The Optimal Monetary Response to a Financial Crisis

Fabio Braggion * Lawrence J. Christiano† Jorge Roldos‡

May 14, 2005§

Abstract

We describe a model in which the optimal monetary policy response to a financial crisis is to raise the interest rate immediately, and then reduce it sharply. This pattern is consistent with what actually happened in the Asian crisis episodes.

*Northwestern University and Tilburg University.

†Northwestern University, and NBER.

‡International Monetary Fund.

§Braggion thanks the European Central Bank-Research Department for its hospitality. Christiano is grateful for the financial support of a National Science Foundation grant to the National Bureau of Economic Research. The authors are grateful for the advice and comments of Jaume Ventura and Michael Woodford. The results reported in this paper do not necessarily reflect the opinion of the International Monetary Fund.

1 Introduction

The Asian financial crises of 1997-98 triggered a sharp debate over the appropriate response of policy to a financial crises. The hallmark of the crises was a “sudden stop” (Calvo, 1998): capital inflows turned into outflows and output suddenly collapsed. Some argued, appealing to the traditional monetary transmission mechanism, that a cut in the interest rate was required to slow or reverse the drop in output. Others argued that because of currency mismatches in balance sheets, the exchange rate depreciation associated with a cut in interest rates might exacerbate the crisis. They argued for an increase in interest rates. Interestingly, a look at the data indicates that *both* pieces of advice were followed in practice. Figure 1 shows what happened to short term interest rates in each of four Asian crisis countries. Initially they rose sharply. Within six months or so, the policy was reversed and interest rates were ultimately driven to below their pre-crisis levels. A casual observer might infer that policy was simply erratic, with policymakers trying out different advice at different times.

In this paper, we argue that the observed policy may have served a single coherent purpose. We describe a model in which the optimal response to a financial crisis is an initial sharp rise in the interest rate, followed by a fall to below pre-crisis levels.

In our model, because of the presence of real frictions, resources are slow to respond in the immediate aftermath of a shock. Over time, resource allocation becomes more flexible.[1] We characterize a financial crisis as a shock in which collateral constraints unexpectedly bind and are expected to remain in place permanently. Our model has the property that when there is a binding collateral constraint and real frictions hinder resource allocation, then the monetary transmission mechanism is the reverse of what it would otherwise be. In particular, a rise in the interest rate increases economic activity and utility. Over time, as the real frictions wear off, the monetary transmission mechanism corresponds to the traditional one in which low interest rates stimulate output and raise welfare.

We now briefly explain the real and financial frictions in the model, and describe how they shape optimal policy after a financial shock. We adopt a small, tradable/non-tradable goods open economy model. The

[1] In effect, we combine into one model, the two studied in Christiano, Gust and Roldos (2004). In one model of that paper, labor in the traded good sector was fixed in each period. In another model, labor was completely flexible.

real friction is that labor in the tradeable sector is chosen prior to the realization of the current period shock.[2] Thus, when the financial shock occurs, the allocation of labor to the tradeable sector cannot respond in the current period, although it can respond in subsequent periods.

We adopt two forms of financial friction.[3] First, to capture the non-neutrality of money our model incorporates the portfolio allocation friction in the limited participation model.[4] In the absence of collateral constraints, our model reproduces the traditional monetary transmission mechanism: when the domestic monetary authority expands the money supply, the liquidity of the banking system increases and interest rates fall, leading to an expansion in output and a depreciation of the exchange rate. Second, our model assumes firms make use of labor and a foreign intermediate input, and that these must be financed in advance. The collateral constraint that is imposed during the crisis applies to these loans.[5]

The surprising feature of optimal policy in our model is that the nominal interest rate rises sharply in the period of the collateral shock. That this is optimal is a consequence of the interaction of the financial and real frictions. When the interest rate is increased, this acts like a tax on the employment of labor in the nontraded good sector, and raises the marginal cost of production in that sector. Because labor in the traded good sector is fixed in the period of the shock, the interest rate rise does not increase the marginal cost of production in that sector. With the marginal cost of non-traded goods rising relative to the marginal cost of traded goods, the relative price of nontraded goods goes up. This in turn increases the traded-good value of the physical capital stock in the non-traded sector. Because this capital is used as collateral in the import of intermediate goods, the collateral constraint is relaxed. This permits expanding imports of

[2] A similar friction is used by Fernandez de Cordoba and Kehoe (2001) to study the role of capital flows following Spain's entry to the European Community.

[3] Other studies have examined the relationship between optimal interest rates and financial crises. Aghion, Bacchetta and Banerjee (2000) present a model with multiple equilibria, in which a currency crisis is the bad equilibrium. The possibility of the bad equilibrium is due to the interplay between the credit constraints on private firms and the existence of nominal price rigidities. The authors show that the monetary authority should tighten monetary policy after any shock that results in the possibility of the currency crisis equilibrium. Our analysis differs from this analysis in three ways. First, equilibrium multiplicity does not play a role in our analysis. Second, our model emphasizes a different set of rigidities. Third, Aghion, Bacchetta and Banerjee focus on the prevention of crises, while we focus on their management after they occur. Similarly, Caballero and Krishnamurthy (2002) show that when the economy faces a binding international collateral constraint, a monetary expansion that would redistribute funds from consumers to distressed firms has no real effects. Given this lack of effectiveness, a monetary authority that trades-off output and an inflation target focuses on the latter and tightens monetary policy to achieve the inflation objective.

[4] For closed economy analyses of this model, see Lucas 1990, Fuerst 1992, Christiano 1991, Christiano and Eichenbaum, 1992, 1995. For open economy applications, see Schlagenhauf and Wrase and Grilli-Roubini (?)

[5] For other papers that study the role of credit constraints in the context of the Asian crisis, see Krugman (1999), Aghion, Bacchetta and Banerjee (2000), Caballero and Krishnamurthy (2000, 2002), Cespedes, Chang and Velasco (2000), Mendoza and Smith (2002), and the references therein.

intermediate goods and the production of tradeable goods. Because tradeable and non-tradeable goods are complements in domestic production, this leads to an expansion in the demand for non-tradables and an expansion in overall economic activity. Welfare is increased by this policy, even though it has the effect of introduction a distortionary wedge in the labor market. The reason welfare increases is that the policy has the effect of sharply reducing another wedge, one that is associated with the collateral constraint. To further clarify this mechanism, we study a sharply simplified non-dynamic version of our model, before proceeding to the full dynamic analysis.

In our model, the effect of the collateral shock is to increase the shadow cost of foreign borrowing, since international debt limits - via the collateral constraint - the ability of firms to purchase foreign intermediate inputs. As a result, imports of intermediate inputs drop and, because they are crucial for domestic production, the latter falls. In addition, the sharp rise in the shadow cost of debt induces agents to pay down that debt by running a current account surplus. This process continues until the debt falls to the point where the collateral constraint is only marginally binding, and now the economy is in a new steady state. Monetary policy has no impact on the presence of the collateral constraint, nor does it have an important impact on the new steady state. Monetary policy affects real variables and welfare primarily by its impact on the nature of the transition from the old to the new steady state.

We compare the dynamic behavior of the variables in the model with data drawn from the Asian crisis economies. Qualitatively, the model reproduces the behavior of data for these economies reasonably well. In particular, the model reproduces, qualitatively, the observed transitory fall of real quantities such as employment, consumption and output. The model also captures the evolution of asset prices, the nominal exchange rate and the behavior of the interest rate. Taken together, this evidence suggests that our model may provide a useful interpretation of the apparently erratic behavior of monetary policy exhibited in Figure 1.

The model does have some empirical shortcomings. Although it captures the direction of movement in the current account, it understates the magnitude. We suspect that this reflects the absence of physical investment in the model. A reduction in investment provides agents with another margin from which to draw resources that can be used to pay off the international debt. The presence of investment may also help the model with persistence, which is another dimension on which there is some weakness.[6] Finally, although the inflation response of the model to the financial shock matches qualitatively, it misses on magnitude.

The paper is organized as follows. First, we provide empirical evidence to support the main assumptions of the model. In particular, we show that collateral constraints were increased during the Asian financial crisis. We also show that imported intermediate inputs are a large fraction of imports, and that they fell sharply during the crisis. Second, we present a simplified example that illustrates how the frictions in our model contribute to the optimal monetary policy outcome. The third section presents our dynamic, monetary model. Section 4 discusses model calibration and section 5 we present the main results. Second 6 concludes.

2 Collateral Constraints, Intermediate Inputs and Exchange Rates

We first show that the use of collateral in emerging markets is widespread, and that collateralization increased in the wake of financial crises. Table 1 reports evidence on syndicated loans to emerging markets. Up until 1996, approximately 20 percent of these loans were secured by collateral. At the onset of the financial crises of 1997, this fraction doubled to over 40 percent. Gelos and Werner (1999) report that around 60 percent of loans are collateralized in Mexico, while survey evidence from the Bank of Thailand put the figure at more than 80 percent for that country. A review of financial conditions of the Asian crises countries (IMF 1999) notes that lending against collateral was a widespread practice also in these countries. Finally, Edison, Luangaram and Miller (2000) report that Thai banks that used to lend up to 70-80 percent of the value of pledged collateral before the crisis, moved to lend up to just 50-60 percent after the crisis.

In our reduced form crisis model, the tightening of the collateral constraint forces a cutback in imports, and this is the proximate cause of the fall in output. In the model, the fall in imports produces a fall in output because imports constitute crucial intermediate inputs. For evidence that intermediate goods are an important component of imports, see Table 2. According to Table 2, intermediate good imports are 50

[6] Discuss the possibility that investment could lead to the wrong outcomes.

percent of total imports for Korea and 70 percent of total imports for Indonesia and Malaysia. Figure 2 shows real GDP and intermediate good imports and shows the close correlation between the two.

In our model, the cutback in imports leads to a fall in the production of tradable goods. Output in the economy falls because of limited substitutability between these goods and non-traded goods in the production of final goods. This limited substitutability implies that the price of non-traded goods, relative to that of traded goods should fall sharply. For evidence on this, consider the data on exchange rates in Figure 3. Note that in each of the Asian crisis countries considered there is a dramatic depreciation in the aftermath of the crisis. The smallest depreciation is 143 percent (Philippines) and the largest is 169 percent (Korea). Given the relatively small movements in inflation in these countries, these movements in the nominal exchange correspond closely to the movement in the real exchange rate.

3 Example

A basic result in the dynamic simulations reported in later sections is that a rise in the domestic interest rate can produce a rise in equilibrium employment when there is a binding collateral constraint. At first glance, this result may seem puzzling since the rise in the interest rate effectively raises the tax rate on labor. Partial equilibrium reasoning suggests this distortion should lead to a decrease in employment, not an increase. In our example, this partial equilibrium effect is overwhelmed by a general equilibrium effect that relaxes the collateral constraint.

Our example has one period only. The economy has a traded good sector and a non-traded good sector. The non-traded good sector uses labor and physical capital and no imported intermediate inputs, while the traded sector uses no labor and an imported intermediate input. Financing for the imported intermediate input must be obtained at the beginning of the period, subject to a binding collateral constraint. The stock of capital in the non-traded sector is used as collateral. International loans are paid off at the end of the period.

We suppose that there is an employment tax levied on firms. Using numerical methods, we find that for all parameterizations considered, the following effects occur. When the collateral constraint is binding, the rise in the labor tax rate increases the marginal cost of producing non-traded goods, and hence leads to a rise in their price. This rise in price increases the value of the collateral in the non-traded good sector and permits an expansion in imports of the intermediate good. The increase in imports leads to an increase in the demand for the non-traded good, because traded and non-traded goods are complementary in the production of a final good. Through this sequence of events, the net effect of the rise in the labor tax rate is to increase employment and utility. In effect, the binding collateral constraint introduces an inefficiency wedge for the economy, by raising the shadow cost on imported goods. By introducing an inefficiency wedge in the labor market, the labor tax rate helps mitigate the effects of the inefficiency wedge associated with the collateral constraint. The overall effect is welfare-improving.

3.1 Model

A representative household has preferences over consumption and labor, c and L, as follows:

$$u(c, L) = c - \frac{\psi_0}{1+\psi} L^{1+\psi}. \tag{1}$$

The non-tradeable consumption good is produced using traded and non-traded intermediate goods using the following Leontief technology:

$$c = \min\left\{(1-\gamma)c^T, \gamma c^N\right\}. \tag{2}$$

Traded and non-traded intermediate goods are produced, respectively, using the following two technologies:

$$y^T = Az^\theta,\ y^N = K^\alpha L^{1-\alpha}. \tag{3}$$

Here, z is a good which is imported from abroad, and y^T is the gross amount of traded goods produced. Traded goods are used in domestic production, and for paying international debt as follows:

$$y^T = c^T + R^* z, \tag{4}$$

where R^* is the gross rate of interest, in traded good terms. In (4), z is the amount borrowed from abroad to finance the purchase of z for use in (3), so that $R^* z$ is the total quantity of traded goods owed to foreign creditors at the end of the period. Equation (4) is the market clearing condition in the market for traded goods. Non-traded goods can only be used as intermediate goods in production of c, so that:

$$y^N = c^N.$$

We consider a competitive market environment. The representative household maximizes utility, (1), subject to the budget constraint,

$$pc \leq wL + \pi + T.$$

Here, p denotes the price of the consumption good, w denotes the wage rate, π denotes profits, and T is a lump-sum transfer payment from the government. All these quantities are measured in units of the traded good.

The consumption good, c, is produced by a representative firm using the technology, (2). This firm takes as given the price, p, of its output as well as the price of nontraded goods, p^N. The traded intermediate good is the numeraire, and its price is taken to be unity.

A representative intermediate good firm operates the two technologies, (3), and seeks to maximize profits,

$$\pi = p^N y^N + y^T - q(K - K_0) - w(1+\tau)L - R^* z.$$

It is convenient express the firm's profits in non-traded goods units:

$$\frac{\pi}{p^N} = y^N + \frac{1}{p^N}\left[y^T - R^* z\right] - \frac{q}{p^N}(K - K_0) - \frac{w}{p^N}(1+\tau)L \tag{5}$$

In (5), τ denotes a tax on labor. This tax is rebated in lump sum form to households via T in their budget constraint. In addition, K_0 is the initial endowment of capital of the firm, q is the price of capital, and K is the actual capital used in production. Foreign creditors impose a borrowing constraint which stipulates that a fraction, τ^N, of the value of capital, qK, must be no less than the firm's end-of-period international obligations:

$$\tau^N qK \geq R^* z. \tag{6}$$

The timing of the intermediate good firm's decisions are as follows. First, the tax rate, τ, becomes known. Then, a market opens in which intermediate good firm trades capital among themselves at a price, q. Then z, L, c, y^N and y^T are determined and production occurs. Immediately after paying its wage bill, the intermediate good firm decides whether to default on its international loans. If it does, then the creditors can seize from the firm an amount of output equal to the firm's obligations. It is easy to verify that the firm's revenues, after paying the wage bill, are sufficient for this.[7]

A competitive equilibrium is a set of allocations and prices where households and firms solve their problems subject to their constraints and markets clear.

3.2 Equilibrium Characterization

We list the seven equations that characterize seven equilibrium variables - p, w, p^N, q, L, z and the Lagrange multiplier on (6) - for our example. Consider the representative final good producer. As long as input prices are strictly positive, the final good producer always sets $c^T = [\gamma/(1-\gamma)]\, y^N$. Combining (3) and (4), this implies:

$$Az^{\theta} - R^{*}z = \frac{\gamma}{1-\gamma}K^{\alpha}L^{1-\alpha}. \tag{7}$$

If the price of, say, c^T, were zero, then the final good producer would be indifferent between purchasing an amount of c^T consistent with (7), or purchasing more. In such a case, we suppose that the producer resolves the indifference by imposing (7). Competition in final goods implies that price equals marginal cost:

$$p = \frac{1}{1-\gamma} + \frac{1}{\gamma}p^N, \tag{8}$$

The representative intermediate good firm's optimal choice of capital leads to the following expression for the price of capital:

$$q = \frac{\alpha p^N K^{\alpha-1}L^{1-\alpha}}{1-\lambda\tau^N}. \tag{9}$$

This is the first order necessary condition for optimization in the Lagrangian representation of the intermediate good firm's optimization problem, in which $\lambda \geq 0$ is the multiplier on (6). The labor demand choice by the intermediate good firm leads it to equate the marginal cost, $(1+\tau)w$, and value marginal product of labor in the production of non-traded goods to obtain (after making use of (8)),

$$\frac{1-\alpha}{\left(\frac{1}{1-\gamma}\frac{1}{p^N}+\frac{1}{\gamma}\right)(1+\tau)}K^{\alpha}L^{-\alpha} = \frac{w}{p}. \tag{10}$$

Optimization in the choice of z leads to the following first order condition:

$$\frac{1}{p^N}\left[\theta Az^{\theta-1} - R^{*}(1+\lambda)\right] = 0. \tag{11}$$

[7] Implicitly, we suppose that z has no value to the intermediate good producer other than as an input to production. For example, the producer has no incentive to abscond with z without producing anything.

Evidently, for $p^N < \infty$, (11) corresponds to setting the expression in square brackets to zero. However, we will also allow $p^N = \infty$ (this corresponds to a zero price on c^T), in which case (11) does not require the numerator to be zero. Finally, the complementary slackness condition on λ for intermediate good firm optimization is:

$$\lambda \left[\tau^N qK - R^* z\right] = 0,\ \lambda \geq 0,\ \tau^N qK - R^* z \geq 0. \tag{12}$$

Market clearing requires that prices be strictly positive:

$$q,\ p^N > 0. \tag{13}$$

The latter, in combination with (9) impose an upper bound on λ, $\lambda \leq 1/\tau^N$.

Household optimization of employment leads to the following labor supply curve:

$$\psi_o L^{\psi} = \frac{w}{p}. \tag{14}$$

The seven equations that characterize equilibrium are (7)-(12) and (14), together with the nonnegativity constraints, (13). We analyze these equations in the next subsection. A strategy for solving the equations is described in the appendix.

3.3 Analysis

The labor demand and supply curves, (10) and (14), are displayed in Figure 4. The figure indicates that a rise in τ, holding p^N fixed, shifts the labor demand curve left, and results in a fall in employment. At the same time, a rise in p^N shifts the labor demand curve to the right. Because the labor supply curve is not a function of τ or p^N, a rise in p^N leads to a rise in employment and output. So, if general equilibrium effects raise p^N by enough after a rise in τ, equilibrium employment could increase.

Could the general equilibrium effects on p^N really be so great as to reverse the negative effects on employment of a tax increase? To see that the answer may be yes, suppose that the collateral constraint is not binding, so that $\lambda = 0$. In this case, (11) pins down a unique value of z that is independent of τ. As long as this value of z is not too great, so that $p^N < \infty$, the implied quantity of c^T will be fully utilized in the production of final goods. The Leontief assumption on production, (7), then pins down the equilibrium level of employment, L. Thus, both z and L are determined independently of the value of τ. From Figure 4 it is apparent that a rise in τ must produce a rise in p^N that is large enough to completely undo the effect on labor demand of any rise in τ. So, it is perhaps not surprising that in a perturbation of our economy in which the collateral constraint is binding, it is possible for a rise in p^N to more than compensate for a rise in τ. To see that this is so, we computed a numerical example.

We adopted the following parameter values:

$$A = 2,\ R^* = 1.06,\ \theta = 0.1,\ \gamma = 0.43,\ \alpha = 0.25,\ \tau^N = 0.1,\ \psi_0 = 0.06,\ \psi = 1,\ K = 1.$$

We computed equilibrium allocations corresponding to τ in the range, 0.01 to 1.00. In the appendix, we show that the admissible set of equilibrium values of λ belongs to the compact set, $J = \left[0, 1/\tau^N\right]$. By considering a fine grid of $\lambda \in J$, we found that, for each value of τ considered, the equilibrium is unique. The values of utility, $1/p^N$, q, λ, z, L corresponding to each τ are displayed in Figure 5. Note that for τ in the range of 0 to 0.4, utility is strictly increasing. In this range, an increase in the tax rate raises p^N and raises q as well. The latter has the effect of relaxing the collateral constraint, which is reflected in the fall in λ. Note that the initial value of λ is extremely high. According to (11), λ is equivalent to a tax on the purchase of the foreign intermediate input. When $\tau = 0$ this tax wedge is about 175%. By increasing the labor tax rate, the shadow tax rate on foreign borrowing is completely eliminated. The increase in the labor wedge has, in effect, entirely eliminated the collateral wedge. The result is an increase in imports (z rises by a multiple of over 3), which in turn leads to an expansion in L. The increase in L and in utility continues until λ has been driven to zero.

For τ in the range $0.4 < \tau < 0.72$, utility and employment are invariant to additional increases in τ. This is because in this range, z is in a sense a binding constraint on domestic production. The amount of z, which is now pinned down by A and R^* in (11), determines L through (7). Eventually, with additional increases in τ, it is employment that becomes the binding constraint in production. At this point, additional increases τ result in a reduction in L and 'excess supply' of c^T. Although the economy can produce the c^T implied by the equation in square brackets in (11) and (4), some of this c^T goes unused. On the margin, c^T is literally free and this is reflected in $p^N = \infty$.[8] With additional increases in τ beyond this point, L

[8] Technically, in the range where L is constant, κ in (34) in the Appendix is constant. As long as $\kappa/(1+\tau) > 1$, p^N is finite, but $p^N = \infty$ when increases in τ result in $\kappa = 1 + \tau$.

falls and utility declines.

To investigate robustness, we considered a series perturbations on the above example. In each case, if the collateral constraint was binding, then an increase in τ produced an increase in L and in utility. For example, we varied α from 0.1 to 0.9 in increments of 0.1. For α greater than 0.3, we reduced A to 1, to ensure that the collateral constraint remains binding. In all cases, we found that utility and L increase monotonically as τ is raised from 0.05 to 0.1. The result held when we varied θ from 0.1 to 0.6. For θ larger than 0.6, we encountered nonexistence of equilibrium for $\tau = 0.05$. The result also held when we varied ψ from 0 to 2 in increments of 0.1. For ψ greater than 1.3, the collateral constraint ceased to be binding, so we set $A = 1$ to make the experiments interesting. We also considered values of γ from 0.2 to 0.9, in increments of 0.1. When $\gamma = 0.2$ and 0.3 we set A to 0.5 to ensure the collateral constraint is binding. Again, we found that utility and L increase monotonically in τ for τ in the interval, 0.05 to 0.1. In all the experiments we considered, we never found an example in which L and utility fall with a rise in τ, when the collateral constraint is binding.

4 The Dynamic, Monetary Model

This section describes our dynamic, monetary model. In its basic structure, it is a standard traded good-non traded good small open economy model. The model has households, firms, a financial intermediary, and a domestic monetary authority. For the most part, the model is a version of the one in Christiano, Gust and Roldos (2004), and so the presentation is brief. A key difference between the two models is that here, labor in the traded good sector cannot be quickly adjusted in response to a shock.

4.1 Households

There is a representative household, which derives utility from consumption, c_t, and leisure as follows:

$$\sum_{t=0}^{\infty} \beta^t u(c_t, L_t), \tag{3.1.1}$$

where L_t denotes labor time spent in the market and c_t denotes consumption. We adopt the following specification of utility:

$$u(c, L) = \frac{\left[c - \frac{\psi_0}{1+\psi} L^{1+\psi}\right]^{1-\sigma}}{1-\sigma}. \tag{3.1.2}$$

The household begins the period with a stock of liquid assets, $\tilde{M}_t$. Of this, it allocates deposits, D_t, with the financial intermediary, and the rest, $\tilde{M}_t - D_t$, to consumption expenditures. The cash constraint that the household faces on its consumption expenditures is:

$$P_t c_t \leq W_t L_t + \tilde{M}_t - D_t, \tag{16}$$

where W_t denotes the wage rate and P_t denotes the price level.

The household also faces a flow budget constraint governing the evolution of its assets:

$$\tilde{M}_{t+1} = R_t(D_t + X_t) + P_t^T \pi_t + \left[W_t L_t + \tilde{M}_t - D_t - P_t c_t \right]. \tag{17}$$

Here, R_t denotes the gross domestic rate of interest, π_t is profits which derive from household's ownership of firms, and X_t is a liquidity injection from the monetary authority. π_t is measured in units of traded goods, and P_t^T is the domestic currency price of traded goods. The term on the right of the equality reflects the household's sources of liquid assets at the beginning of period $t+1$: interest earnings on deposits and on the liquidity injection, profits and any cash that may be left unspent in the period t goods market.

The household maximizes (3.1.1) subject to (16)-(17), and the several timing constraints. Since the model is deterministic after the first period, timing assumptions then do not matter. We assume that the employment decision is made at the very beginning of the period, before any shock (e.g., the onset of the financial crisis) is realized. The household deposit decision is made after the financial crisis occurs, but before the monetary authority's response is realized. All other household decisions are made after the monetary authority.

4.1.1 Firms

There are two types of representative, competitive, firms. The first produces the final consumption good, c, purchased by households. Final goods production requires intermediate goods which are produced in traded and non-traded good sectors by the second type of representative firm. We now discuss the decisions facing these firms.

4.1.2 Final Good Firms

The production function of the final good firms is given by:

$$c = \min\left\{(1-\gamma)\, c^T, \gamma c^N\right\}, \tag{18}$$

where c^T and c^N denote quantities of tradeable and non-tradeable intermediate inputs, respectively. As noted above, the price of c is denoted by P, while P^T and P^N denote the money prices of the traded and nontraded inputs, respectively. The firm takes these prices parametrically.

Zero profits and efficiency imply the following relation between prices:

$$p = \frac{1}{1-\gamma} + \frac{p^N}{\gamma},\ p = \frac{P}{P^T}. \tag{19}$$

The object, P, in the model corresponds to the model's 'consumer price index', denominated in units of the domestic currency. The object, p, is the consumer price index denominated in units of the traded good.

4.1.3 Intermediate Inputs

A single representative firm produces the traded and non-traded intermediate inputs. That firm manages three types of debt, two of which are short-term. The firm borrows at the beginning of the period to finance its wage bill and to purchase a foreign input, and repays these loans at the end of the period. In addition, the firm holds the outstanding stock of external (net) indebtedness, B_t.

The firm's optimization problem is:

$$\max \sum_{t=0}^{\infty} \beta^t \Lambda_{t+1} \pi_t, \tag{20}$$

where

$$\pi_t = p_t^N y_t^N + y_t^T - w_t^N R_t L_t^N - w_t^T R_t L_t^T - R^* z_t - r^* B_t + (B_{t+1} - B_t), \tag{21}$$

denotes dividends, denominated in units of traded goods. Also, B_t is the stock of external debt at the beginning of period t, denominated in units of the traded good; R^* is the gross rate of interest (fixed in units of the traded good) on loans for the purpose of purchasing z_t; and r^* is the net rate of interest (again, fixed in terms of the traded good) on the outstanding stock of external debt. The price, Λ_{t+1}, is taken parametrically by firms. In equilibrium, it is the multiplier on π_t in the (Lagrangian representation of the) household problem:[9]

$$\Lambda_{t+1} = \beta\left(\frac{u_{c,t+1}P_t^T}{P_{t+1}} + \Omega_{t+1}P_t^T\right) = \tag{22}$$
$$= \beta\frac{u_{c,t+1}p_t^T}{p_{t+1}p_{t+1}^T}\frac{1}{(1+x_t)}$$

where

$$p_t^T = \frac{P_t^T}{M_t}.$$

Here, M_t is the aggregate stock of money at the beginning of period t, which is assumed to evolve according to:

$$\frac{M_{t+1}}{M_t} = 1 + x_t. \tag{23}$$

Note that under our notational convention, all lower case prices except one, expresses that price in units of the traded good. The exception, p_t^T, is the domestic currency price of traded goods, scaled by the beginning of period stock of money. Alternatively, p_t^T is the inverse of a measure of real balances.

The firm production functions are:

$$y^T = \left\{\theta\left[\mu_1 V\right]^{\frac{\xi-1}{\xi}} + (1-\theta)\left[\mu_2 z\right]^{\frac{\xi-1}{\xi}}\right\}^{\frac{\xi}{\xi-1}}, \tag{24}$$
$$V = A\left(K^T\right)^{\nu}\left(L^T\right)^{1-\nu},$$
$$y^N = \left(K^N\right)^{\alpha}\left(L^N\right)^{1-\alpha},$$

where ξ is the elasticity of substitution between value-added in the traded good sector, V_t, and the imported intermediate good, z_t. In the production functions, K^T and K^N denote capital in the traded and non-traded good sectors, respectively. They are owned by the representative intermediate input firm. We keep the stock of capital fixed throughout the analysis. It does not depreciate and there exists no technology for making it bigger.

Total employment of the firm, L_t, is:

$$L_t = L_t^T + L_t^N.$$

[9] The intuition underlying (22) is straightforward. The object Λ_{t+1} in (22), is the marginal utility of one unit of dividends, denominated in traded goods, transferred by the firm to the household at the end of period t. This corresponds to $P_t^T\pi_t$ units of domestic currency. The households can use this currency in period $t+1$ to purchase $P_t^T\pi_t/P_{t+1}$ units of the consumption good. The value, in period t, of these units of consumption goods is $\beta u_{c,t+1}P_t^T\pi_t/P_{t+1}$, or $\beta u_{c,t+1}P_t^T\pi_t/(p_{t+1}P_{t+1}^T)$, where $u_{c,t}$ is the marginal utility of consumption. This is the first expression in (22).

We impose the following restriction on borrowing:

$$\frac{B_{t+1}}{(1+r^*)^t} \to 0, \text{ as } t \to \infty. \tag{25}$$

We suppose that international financial markets impose that this limit cannot be positive. That it cannot be negative is an implication of firm optimality.

The firm's problem at time t is to maximize (20) by choice of B_{t+j+1}, y^N_{t+j}, y^T_{t+j}, z_{t+j}, L^T_{t+j}, L^M_{t+j} and L^N_{t+j}, $j = 0, 1, 2, ...$ and the indicated technology. In addition, the firm takes all prices and rates of return as given and beyond its control. The firm also takes the initial stock of debt, B_t, as given. This completes the description of the firm problem in the pre-crisis version of the model, when collateral constraints are ignored.

The crisis brings on the imposition of the following collateral constraint:

$$\tau^N q^N_t K^N + \tau^T q^T_t K^T \geq R^* z_t + (1+r^*) B_t + \zeta R_t \left(W^T_t L^T_t + W^N_t L^N_t \right) \tag{26}$$

Here, q^i, $i = N, T$ denote the value (in units of the traded good) of a unit of capital in the nontraded and traded good sectors, respectively. Also, τ^i denotes the fraction of these stocks accepted as collateral by international creditors. The left side of (26) is the total value of collateral, and the right side is the payout value of the firm's external debt; ζ indicates the fraction of the wage bill that enters into the liabilities side of the collateral constraint, and represents the share of domestic loans that are collateralized and would compete with foreign creditors' claims on the firm's assets. Before the crisis, firms ignore (26), and assign a zero probability that it will be implemented. With the coming of the crisis, firms believe that (26) must be satisfied in every period henceforth, and do not entertain the possibility that it will be removed.

We obtain q^N_t and q^T_t by differentiating the Lagrangian representation of the firm optimization problem with respect to K^N and K^T, respectively. The equilibrium value of the asset prices, q^i_t, $i = N, T$, is the amount that a potential firm would be willing to pay in period t, in units of the traded good, to acquire a unit of capital and start production in period t. We let $\lambda_t \geq 0$ denote the multiplier on the collateral constraint ($= 0$ in the pre-crisis period) in firm problem. Then, q^i_t solves

$$q^i_t = \frac{VMP^i_{k,t} + \beta \frac{\Lambda_{t+2}}{\Lambda_{t+1}} q^i_{t+1}}{1 - \lambda_t \tau^i}, \; i = N, T. \tag{27}$$

Here, $VMP_{k,t}^i$ denotes the period t value (in terms of traded goods) marginal product of capital in sector i.

When $\lambda_t \equiv 0$, (27) is just the standard asset pricing equation. It is the present discounted value of the value of the marginal physical product of capital. When the collateral constraint is binding, so that λ_t is positive, then q_t^i is greater than this. This reflects that in this case capital is not only useful in production, but also for relieving the collateral constraint. In our model capital is never actually traded since all firms are identical. However, if there were trade, then the price of capital would be q_t^i. If a firm were to default on its credit obligations, the notion is that foreign creditors could compel the sale of its physical assets in a domestic market for capital. The price, q_t^i, is how much traded goods a domestic resident is willing to pay for a unit of capital. Foreign creditors would receive those goods in the event of a default. We assume that with these consequences for default, default never occurs in equilibrium.

To understand the impact of a binding collateral constraint on firm decisions, it is useful to consider the Euler equations of the firm. Differentiating Lagrangian representation of the firm problem with respect to B_{t+1}:

$$1 = \beta \frac{\Lambda_{t+2}}{\Lambda_{t+1}} (1 + r^*)(1 + \lambda_{t+1}), \; t = 0, 1, 2, ... \; . \tag{28}$$

Following standard practice in the small open economy literature, we assume $\beta(1 + r^*) = 1$, so that[10]

$$\Lambda_{t+1} = \Lambda_{t+2}(1 + \lambda_{t+1}), \; t = 0, 1, 2, ... \; . \tag{29}$$

A high value for λ, which occurs when the collateral constraint is binding, raises the effective rate of interest on debt. The interpretation is that when λ is large, then the debt has an additional cost, beyond the direct interest cost. This cost reflects that when the firm raises B_{t+1} in period t, it not only incurs an additional interest charge in period $t + 1$, but it is also further tightens its collateral constraint in that period. This has a cost because, via the collateral constraint, the extra debt inhibits the firm's ability to acquire working capital in period $t + 1$. Thus, when λ is high, there is an additional incentive for firms to reduce π and 'save' by paying down the external debt. Although the firm's actual interest rate on external debt taken on in period t is $1 + r^*$, it's 'effective' interest rate is $(1 + r^*)(1 + \lambda_{t+1})$.

[10] See, for example, Obstfeld and Rogoff (1997).

4.2 Financial Intermediary and Monetary Authority

The financial intermediary takes domestic currency deposits, D_t, from the household at the beginning of period t. In addition, it receives the liquidity transfer, $X_t = x_t M_t$, from the monetary authority.[11] It then lends all its domestic funds to firms who use it to finance their employment working capital requirements, WL. Clearing in the money market requires $D_t + X_t = W_t L_t$, or, after scaling by the aggregate money stock,

$$d_t + x_t = p_t^T \left[w_t^N L_t^N + w_t^T L_t^T \right], \tag{30}$$

where $d_t = D_t / M_t$.

The monetary authority in our model simply injects funds into the financial intermediary. Its period t decision is taken after the household has selected a value for D_t, and before all other variables in the economy are determined. This is the standard assumption in the limited participation literature. It is interpreted as reflecting a sluggishness in the response of household portfolio decisions to changes in market variables. With this assumption, a value of x_t that deviates from what households expected at the time D_t was set produces an immediate reaction by firms and the financial intermediary but not, in the first instance, by households. The name, 'limited participation', derives from this feature, namely that not all agents react immediately to (or, 'participate in') a monetary shock. As a result of this timing assumption, many models exhibit the following behavior in equilibrium. An unexpectedly high value of x_t swells the supply of funds in the financial sector. To get firms to absorb the increase in funds, a fall in the equilibrium rate of interest is required. When that fall does occur, they borrow the increased funds and use them to hire more labor and produce more output.

We abstract from all other aspects of government finance. The only policy variable of the government is x_t.

[11] In practice, injections of liquidity do not occur in the form of lump sum transfers, as they do here. It is easy to show that our formulation is equivalent to an alternative, in which the injection occurs as a result of an open market purchase of government bonds which are owned by the household, but held by the financial intermediary. We do not adopt this interpretation in our formal model in order to conserve on notation.

4.3 Equilibrium

We consider a perfect foresight, sequence-of-markets equilibrium concept. In particular, it is a sequence of prices and quantities having the properties: (i) for each date, the quantities solve the household and firm problems, given the prices, and (ii) the labor, goods and domestic money markets clear.

Clearing in the money market requires that (30) hold and that actual money balances, M_t, equal desired money balances, $\tilde{M}_t$. Combining this with the household's cash constraint, (16), we obtain the equilibrium cash constraint:

$$p_t^T p_t c_t = 1 + x_t. \tag{31}$$

According to this, the total, end of period stock of money must equal the value of final output, c_t. Market clearing in the traded good sector requires:

$$y_t^T - R^* z_t - r^* B_t - c_t^T = -\left(B_{t+1} - B_t\right). \tag{32}$$

The left side of this expression is the current account of the balance of payments, i.e., total production of traded goods, net of foreign interest payments, net of domestic consumption. The right side of (32) is the change in net foreign assets. Equation (32) reflects our assumption that external borrowing to finance the intermediate good, z_t, is fully paid back at the end of the period. That is, this borrowing resembles short-term trade credit. Note, however, that this is not a binding constraint on the firm, since our setup permits the firm to finance these repayments using long term debt. Market clearing in the nontraded good sector requires:

$$y_t^N = c_t^N. \tag{33}$$

Our procedure for computing the equilibrium of the model is a generalization on the multiplier-based method used in the Appendix. It corresponds a variation on the procedure applied in Christiano, Gust and Roldos (2004) and the details are available from the authors on request.

5 Quantitative Analysis

In this section we begin with a discussion of the parameterization of the model. We then report the results for optimal monetary policy.

5.1 Parameter Values and Steady State

The parameter values are displayed in Table 3. These were chosen to so that the model's steady state in the absence of collateral constraints roughly matches features of Korean and Thai data during the first semester of 1997. The share of tradables in total production for Korea, assuming that tradables correspond to the non-service sectors, was approximately one third before the crisis. Combining this assumption with estimates of labor shares from A. Young (1995), we estimate shares of capital for the tradable and nontradable sector in Korea to be respectively 0.48 and 0.21. Based on figures for Argentina, Uribe (1995) and Rebelo and Vegh (1995) estimate the same shares to be 0.52 and 0.37. We take an intermediate point between these estimates by specifying $\nu = 0.50$ and $\alpha = 0.36$. Reinhart and Vegh (1995) estimate the elasticity of intertemporal substitution in consumption for Argentina to be equal to 0.2. We adopt a somewhat higher elasticity by setting $\sigma = 2$. We take the foreign interest rate to be equal to 6 percent and we assume a rate of money growth of 6 percent to obtain a nominal domestic interest rate of 12.3 percent, roughly in line with the experience of Korea and Thailand in the years before the crises. We set $\psi = 3$, implying a labor supply elasticity of 1/3. This is low by comparison to that used in standard business cycle models. Our choice of a low labor supply elasticity is conservative. We presume that a higher labor supply elasticity would have simply resulted in a smaller recession.

The parameters μ_1 and μ_2, in the production function were chosen to reproduce the ratio of imported intermediate inputs in manufacturing to manufacturing value-added in Korea for the year 1995. In that year the ratio is 0.4, in other words $z/V = 0.4$.

As mentioned above, the share of tradable goods in production is roughly one third, so we calibrate the remaining parameters of the model to produce a ratio of consumption of nontradables to tradables of approximately 2. In addition, we chose τ and the stock of debt in the initial steady state equilibrium so that the initial and final debt to output ratio correspond roughly to the experience of Korea and Thailand. Korea's (Thailand's) external debt started at 33% of GDP by end-1997 (60.3%) and was around 26.8% of GDP (51% of GDP) and the end of the year 2000. The interest rate in the initial steady state is set to 11 percent, in annual terms. This is very close to the pre-crisis interest rates in Korea and Thailand. The pre-crisis steady state of the model is reported in Table 4.

5.2 Optimal Monetary Policy

We now consider the optimal monetary policy response to the unexpected imposition of the collateral constraint. The timing of the experiment can be seen in Figure 6. Up until period 0, the economy is in a nonstochastic steady state in which the collateral constraint is not binding. At the start of period 0, the household makes its employment decision in the traded good sector. After this, the collateral constraint on borrowing is unexpectedly imposed. This constraint is binding. Then, the household makes its deposit decision. In making its deposit decision the household assumes money growth will continue at its previous constant rate. After this, the monetary action occurs. Finally, all activity occurs. The remainder of all time unfolds in a non-stochastic way. The collateral constraint remains in force for ever after.

The results are reported in Figure 7. A period in the model is taken to be 6 months. As a benchmark, we include actual (semi-annual) data for Korea. Note the sharp rise in the current account. Also, the drop in GDP, relative to its pre-crisis trend, is nearly 15 percent. The drop in employment is less, though it takes longer to recover. Interestingly, this represents a substantial drop in labor productivity. The drop in consumption is a little larger and more persistent than the drop in output. Share prices fall and then recover. The interest rate rises sharply (as noted in Figure 1), and then falls substantially below its pre-crisis level. The exchange rate initially depreciates by about 50 percent, although the depreciation is ultimately smaller. Finally, inflation jumps from about 5 percent initially to about 12 percent, before stabilizing at a lower level.

Now consider the response of the model under the optimal monetary policy. Note that the current account in the model increases, though not as much as in the Korean data. We suspect that the absence of investment in our model is part of the reason for this. With domestic investment there is an additional margin that can be used to cut back domestic absorption and increase the current account. We expect that in a version of our model with investment, agents would exploit this margin given the very high value of the multiplier on the collateral constraint. The drops in domestic output and consumption are of a similar order of magnitude to corresponding drops in Korea, but substantially less persistent. In the case of employment, the model substantially overstates the initial drop. This is an interesting miss. In effect, the model cannot explain the substantial drop in labor productivity observed in the wake of the Korean financial crisis. The model matches the behavior of asset prices and the nominal exchange rate quite well. However, the model substantially overstates the nominal interest rate and the rate of inflation in the wake of the Korean crisis.

Overall, we believe that the model captures reasonably well the behavior of the Korean data during the currency crisis. Figure 8 helps to assess the optimal monetary policy by comparing it with a particular benchmark. In the benchmark, money growth is held fixed at its pre-shock level. Note that relative to this benchmark, the optimal monetary policy stimulates aggregate output, consumption, employment and imports. It does so by raising the nominal interest rate substantially.

The economic intuition underlying these results can be found in contemplating the collateral constraint. The rise of the interest rate in period 0 slows the exchange rate depreciation and this contributes to a smaller reduction in asset prices. This relative improvement on the asset side of the collateral constraint allows for a smaller drop in imports of intermediate inputs, and a smaller reduction in real GDP, employment and consumption. Once the initial increase in interest rates and exchange rate depreciation set in motion the external adjustment process, labor is reallocated to the traded sector. From that moment onwards, the optimal monetary policy consists of reducing interest rate to values very close to the arrival steady state level of 2%. It is worth noting that during this transition period, and in consonance with the evidence on the crises countries, interest rate cuts are associated with nominal (and real) exchange rate depreciations (Mussa, 2000).

6 Conclusion

In this paper we studied the optimal monetary policy response to a financial crisis of the kind experienced by the Asian economies in 1997-98. These crises, as many other emerging market crises, were characterized by a sudden reversal in capital inflows. Using a particular open economy model with collateral constraints, we found that the optimal monetary response to such a crisis involves an initial increase in interest rates, followed by a relatively sharp and rapid reduction in rates in the aftermath of the crisis. Interestingly, this is the policy that was actually followed.

To keep the analysis simple, our model does not include variable investment. In principle, including investment could improve the model's empirical implications. However, whether it does so remains an important, open question. Because capital appears in the collateral constraint, investment in physical capital represents an alternative strategy - beyond paying off international debt - by which agents can reduce the burden of the collateral constraint. In effect, the imposition of the collateral constraint is equivalent to a subsidy to paying off international debt, as well as to investing in domestic capital.[12] Thus, without additional assumptions, we cannot rule out the possibility that in an environment in which investment is variable, a binding collateral constraint could lead to an increase in investment, and to a *fall* in the current account. Clearly, this would deal a blow to the idea that tightening collateral constraints were the driving force behind the Asian financial crises. We suspect, however, that with reasonable investment adjustment costs and other frictions, paying off the international debt would dominate investment in physical capital as a strategy for reducing the burden of the collateral constraint. If so, then the introduction of variable investment would improve our model's empirical implications, by magnifying the rise in the current account in the wake of a financial crisis.

At a methodological level, this paper adds to the literature that studies the impact of financial frictions on the monetary transmission mechanism. In traditional models, financial frictions have the effect of magnifying the effects of monetary actions, without changing their sign. In this model we have shown that financial frictions could actually reverse the sign of the effect of a monetary action.

[12] For a formal statement of this, see Chari, Kehoe and McGrattan (2005).

References

[1] Aghion, Philippe, Philippe Bacchetta, Abhijit Banerjee, 2000, “Currency Crises and Monetary Policy in an Economy with Credit Constraints”, mimeo.

[2] Auernheimer, Leonardo and Roberto Garcia-Saltos, 1999, “International Debt and the Price of Domestic Assets”, mimeo.

[3] Black, Jane, David de Meza and David Jeffreys, 1996, “House Prices, the Supply of Collateral and the Enterprise Economy”, *The Economic Journal, 106: 60-75.*.

[4] Burnside, Craig, Martin Eichenbaum and Sergio Rebelo, 1999, “Hedging and Financial Fragility in Fixed Exchange Rate Systems”, NBER Working Paper No. 7143.

[5] Caballero, Ricardo and Arvind Krishnamurty, 1999, “Emerging Markets Crises: An Asset Markets Perspective”, mimeo.

[6] Calvo, Guillermo, 1998, “Capital Flows and Capital Market Crises”, mimeo, University of Maryland.

[7] Cespedes, Luis, Roberto Chang and Andres Velasco, 2000, “Balance Sheets and Exchange Rate Policy”, mimeo.

[8] Chari, V.V., Patrick Kehoe and Ellen McGrattan, 2005, ‘Sudden Stops and Output Drops,’ manuscript.

[9] Christiano, Lawrence J. and Martin Eichenbaum, “Liquidity Effects and The Monetary Transmission Mechanism”, *American Economic Review, 82: 346-53.*

[10] Christiano, Lawrence J. and Martin Eichenbaum, “Liquidity Effects, Monetary Policy and the Business Cycle”, *Journal of Money, Credit and Banking, 27: 1113-1136.*

[11] Christiano, Lawrence J., Christopher Gust and Jorge Roldos, 2004, ”Monetary Policy in a Financial Crisis”, *Journal of Economic Theory*, Volume 119, Issue 1, Pages 1-245, November.

[12] Corsetti, G., C. Pesenti and N. Roubini, 1998, "What Caused the Asian Currency and Financial Crisis? Part I: A Macroeconomic Overview", NBER Working Paper No. 6833.

[13] Dooley, Michael, 2000, "A Model of Crises in Emerging Markets", *The Economic Journal, 110: 256-272.*

[14] Edison, Hali, Pongsak Luangaram and Marcus Miller, 2000, "Asset Bubbles, Leverage and "Lifeboats": Elements of the East Asian Crisis", *The Economic Journal, 110: 245-255.*

[15] Fuerst, Timothy, 1992, "Liquidity, Loanable Funds, and Real Activity", *Journal of Monetary Economics, 29: 3-24.*

[16] Gelos, Gaston and Alejandro Werner, 1999, "Financial Liberalization, Credit Constraints and Collateral: Investment in the Mexican Manufacturing Sector", IMF Working Paper No.99/25.

[17] Kiyotaki, Nobuhiro, and John Moore, 1997, "Credit Cycles" *Journal of Political Economy, 105: 211-248.*

[18] Krugman, Paul, 1999, "Balance Sheets, the Transfer Problem, and Financial Crises", in P.Isard, A. Razin and A.Rose, eds., *International Finance and Financial Crises: Essays in Honor of Robert P. Flood, Jr.,* Kluwer Academic Publishers.

[19] Krugman, Paul, 1999, *The Return of Depression Economics,* WW Norton &Company, New York.

[20] Lucas, Robert E., 1990, "Liquidity and Interest Rates", *Journal of Economic Theory, 50:273-264.*

[21] Mendoza, Enrique, 2001, "The Benefits of Dollarization when Stabilization Policy Lacks Credibility and Financial Markets are Imperfect", *Journal of Money, Credit and Banking.*

[22] Mussa, Michael, 2000, "Using Monetary Policy to Resist Exchange Rate Depreciation", mimeo, IMF.

[23] Obstfeld, Maurice, and Kenneth Rogoff, 1997, *Foundations of International Macroeconomics*, MIT Press.

[24] Rebelo, Sergio and Carlos Vegh, 1995, "Real Effects of Exchange-rate-based Stabilization: An Analysis of Competitng Theories", *NBER Macroeconomics Annual, 125-187.*

[25] Uribe, Martin, 1997, "Exchange-rate-based Inflation Stabilization: The Initial Real Effects of Credible Plans", *Journal of Monetary Economics, 39: 197-221.*

[26] Young, Alwyn, 1995, "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience", *Quarterly Journal of Economics, 110(3): 641-680.*

Table 1: Syndicated Loans to Emerging Markets
(in billions of U.S. dollars)

Year	Total	Secured	Secured as % of Total
1993	47.5	7.9	16.5
1994	64.9	11.5	17.7
1995	93.0	16.1	17.3
1996	104.3	22.0	21.1
1997	143.7	61.4	42.7
1998	77.3	25.9	33.5
1999	73.1	26.3	35.9

Source: Capital Data, Loanware

Table 2: Intermediate Imports and Total Imports

Panel A: **Thailand**

Year	Total	Intermediate	% of Total
1993	45,995	17,184	37%
1994	54,338	19,294	36%
1995	70,718	25,061	35%
1996	72,248	24,874	34%
1997	63,286	21,860	35%
1998	42,403	14,744	35%
1999	49,919	18,205	36%
2000	62,181	23,663	38%
2001	61,847	22,978	37%
2002	64,317	24,461	38%

Panel B: **Korea**

Total	Intemediate	% of Total
83,800	43,987	52%
102,348	50,158	49%
135,119	64,611	48%
150,339	68,556	46%
144,616	69,361	48%
93,282	45,593	49%
119,752	57,253	48%
160,481	78,975	49%
141,098	71,929	51%
152,126	73,891	49%

Panel C: **Malaysia**

Year	Total	Intermediate	% of Total
1993			
1994			
1995	77,601	50,447	65%
1996	78,426	52,201	67%
1997	79,036	51,922	66%
1998	58,293	40,901	70%
1999	65,389	48,321	74%
2000	81,963	61,233	75%
2001	73,856	53,271	72%
2002	79,881	56,939	71%

Panel D: **Indonesia**

Total	Intermediate	% of Total
28,376	20,035	71%
32,222	23,146	72%
40,921	29,610	72%
44,240	30,470	69%
46,223	30,230	65%
31,942	19,612	61%
30,600	18,475	60%
40,367	26,073	65%
34,669	23,879	69%
	24,118	

Panel E: **Philippines**

Year	Total	Intermediate	% of Total
1993	17,597	7,855	45%
1994	21,333	9,559	45%
1995	26,538	12,174	46%
1996	32,427	14,015	43%
1997	35,933	14,663	41%
1998	29,660	11,586	39%
1999	30,726	12,596	41%
2000	34,491	16,747	49%
2001	33,058	15,121	46%
2002	35,427	14,791	42%

Source: CEIC

Table 3: Parameters Values of the Model

β	0.943	γ	0.3
ψ	3.00	R	1.11
R^*	1.06	r^*	0.06
α	0.36	K^N	10
ν	0.5	K^T	5
μ_1	1	μ_2	3.5
τ	0.08	θ	0.5
ψ_0	0.0036	σ	2
A	1.5	ξ	0.1
		ζ	0.6

Note : Here, β, R and R^* are expressed in annualized terms.

Table 4: Steady State Ignoring Collateral Constraint

L	30	z	2.67
L^T	7.75	L^N	22.25
c^T	6.17	c^N	16.68
w	0.3824	V	9.33
$\frac{p^N c^N}{c^T}$	2.39	y^T	9.34
p^N	0.8861	p^T	0.0515
q^T	22.95	q^N	18.54
B	14.2	$\frac{B}{p^N c^N + y^T - R^* z}$	0.6644

Table 5: Arrival Steady State with Monetary Experiment

L	30.69	z	2.703
L^T	7.911	L^N	22.78
c^T	6.264	c^N	16.94
w	0.4088	V	9.4341
$\frac{p^N c^N}{c^T}$	2.3912	y^T	9.44
p^N	0.8844	p^T	0.047
q^T	23.19	q^N	18.78
B	13.37	$\frac{B}{p^N c^N + y^T - R^* z}$	0.618

7 Appendix: Strategy for Solving Model in Section 3

For purposes of numerical analysis of the example in section 3, it is convenient to substitute out the real wage rate by combining (10) and (14). Solving the resulting expression for p^N, we obtain:

$$\frac{1}{p^N} = \frac{1-\gamma}{\gamma}\left[\frac{\kappa}{1+\tau} - 1\right],\ \kappa \equiv \frac{\gamma\,(1-\alpha)\,K^{\alpha}}{\psi_o L^{\psi+\alpha}}. \tag{34}$$

In (34), κ is of interest because a planner for whom c^T is free would set L so that $\kappa = 1$. We now have five variables, p^N, q, L, z, λ, whose equilibrium values can be determined by the five equations, (7), (9), (11), (12), (34), as well as the nonnegativity constraints, (13).

These equations suggest a simple strategy for computing an equilibrium. We define a mapping from the space of admissible equilibrium multipliers, $J = [0, 1/\tau^N]$, to candidate equilibrium outcomes that satisfy our five equilibrium conditions, excluding (12). We then adjust $\lambda \in J$ until (12) is satisfied. When this is so, the candidate equilibrium outcomes constitute an actual equilibrium. The mapping from $\lambda \in J$ to candidate outcomes is as follows. First, conjecture that p^N takes on a positive, finite value. Then, compute the value of z that solves (11). After this, compute the value of L that satisfies (7) and evaluate κ in (34). If $\kappa > (1+\tau)$, then use (34) to compute p^N (note that the finiteness assumption on p^N is verified). In this case q can be computed from (9). Finally, compute $\tau^N qK - R^* z$, so that (12) can be evaluated. Now suppose $\kappa \leq (1+\tau)$. In this case, set $p^N = \infty$ (i.e., $1/p^N = 0$) and $\kappa = 1+\tau$. The latter expression determines a value for L, which replaces the (larger) value computed above. Solve for the smaller of the two values of z which satisfy (7) with the given L (it can be verified that there must be two solutions because the object on the left of the equality in (7) forms an inverted 'U' shape when graphed as a function of z and because (7) was satisfied for the previous, larger, value of L). According to (9), $q = \infty$ and therefore $\tau^N qK - R^* z = \infty$ also.

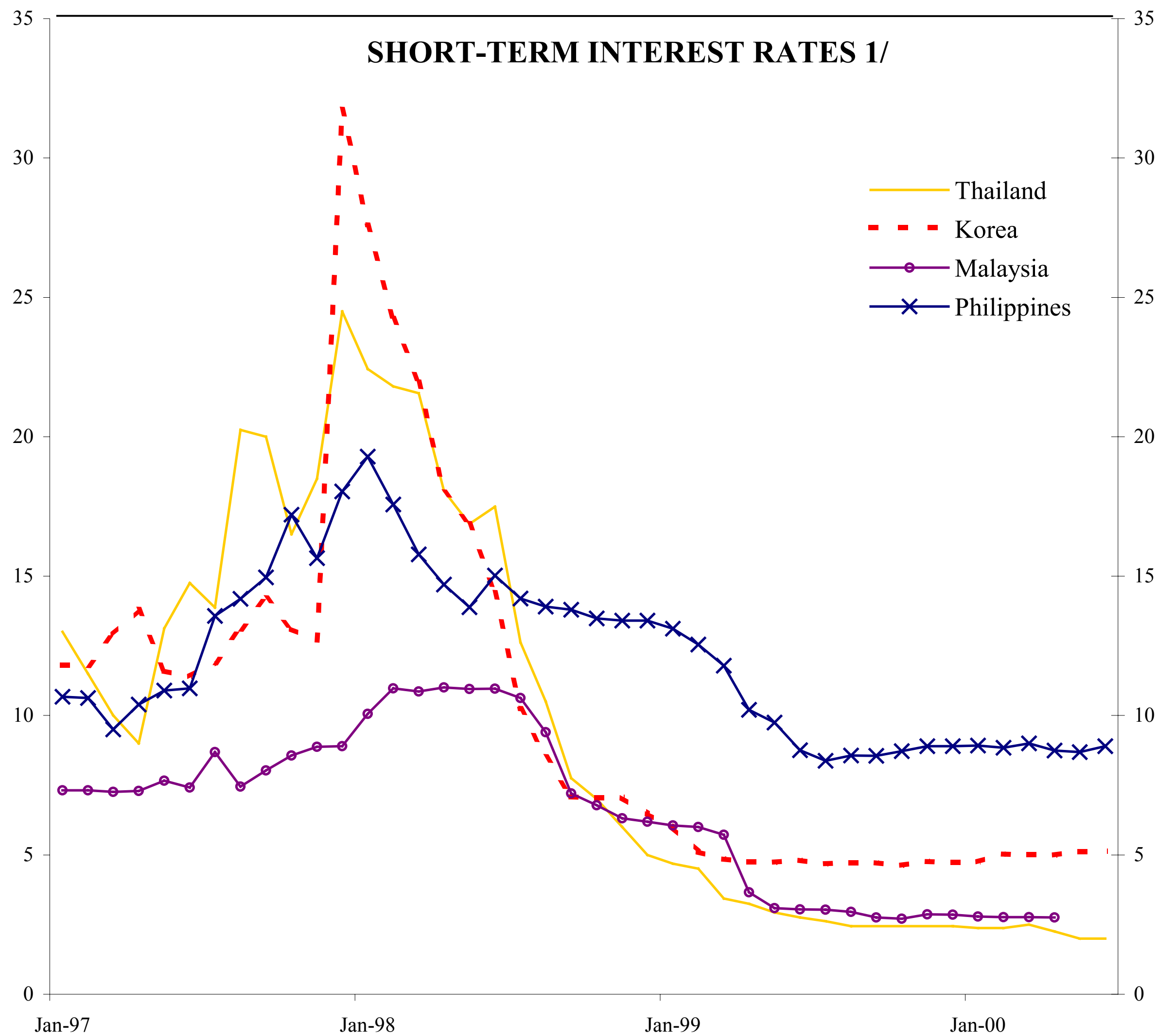
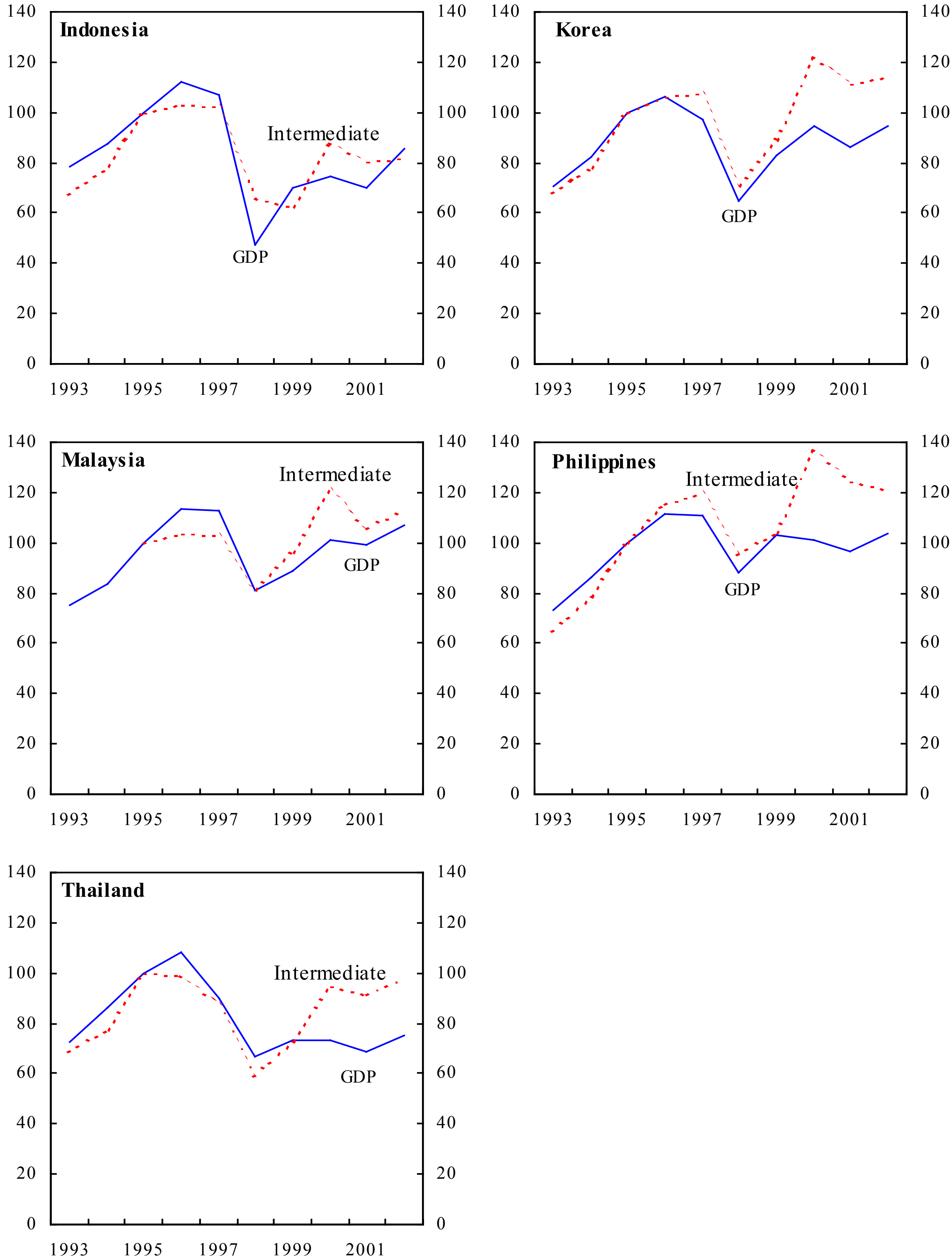

SHORT-TERM INTEREST RATES 1/
Thailand
Korea
Malaysia
Philippines
35
30
25
20
15
10
5
0
Jan-97
Jan-98
Jan-99
Jan-00

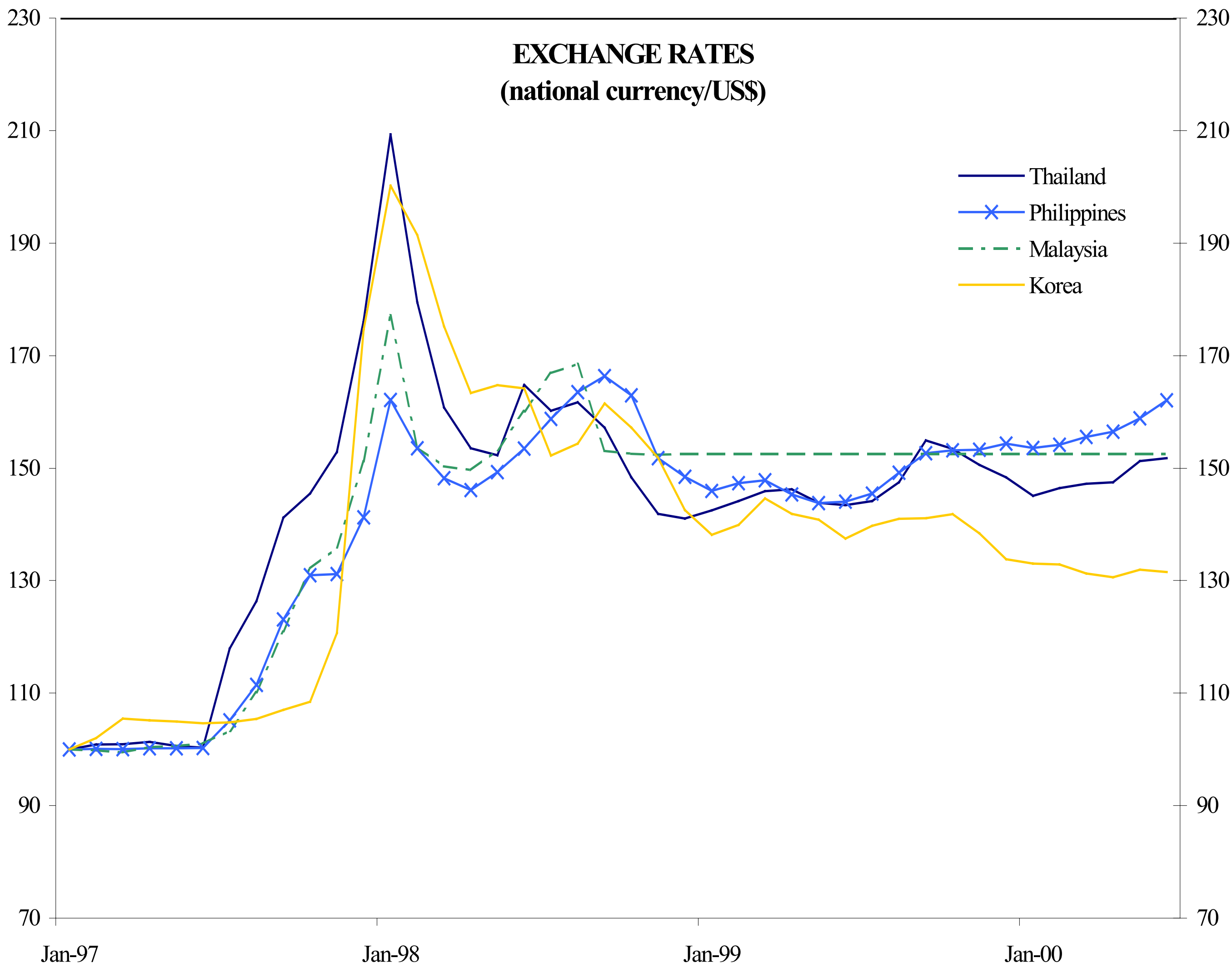
Figure 1

Intermediate Goods Import vs. GDP
(Index 1995 = 100)



Sources: CEIC; and WEO.

Figure 2



EXCHANGE RATES
(national currency/US$)
Thailand
Philippines
Malaysia
Korea
230
210
190
170
150
130
110
90
70
Jan-97
Jan-98
Jan-99
Jan-00

Figure 3

Figure 4: Labor Market Equilibrium

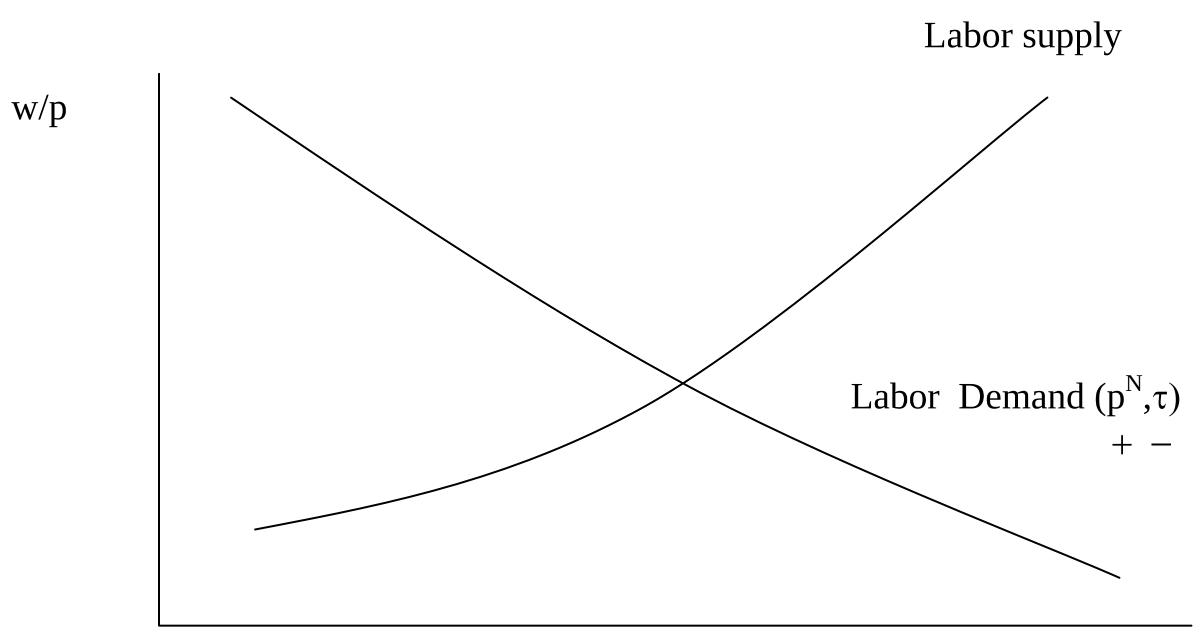


Figure 5: Equilibrium Associated With Various Tax Rates

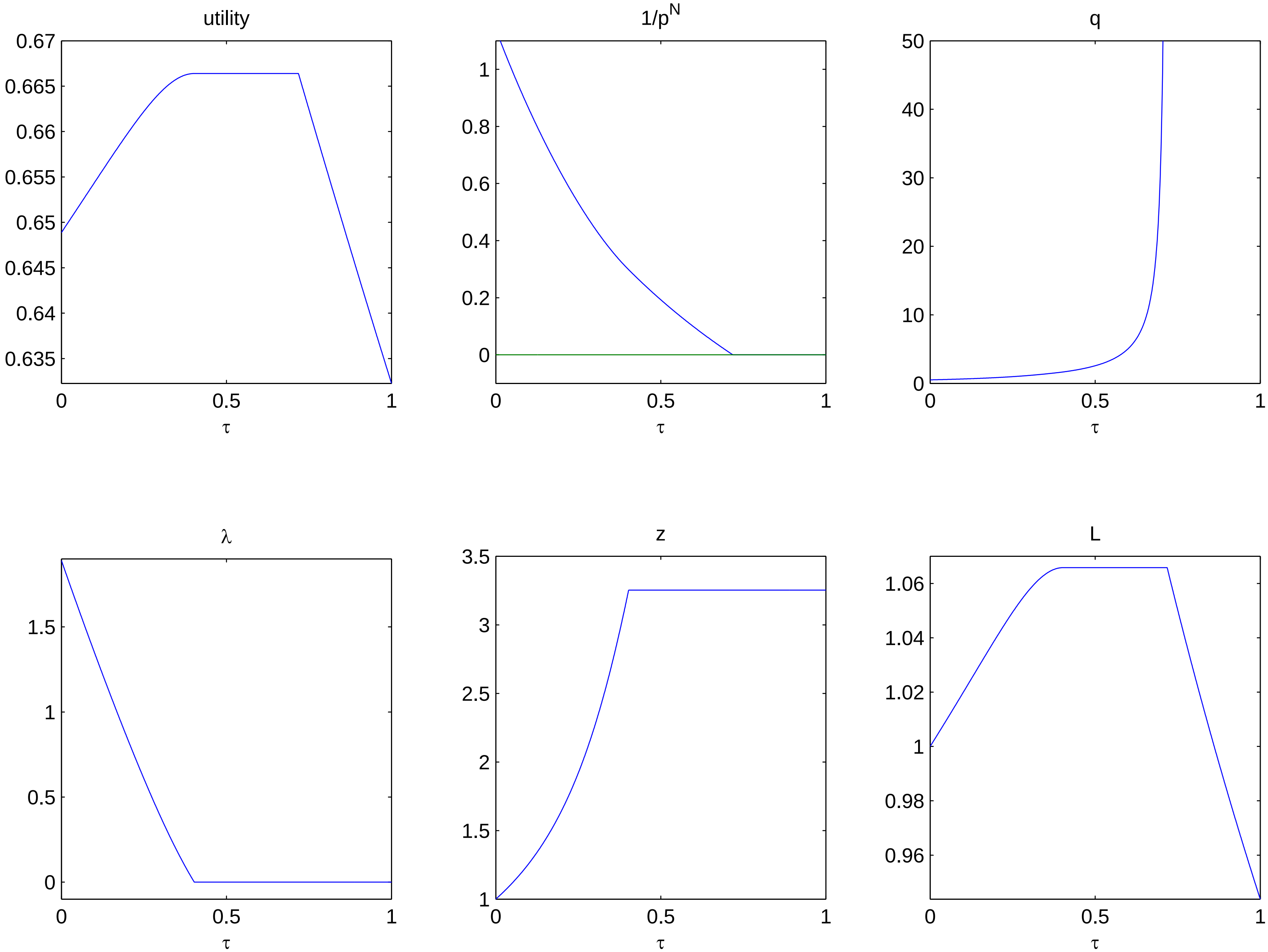


Figure 6: Timing

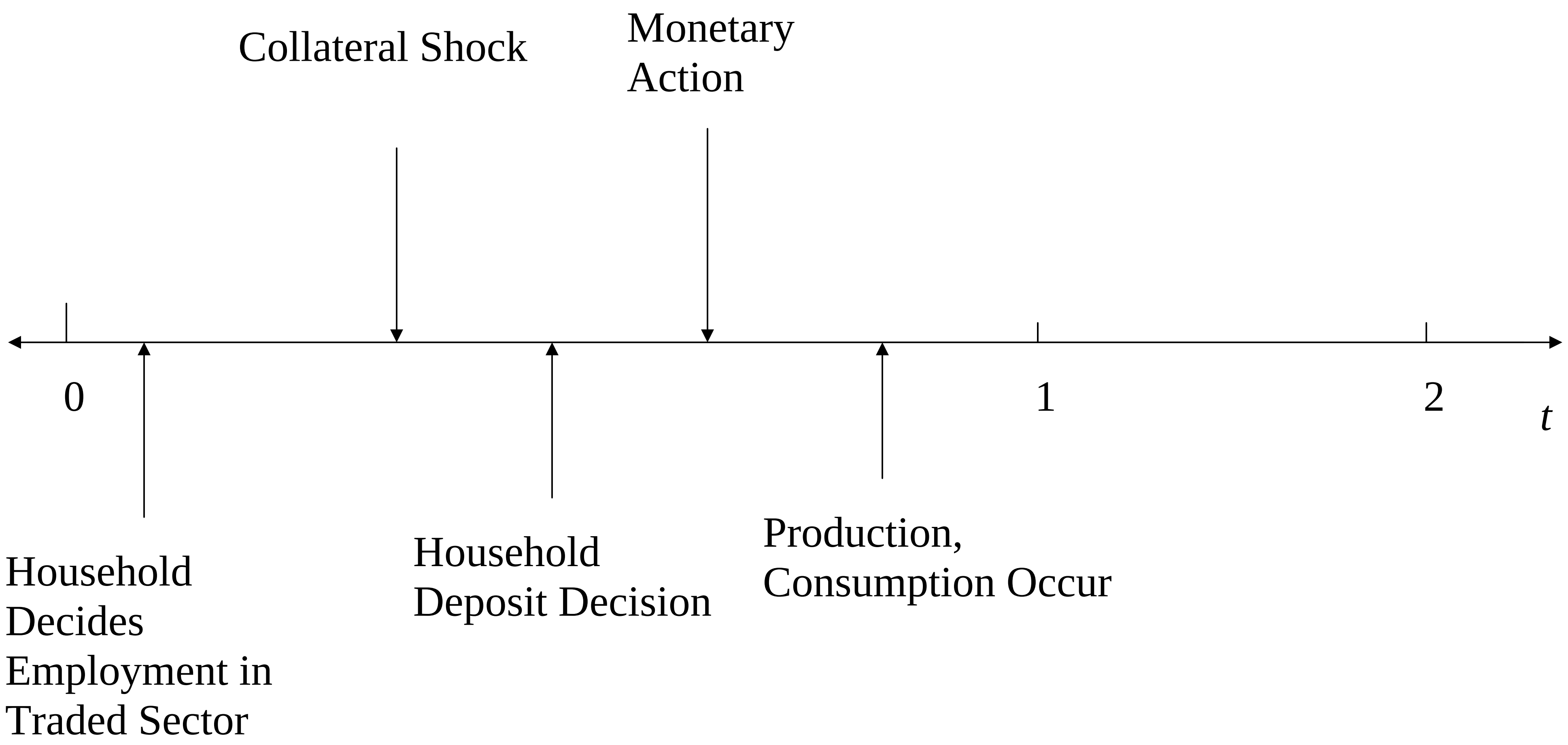


Figure 7: Optimal and Constant Money Growth

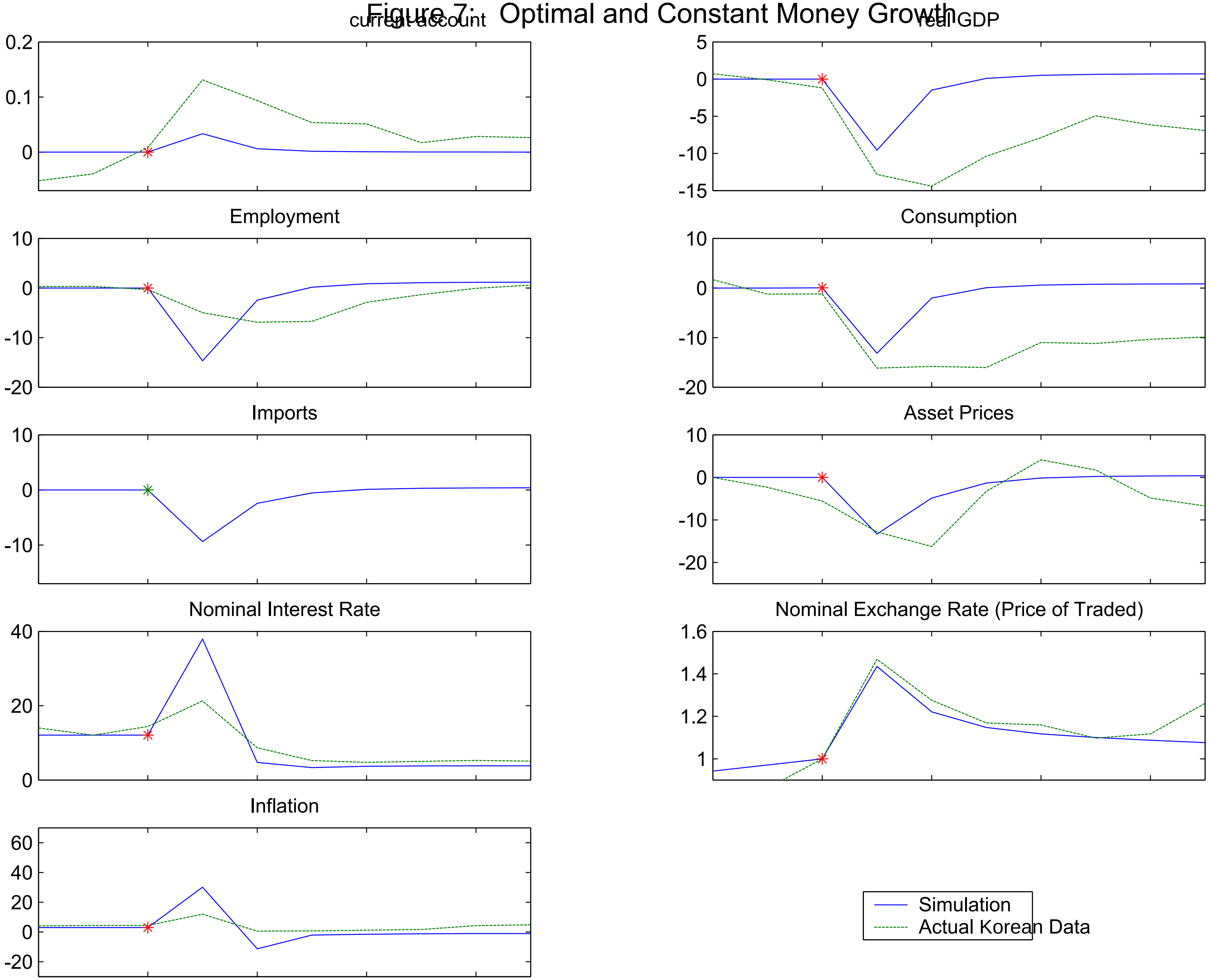


Figure 8: Optimal and Constant Money Growth