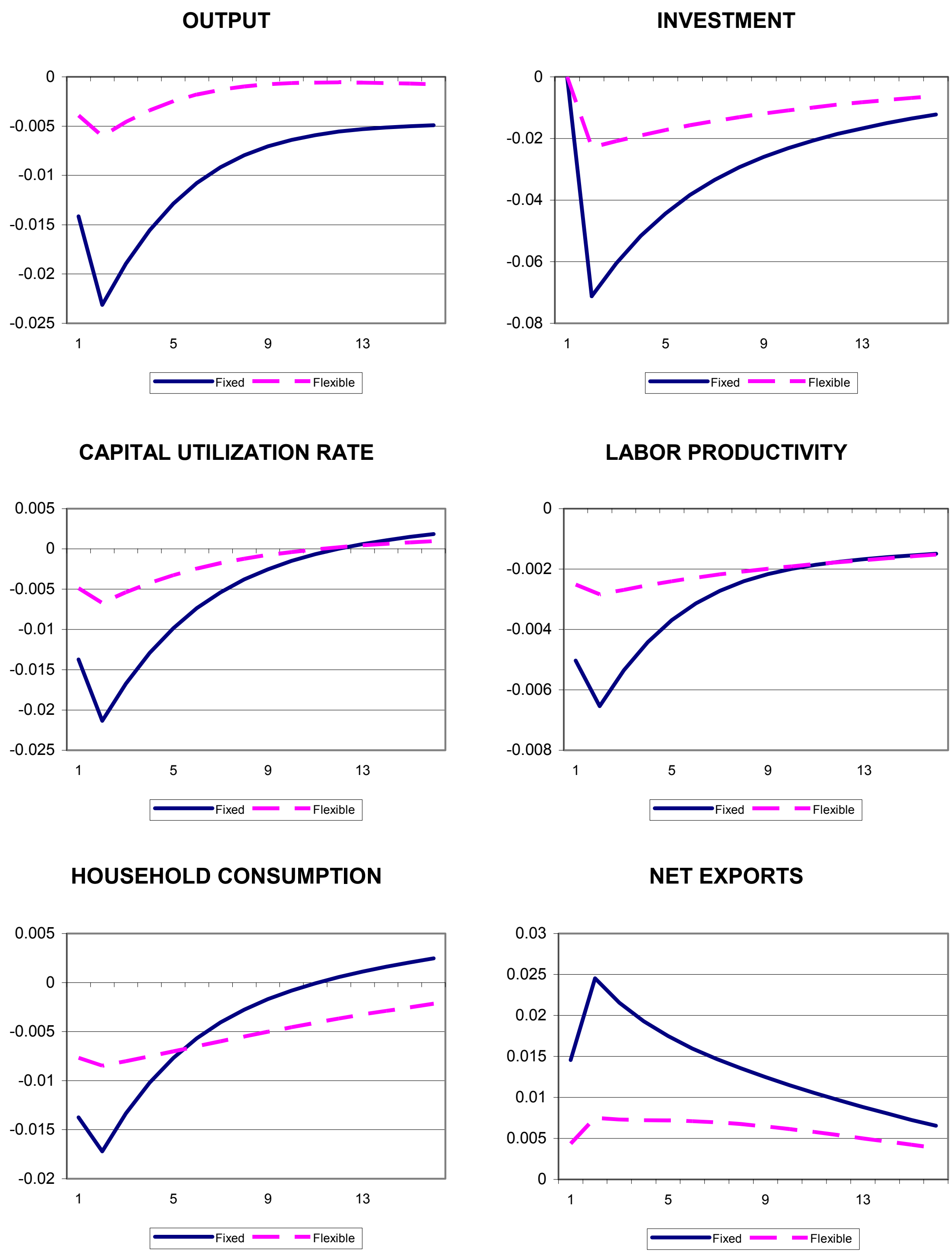


FIGURE 4 B: FOREIGN INTEREST RATE SHOCK

FIXED VS. FLEXIBLE EXCHANGE RATE (cont'd)

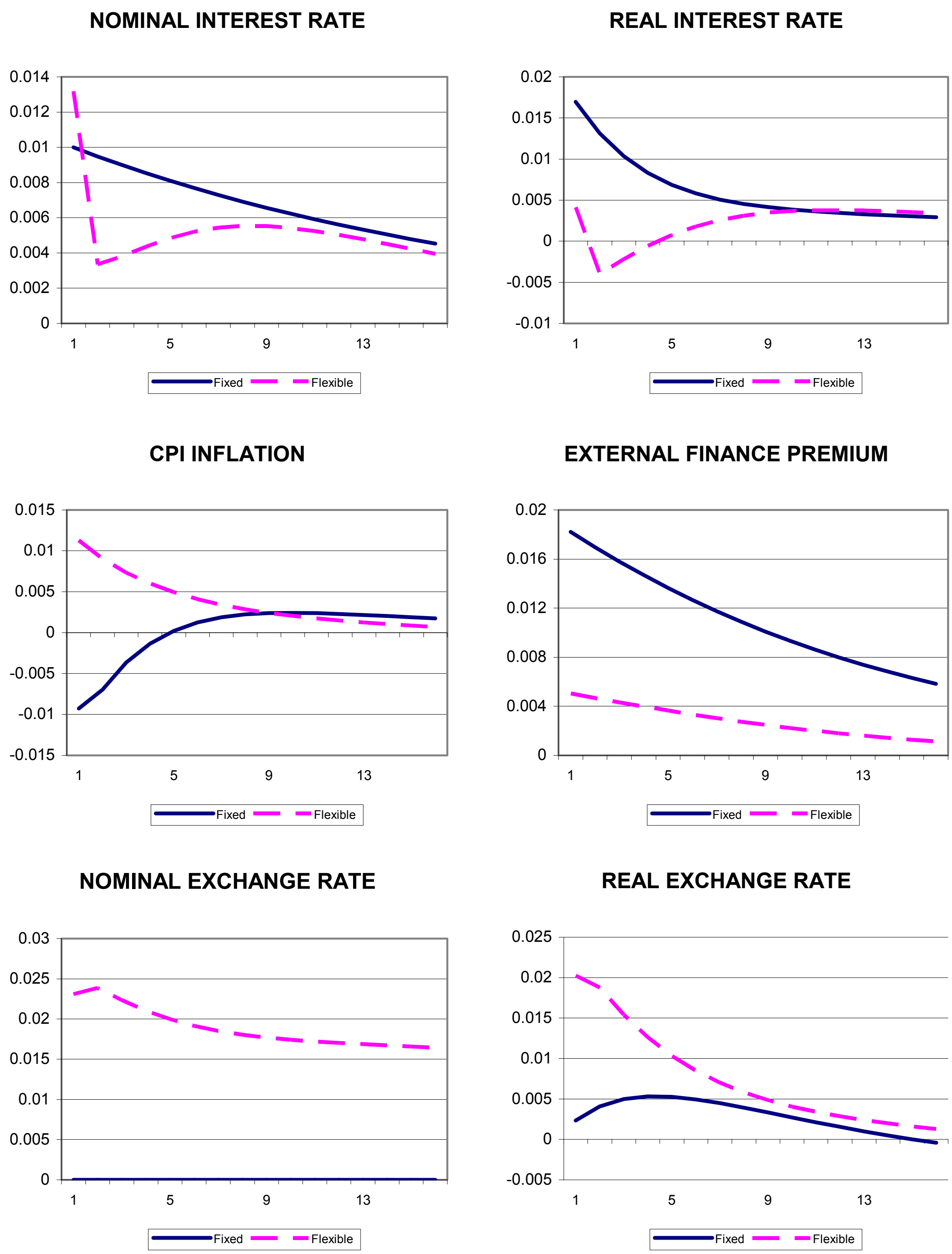
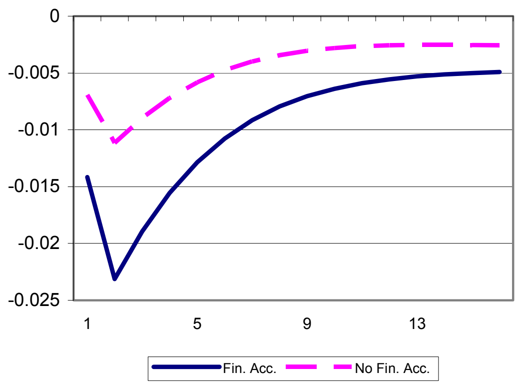


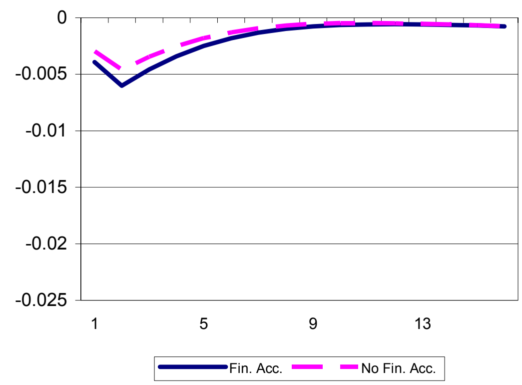
FIGURE 5: FOREIGN INTEREST RATE SHOCK

WITH VS. WITHOUT FINANCIAL ACCELERATOR

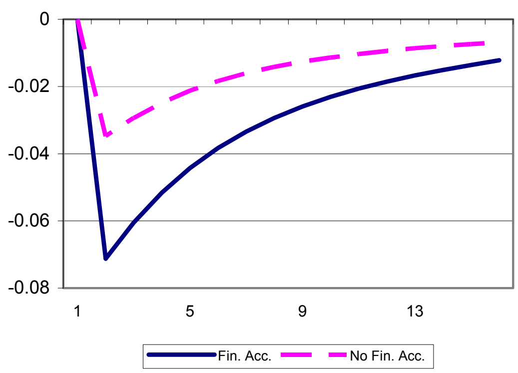
OUTPUT: FIXED RATES



OUTPUT: FLEXIBLE RATE



INVESTMENT: FIXED RATES



INVESTMENT: FLEXIBLE RATES

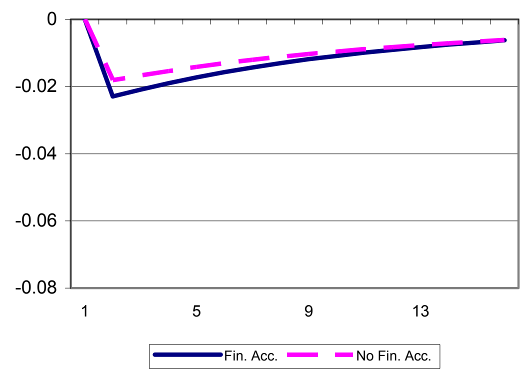
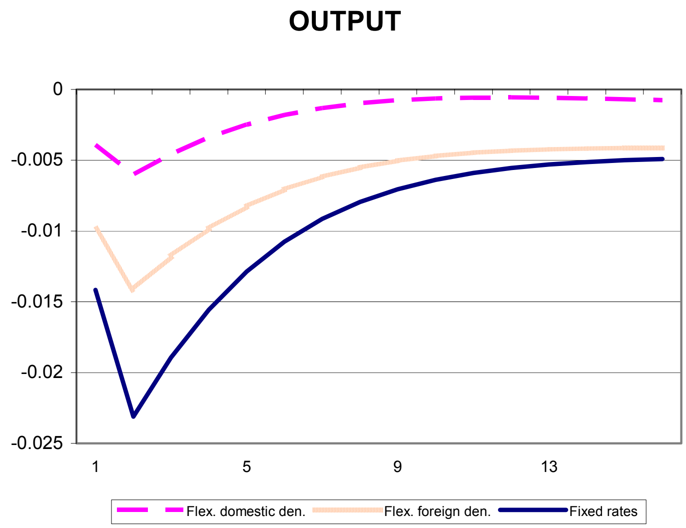


FIGURE 6: FIGURE 6: <u>FOREIGN INTEREST RATE SHOCK</u>

DOMESTIC VS. FOREIGN DENOMINATED DEBT



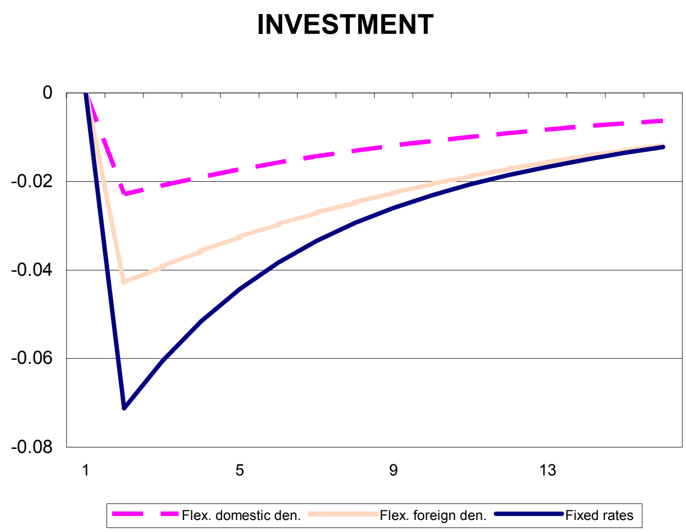


FIGURE 7A

KOREAN CRISIS EXPERIMENT

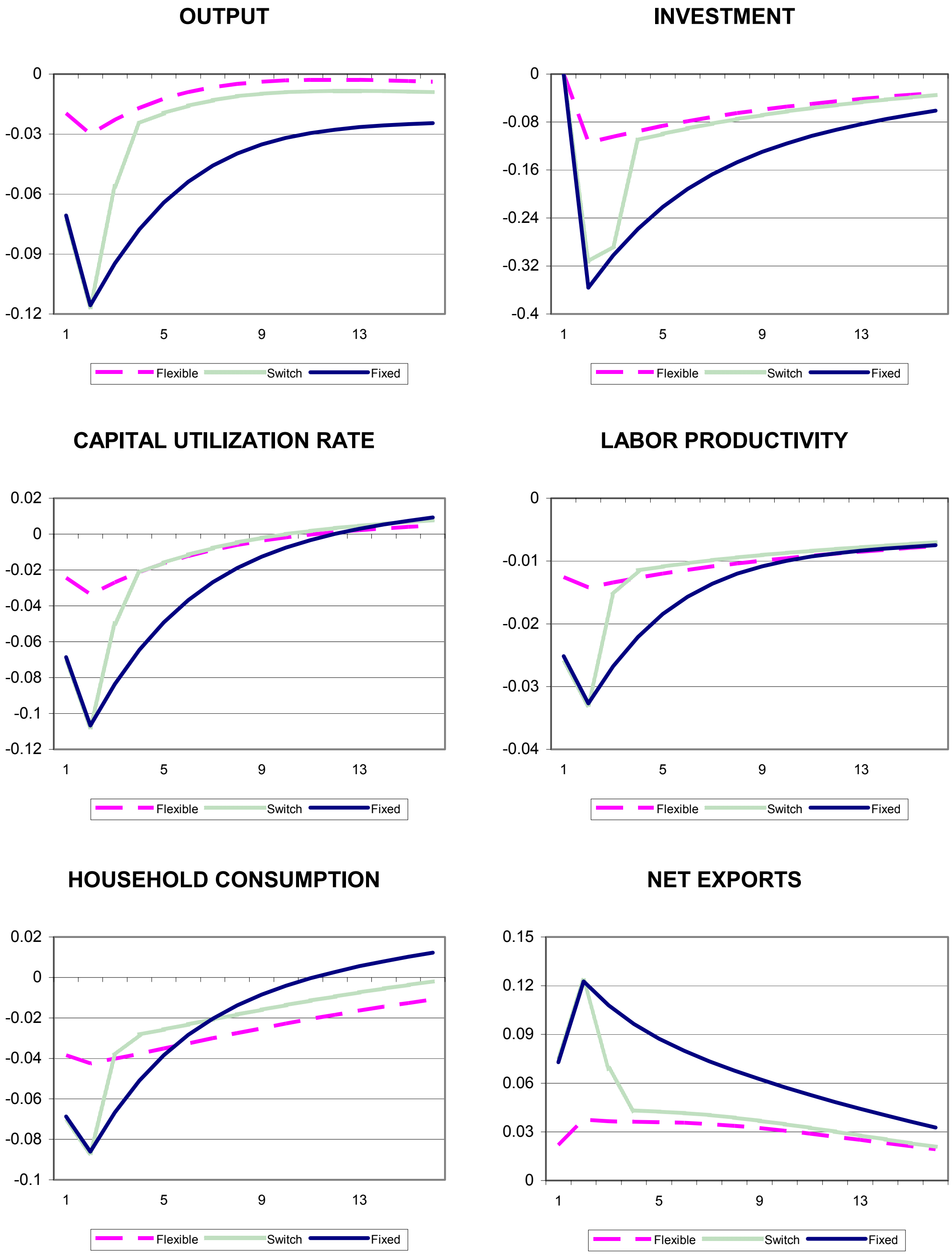


FIGURE 7B

KOREAN CRISIS EXPERIMENT (cont'd)