Smoothing Sudden Stops: Interest-Rate Rule Matters

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November 2009

Abstract

Emerging economies are still prone to sudden stops. Designing a monetary policy that would enable a smoother exit from a sudden stop is an ongoing challenge for economists. Many emerging economies are now adapting flexible exchange rate regimes with a strong commitment to inflation targeting by means of interest rate as a policy instrument. Although inflation targeting is considered as a good policy choice for tranquil times, its potency to pull the economies out of sudden stops is yet to be explored. In this respect, this paper investigates the competence of alternative interest rate rules. The results suggest that in targeting inflation the monetary authority of an emerging economy should focus on the dynamics of consumer price index and adopt a regime switching policy where at the start of a sudden stop the authority adjusts the interest rate according to forward-looking smoothing interest rate rule and once the economy returns to its pre-crisis output level, the authority switches to using the simple interest rate rule.

JEL Codes: E5, F3, F4

Keywords: Sudden Stops, Inflation Targeting, Forward-looking Interest Rate Rules, Interest-Rate Smoothing

*I am grateful to Vincenzo Quadrini, Robert Dekle and Fernando Zapatero for their valuable suggestions and their support. All errors are my own.

1 Introduction

Emerging economies are still prone to sudden stops and a fixed exchange-rate regime is no longer an option due to difficulty of maintaining such a policy during a financial crisis. The search for a monetary policy rule that would maintain a low inflation target in tranquil times and possibly manage a smooth exit from sudden stops is still ongoing. Currently emerging economies are adopting flexible exchange rate regimes with a strong commitment to inflation targeting, by means of interest rate as a policy instrument. Although inflation targeting is known to perform well in tranquil times, its performance during sudden stops has not been adequately explored[1].

This paper studies the potency of inflation targeting in smoothing sudden stops. The model introduced in the paper is a modified version Gertler et al. (2006) which is a small open economy version of Bernanke et al. (2000) built on the so-called financial accelerator framework. The financial accelerator framework is well-known for its competency in explaining the balance sheet problems that arise during financial crises, mainly in the form of currency mismatches and non-performing loans [Krugman (1999) and Dornbusch (2001)]. This framework has been the basis of papers which study fixed versus flexible exchange rate policies [Céspedes et al. (2002), Gertler et al. (2006), Cúrdia (2007)] or exchange rate defense via interest rates during financial crises [Aghion et al. (2000), Christiano et al. (2002), Braggion et al. (2007)]. In this paper, this framework will be used to investigate the effectiveness of inflation targeting with alternative interest rate rules in alleviating the adverse effects of sudden stops. The alternative rules are four types of interest rate rules. The first is a simple interest rate rule where the domestic interest rate is governed by the deviations of current inflation from its respective target value. The second rule is a smoothing interest rate rule where the domestic interest rate adjusts to the deviations of the aforementioned variable but is also restricted within in a band around the previous period's interest rate. The third rule is a forward-looking simple interest rate rule where the domestic interest rate is governed by the deviations of future expected inflation from its respective target value. Finally, the fourth rule is a forward-looking smoothing interest rate rule.

The quantitative analysis of the model yields two important results. First, the model suggests that in targeting inflation the monetary authority should focus on the dynamics of consumer price in-

[1]Theoretical studies that examine inflation targeting with simple interest rate rule as an optimal policy for sudden stops are Caballero and Krishnamurty (2003), Cúrdia (2007). Mishkin (2000) and Fraga et al. (2003) discuss the optimality of inflation targeting for emerging economies and develop prescriptions for inflation targeting design. Moron and Winkelried (2003) suggest that inflation targeting with a policy rule that defends the exchange rate which also takes private sector's inflation expectations into account could be optimal for emerging economies.

dex rather than domestic price index. This is mainly because when consumer price index is the inflation target the exchange rate becomes a determinant in policy response and this allows the monetary authority to reduce the distortion on the return to capital that arises due to financial market imperfections and high liability dollarization in the economy. Second, the model suggests that a monetary authority of an emerging economy should adopt a regime switching policy, where at the start of a sudden stop the authority adjust the domestic interest rate according to the forward-looking smoothing interest rate rule and, once the economy returns to its pre-crisis output level, the authority switches to using the simple interest rate rule. This follows from the simulation results presented in section 4. Accordingly, during a sudden stop the contraction is less under the forward-looking smoothing rule whereas once the recovery starts the growth in real activity is more rapid under simple rule. In the model, a sudden stop is characterized as an unanticipated increase in the foreign interest rate. Under both rules, the unanticipated increase in the foreign interest rate requires an immediate depreciation of the domestic currency and an upward adjustment of domestic interest rate against inflationary pressures. As opposed to the simple rule, under the forward-looking smoothing rule, the upward adjustment in the domestic interest rate is limited. Thus, under the forward-looking smoothing rule, while the domestic interest rate increases less, the domestic currency depreciates more. This has three important implications. First, since under the forward-looking smoothing rule the depreciation of the domestic currency is larger, the country becomes more competitive in the world market. This stimulates the foreign demand for domestic goods, i.e. exports of the country. The increased demand for domestic goods stimulates production in the wholesale sector. Second, the larger depreciation of the domestic currency under the smoothing rule would lead to less demand for foreign goods due to the relatively higher price of the foreign good in domestic currency units. Finally, since under the forward-looking smoothing rule the increase in the domestic interest rate is less than the simple rule, the decline in the asset prices and the rental rate on capital will also be less. This eases the pressure on the firms' financing and encourages investment thus production. However, after the sudden stop the relation reverses. Under the forward-looking smoothing rule the growth in the real output, consumption, investment is less than that under the simple rule after the sudden stop. This is mainly because, unlike the simple rule, under forward-looking smoothing rule once the economy enters the recovery period the necessary downward adjustment in the interest rate and the corresponding correction in the exchange rate is not as rapid.

In section 2 the problem is explained and the model is characterized. Section 3 introduces the parameter values used for the quantitative analysis of the model. In section 4, the results are presented. Finally, in section 5 we conclude.

2 The Model

This is a variant model of Gertler et al. (2006) which is a small open economy version of the financial accelerator model introduced in Bernanke et al. (2000) excluding the inclusion of money and price rigidities. The model consists of three types of producers: wholesale, capital and retail sectors, and three types of agents: households who own the retail firms, entrepreneurs who manage the wholesale firms, and capital producers. In the model, there is also a monetary authority which determines the domestic interest rate via a policy rule, a government which follows a balanced budget policy.

Briefly, the circular flow in the economy is as follows: the capital producers utilize domestic and foreign final goods in the production of the capital good; the wholesale producers employ the capital good as an input; the retail firms utilize wholesale goods to produce differentiated goods that are aggregated into the final good; the households receive labor income, profits and asset returns from which they can consume a composite good of domestic and foreign final goods.

2.1 Households

The household's consumption good, C_t, in this economy is a composite of domestic and foreign final goods, C_t^d and C_t^f, respectively. Assuming that the household's intratemporal elasticity of substitution between domestic and foreign goods, ν, is constant over time, the consumption composite is obtained by

$$C_t = \begin{cases} \left[(\gamma)^{\frac{1}{\nu}} \left(C_t^d\right)^{\frac{\nu-1}{\nu}} + (1-\gamma)^{\frac{1}{\nu}} \left(C_t^f\right)^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}} & \text{if } \nu \geq 0 \\ \left(C_t^d\right)^{\gamma} \left(C_t^f\right)^{(1-\gamma)} & \text{if } \nu = 1 \end{cases} \tag{2.1.1}$$

where $\gamma \in (0,1)$. Here, γ determines the relative weights that domestic and foreign final goods receive in the consumption composite. Given the preferences of the household over domestic and foreign final goods and the prices, the cost minimization implies the following demand functions

$$C_t^d = \gamma \left(\frac{P_t^d}{P_t}\right)^{-\nu} C_t \tag{2.1.2}$$

$$C_t^f = (1-\gamma) \left(\frac{P_t^f}{P_t}\right)^{-\nu} C_t \tag{2.1.3}$$

and the consumer price index P_t

$$P_t = \begin{cases} \left[\gamma\,(P_t^d)^{1-\nu} + (1-\gamma)\,(P_t^f)^{1-\nu}\right]^{\frac{1}{1-\nu}} & \text{if } \nu \geq 0 \\ (P_t^d)^{\gamma}\,(P_t^f)^{(1-\gamma)} & \text{if } \nu = 1 \end{cases} \tag{2.1.4}$$

where P_t^d and P_t^f are the price of a domestic and foreign final goods in domestic currency units. On the other hand, the price of the foreign good in units of foreign currency, P_t^{f*}, can be written as

$$P_t^{f*} \;=\; \frac{P_t^{Wf}}{S_t} \tag{2.1.5}$$

where P_t^{Wf} is the wholesale price of the foreign good in domestic currency units, and S_t is the nominal exchange rate. The above equality implies that at the wholesale level, before pricing in the retail sector, the law of one price holds.

Given the characterization of the consumption composite above, the preferences of the household over the composite good and the leisure is represented by

$$E_0 \sum_{t=0}^{\infty} \beta^t\, u(C_t, L_t) \tag{2.1.6}$$

where $\beta \in (0,1)$ is the subjective time discount factor. The period utility function, $u(.,.)$, depends on both consumption, C_t, and labor supply, H_t, and has the following form

$$u(C_t, H_t) \;=\; ln\,(C_t) - \theta\,\frac{H_t^{1+\vartheta}}{1+\vartheta}$$

where $\vartheta \geq 0$ [2].

The household optimally splits its income after tax, T_t, between consumption and saving in every period subject to the its budget constraint. We assume that the household cannot access the international financial markets. Thus, they can only trade assets, A_{t+1}, denominated in domestic currency with a nominal rate of return of i_t^d. In equilibrium, the domestic assets exist in zero net supply so that $A_t = 0$ for all t. The household income consists of the nominal wage collected, W_t, dividends paid by the retail firms, $\Pi_{r,t}$, and the returns from domestic asset savings $(1 + i_{t-1}^d)\,A_t$.

[2] $\frac{1}{\vartheta}$ is the labor supply elasticity with respect to wage

Finally, the budget constraint of the household can be written as

$$P_t C_t + A_{t+1} \leq W_t H_t + \Pi_{r,t} - T_t + (1 + i^d_{t-1})\, A_t \tag{2.1.7}$$

The household maximizes the expected discounted lifetime utility (2.1.6) subject to the budget constraint (2.1.7). The Euler equation resulting from this maximization is given by

$$1 \;=\; \beta E_t \left[(1 + i^d_t)\, \frac{C^{-\sigma}_{t+1}}{C^{-\sigma}_t}\, \frac{P_t}{P_{t+1}} \right] \tag{2.1.8}$$

The Euler equation (2.1.8) relates the gross nominal interest rate in the domestic market to the expected inflation rate $\pi_{t+1} \;=\; P_{t+1}/P_t$. The household's choice between consumption of the domestic and foreign good is given by

$$\frac{C^d_t}{C^f_t} \;=\; \frac{\gamma}{(1-\gamma)} \left(\frac{P^d_t}{P^f_t} \right)^{-\nu} \tag{2.1.9}$$

Finally, the following equality determines the household's choice between labor versus leisure.

$$\frac{1}{C_t} \frac{W_t}{P_t} \;=\; \theta\, H^{\vartheta} \tag{2.1.10}$$

2.2 Foreign Demand for Domestic Goods

The foreign demand for the domestic goods, C^{d*}_t, is given by

$$C^{d*}_t \;=\; \left[\left(\frac{P^{d*}_t}{P^*_t} \right)^{-\varsigma} Y^*_t \right]^{\varepsilon} (C^{d*}_{t-1})^{1-\varepsilon} \tag{2.2.1}$$

where $\varepsilon \;\in\; (0,1)$, Y^*_t is the exogenously given level of foreign real output, the term $(C^{d*}_{t-1})^{1-\varepsilon}$ represents the inertia in foreign demand for domestic products, and ς is the price elasticity of foreign demand for the exports. According to this formulation, the exports depend on the foreign real output, price of good in foreign currency units, and the inertia term. Note that at the steady state the economy is assumed to have a balanced trade.

2.3 Wholesale Producers

The firms in the wholesale market are owned and operated by risk-neutral entrepreneurs. Given the available technology, entrepreneurs combine capital and labor in the production of wholesale output. They can finance their investment in new capital by using their own funds and through borrowing from foreign financial markets. Here, it is implicitly assumed that entrepreneurs do not have enough internal funds to fully finance their investment projects. For this purpose, entrepreneurs are assumed to manage a wholesale firm for a limited time period so that they never accumulate enough resources to fully finance purchases of new capital with their internal funds. At the end of every period, the entrepreneurs face a positive probability of exit from entrepreneurship, i.e. $1-\phi$,[3]. In order for the population of entrepreneurs to remain stationary, every entrepreneur who exits is replaced with a new entrepreneur whose only endowment is his inelastically supplied labor, H_t^e. This ensures that a new entrepreneur has some initial funds.

Wholesale firms are price takers in the competitive market. Let L_t and K_t be the labor and capital used by entrepreneurs in the production of wholesale good. Labor is a composite of labor supplied by households and the entrepreneur's own labor and is given by

$$L_t = H_t^{e\,\Omega}\, H_t^{1-\Omega} \tag{2.3.1}$$

Also, the portion of capital that is employed in wholesale production is measured by the utilization rate u_t. The capital utilization rate is endogenously determined by the firm. Denoting real output as Y_t^W, the production technology is given as

$$Y_t^W = \omega_t Z_t \left(u_t K_t\right)^{\alpha}\ L_t^{1-\alpha} \tag{2.3.2}$$

where, Z_t is the total factor productivity shock which is the only source of aggregate uncertainty, ω_t is the idiosyncratic shock to the individual firm, and α is the income share of capital services. The distribution of Z_t is publicly known. ω_t is a continuous random variable independently and identically distributed across firms and time with mean equal to unity.

Given the capital stock, K_t, determined at the end of the previous period, $t-1$, the labor demand

[3]The expected horizon for an entrepreneur will be $\frac{1}{1-\phi}$.

of the wholesale firm is expressed as

$$(1-\alpha)(1-\Omega)\,\frac{Y_t^W}{H_t} = \frac{W_t}{P_t^W} \tag{2.3.3}$$

$$(1-\alpha)\Omega\,\frac{Y_t^W}{H_t^e} = \frac{W_t^e}{P_t^W} \tag{2.3.4}$$

where P_t^W is the nominal price of the domestic wholesale output.

On the other hand, the capital available to a wholesale firm in the current period is determined in the previous period. Hence, an entrepreneur chooses the labor and capital utilization rate before purchasing the capital to be used in the next period. Capital depreciates via the production process and the rate of depreciation is assumed to be a convex function of the utilization rate. Following Baxter and Farr (2001), let the depreciation rate have the following form:

$$\delta(u_{t+1}) \;=\; a + \frac{b}{1+\xi}\,(u_{t+1})^{1+\xi} \tag{2.3.5}$$

with $a, b, \xi \; > 0$. According to this function, the depreciation of capital is higher at higher rates of capital utilization. The optimality condition for capital utilization is

$$\alpha\,\frac{Y_t^W}{u_t} \;=\; \delta'(u_t)\,K_t\,\frac{P_t^I}{P_t^W} \tag{2.3.6}$$

where P_t^I denotes the price of new investment goods, and $\delta(u_t)$ is the capital depreciation rate. According to the above expression, the wholesale firm optimally determines the level of capital utilization taking its marginal cost, i.e. capital depreciation, into account.

At the end of period t, the firm has to purchase capital which can be used in the subsequent period $t+1$ to produce output at that time. The firm finances the acquisition of capital by its own net worth available at the end of the period, and by external financing. The external financing is in the form of nominal bonds issued in the international financial markets. If we denote the capital stock purchased, net worth of the firm in domestic currency and the foreign currency denominated nominal bond issued at time t as K_{t+1}, N_{t+1}, and B_{t+1}, respectively, then the capital financing can be written as

$$Q_t^K\,K_{t+1} \;=\; N_{t+1} + S_t\,B_{t+1} \tag{2.3.7}$$

where Q_t^K is the nominal price of capital in domestic currency.

The demand for capital depends on the expected marginal return on capital and the expected marginal financing cost. The gross real return of capital, i.e. $(1 + r^K_{t+1})$, is given by the following optimality condition

$$E_t \left[1 + r^K_{t+1}\right] \; = \; E_t \left[\frac{P^W_{t+1} \left(\alpha \frac{Y^W_{t+1}}{K_{t+1}} \right) + Q^K_{t+1} - \delta(u_{t+1}) P^I_{t+1}}{Q^K_t} \right] \tag{2.3.8}$$

where $\left(\alpha \frac{Y^W_{t+1}}{K_{t+1}} \right)$ is the marginal product of capital. In the above equation (2.3.8) the price of capital reflects the aggregate adjustment costs born by the capital-producing sector. The adjustment costs apply to net capital. To formulate such a specification, the firms are assumed to pay the depreciation costs associated with capital before it is sold in the market.

Once the demand for capital is known, given its net worth, the firm's external financing need is determined. The interest rate charged to the firm for its external finance is more expensive than the internal finance. This is mainly because the lender charges a premium against the firm's risk of repudiation and collateralizes the firm's debt. Accordingly, the premium increases as the firm's leverage ratio, i.e. real debt-to-net worth, increases[4]. Following this, the firm's marginal cost of fund is defined as the product of the gross premium for external financing, $\chi_t(.)$, and the gross real opportunity cost of funds that would arise in the absence of capital market frictions.

$$E_t \left[1 + r^k_{t+1}\right] \; = \; \left(\frac{S_t B_{t+1}}{N_{t+1}} \right)^{\chi} \; E_t \left[(1 + r^f_t) \frac{S_{t+1}}{S_t} \right] \tag{2.3.9}$$

with

$$\chi'(.) \; > \; 0, \; \chi'(0) \; = \; 0, \; \chi'(\infty) \; = \; \infty \tag{2.3.10}$$

In the above equation, $(1+r^f_t)$ is the real interest rate on foreign assets. It is exogenously given. The interest rate includes the country risk premium and therefore is greater than the risk-free interest rate.

$$(1 + r^f_t) = \Lambda_t \, (1 + r^{rf}) \tag{2.3.11}$$

Moreover, the interest rate on foreign assets is related to that of domestic assets through uncovered

[4] The firm's contracting problem for its external financing is similar to that presented in the working paper version of Gertler et al. (2006).

interest parity condition

$$0 \;=\; E_t \left[\frac{P_t}{P_{t+1}} \left[(1+i_t^d) - (1+i_t^f)\, \frac{S_{t+1}}{S_t} \right] \right] \tag{2.3.12}$$

Equation (2.3.9) provides the foundation for the financial accelerator. Accordingly, the firm would demand capital to the extent that its return is no more than its cost of financing. Equations (2.3.8) and (2.3.9) links the movements in the price of capital to the collateral.

Another financial accelerator is the relation that describes the evolution of net worth. Let V_t denote the value of firm's capital net of borrowing costs carried over from the previous period. Then, the total net worth of the firms in the wholesale market is the sum of the remaining entrepreneurs value, V_t, and wage income of all entrepreneurs $W_t^e H_t^e$:

$$N_{t+1} \;=\; \phi\, V_t + W_t^e H_t^e \tag{2.3.13}$$

with

$$V_t \;=\; \left(1+r_t^k\right)\; Q_{t-1}^K\; K_t - \left[\chi_{t-1}(.)\; (1+r_{t-1}^f)\, \frac{S_t}{S_{t-1}} \right]\; S_{t-1}\; B_t \tag{2.3.14}$$

According to equations (2.3.13) and (2.3.14), the movements in the firm's net worth is related to unanticipated movements in exchange rates, returns and borrowing costs. The entrepreneurs who exit at the end of the period t consumes their net worth:

$$P_t C_t^e = (1-\phi) V_t \tag{2.3.15}$$

where C_t^e is the amount of composite consumption good consumed by the exiting entrepreneurs.

2.4 Capital Producers

Capital producers are assumed to repair the depreciated capital and to produce new capital goods. New capital is not used to replace the depreciated part of the old capital. Instead, the old capital is repaired by the capital producers as a separate task. Capital producers operate in a competitive market and thus are price takers. They use a composite investment good as an input. The investment good is obtained through

$$I_t \;=\; \left[(\gamma_i)^{\frac{1}{\nu_i}}(I_t^d)^{\frac{\nu_i-1}{\nu_i}} + (1-\gamma_i)^{\frac{1}{\nu_i}}(I_t^f)^{\frac{\nu_i-1}{\nu_i}}\right]^{\frac{\nu_i}{\nu_i-1}} \tag{2.4.1}$$

where I_t^d and I_t^f are domestic and foreign inputs for capital production[5], respectively, $\gamma_i \in (0,1)$ quantifies the relative weights of domestic and foreign inputs, and $\nu_i \geq 0$ is the intratemporal elasticity of substitution.

Given $(2.4.1)$, and the prices of domestic and foreign final goods, P_t^d and P_t^f, the cost minimization implies the following demand functions of capital producers for the domestic and foreign inputs

$$I_t^d \;=\; \gamma_i \left(\frac{P_t^d}{P_t^I}\right)^{-\nu_i} I_t \tag{2.4.2}$$

$$I_t^f \;=\; (1-\gamma_i) \left(\frac{P_t^f}{P_t^I}\right)^{-\nu_i} I_t \tag{2.4.3}$$

where P_t^I is the price of the composite investment good. The price index for the investment good, P_t^I, is given by

$$P_t^I \;=\; \left[(\gamma_i)(P_t^d)^{1-\nu_i} + (1-\gamma_i)(P_t^f)^{1-\nu_i}\right]^{\frac{1}{1-\nu_i}} \tag{2.4.4}$$

The used capital is repaired by the capital producers. Entrepreneurs pay the cost of repairing capital to the capital producers. Since the capital market is competitive, the price the entrepreneurs pay to the capital producers for each unit of depreciated capital repaired is just the price of the investment composite. In this process, $\delta(u_t)K_t$ units of investment good is used up.

Conversely, there are adjustment costs in the production of new capital goods. After production of the wholesale good at time t, the new capital is produced in a competitive market by capital producers. I_t units of the investment composite yields $\Phi\left(\frac{I_t}{K_t}\right)K_t$ units of new capital. The $\Phi(.)$ is the adjustment cost function. This function is assumed to exhibit constant returns to scale. Note that the function is concave and increasing with the following two features: $\Phi(\delta) = \delta$ and $\Phi^{'}(\delta) = 1$. Thus, the capital accumulation process is written as

$$K_{t+1} = (1-\delta(u_t))\,K_t + \Phi\left(\frac{I_t}{K_t}\right)K_t. \tag{2.4.5}$$

[5]The inputs are final goods.

It is assumed that the capital producers make their production plans one period in advance in order to capture the delayed response of investment observed in the data. A capital producer firm maximizes its expected profits by choosing I_t and K_t. A capital producer plans his investment to satisfy the following optimality condition from his profit maximization [6]

$$E_{t-1}\left[Q_t^K \Phi'\left(\frac{I_t}{K_t}\right) - \frac{P_t^I}{P_t}\right] = 0 \tag{2.4.6}$$

The first order condition of a capital producer firm with respect to capital [7] is not essential for the solution of the model.

2.5 Retail Firms

The retail sector is populated by a continuum of monopolistically competitive firms of a unit measure indexed by $j \in (0,1)$. The production technology in the retail sector uses the domestic wholesale good as input and differentiates it. During this process, the retailers are assumed to incur a fixed cost, κ. the fixed cost is chosen so that at steady-state the retailers' profit is zero. Let $Y_t^d(j)$ be the amount of the good produced by retailer j. The domestic final consumption good, Y_t^d, can then be defined as

$$Y_t^d \;=\; \left[\int_0^1 \left(Y_t^d(j)\right)^{\frac{\nu_r}{\nu_r-1}} \; dj\right]^{\frac{\nu_r}{\nu_r-1}} - \kappa \tag{2.5.1}$$

The corresponding price of the retail good is also a CES composite of differentiated prices, $P_t^d(j)$,

$$P_t^d \;=\; \left[\int_0^1 \left(P_t^d(j)\right)^{1-\nu_r} \; dj\right]^{\frac{1}{1-\nu_r}} \tag{2.5.2}$$

Cost minimization implies that the demand for each retail good j is

$$Y_t^d(j) \;=\; \left(\frac{P_t^d(j)}{P_t^d}\right)^{-\nu_r} \; Y_t^d \tag{2.5.3}$$

The price stickiness in the final goods market is a la Calvo (1983), i.e. with probability ϱ that is the same for each retailer, which sets its price independent of the time elapsed since the last

[6] This formulation allows for investment delays.

[7] $E_{t-1}\left[Q_t^K\left\{\Phi\left(\frac{I_t^n}{K_t}\right) - \Phi'\left(\frac{I_t^n}{K_t}\right)\frac{I_t^n}{K_t}\right\} - l_t^K\right] = 0$ where l_t^K is the lease rate of capital.

adjustment. So the price of the domestic final good evolves according to

$$P_t^d \;=\; \left(P_{t-1}^d\right)^{\varrho}\;\left(\overline{P}_t^d\right)^{1-\varrho} \tag{2.5.4}$$

where $\overline{P}_t^d$ is the optimal price obtained through maximization of the monopolistically competitive retailer firms' expected discounted profits subject to equation (2.5.4).

$$\overline{P}_t^d \;=\; \mu\,\Pi_{i=0}^{\infty}\;\left(P_{t+i}^W\right)^{(1-\beta\varrho)(\beta\varrho)^i} \tag{2.5.5}$$

where $\mu = \frac{1}{1-1/\varrho}$ is the retail firms' gross markup rate[8].

Combining equation (2.5.4) and (2.5.5), we derive an expression for the gross domestic inflation rate (within the neighborhood of a zero-inflation steady state)

$$\frac{P_t^d}{P_{t-1}^d} \;=\; \left(\mu\,\frac{P_t^W}{P_t^d}\right)^{\psi}\;E_t\left[\frac{P_{t+1}^d}{P_t^d}\right]^{\beta} \tag{2.5.6}$$

where $\psi = \frac{(1-\varrho)(1-\beta\varrho)}{\varrho}$ is decreasing in ρ, the measure of price rigidity. We assume the inflation process for the foreign goods sold in the domestic market similar to that of the domestic goods. The inflation rate for foreign final goods is expressed as

$$\frac{P_t^f}{P_{t-1}^f} \;=\; \left(\mu^f\;\frac{S_t P_t^{f^*}}{P_t^f}\right)^{\psi^f}\;E_t\left[\frac{P_{t+1}^f}{P_t^f}\right]^{\beta} \tag{2.5.7}$$

where $\psi^f = \frac{(1-\varrho^f)(1-\beta^f\varrho^f)}{\varrho^f}$. Due to our law of one price assumption, this specification allows for delay in the exchange-rate pass through mechanism. Using equation (2.5.6) and (2.5.7) we can write the CPI inflation as

$$\frac{P_t}{P_{t-1}} \;=\; \left(\frac{P_t^d}{P_{t-1}^d}\right)^{\gamma}\;\left(\frac{P_t^f}{P_{t-1}^f}\right)^{(1-\gamma)} \tag{2.5.8}$$

[8]We can substitute 2.5.2 at t-1 into 2.5.4 for the first term on the RHS, because the second term is the same for all retail firms.

2.6 Government

The government is assumed to finance its expenditures by lump-sum taxes collected from the households. Thus, the fiscal budget is balanced at all times.

$$G_t = T_t \tag{2.6.1}$$

where the government expenditures are exogenous.

2.7 Resource Constraint

Given the setup of the economy, the resource constraint of the economy is given by

$$Y_t^d \;=\; C_t^d + C_t^{d*} + C_t^W + I_t^d + G_t \tag{2.7.1}$$

2.8 Monetary Policy

In this economy, the monetary authority is committed to implement inflation targeting by means of an interest rate rule. The types of interest rate rules are as follows. In targeting inflation, the monetary authority uses two different price index to focus on, the consumer price index (CPI) and the domestic price index (DPI), respectively. The difference between a CPI and DPI is that the former is a weighted average of the latter and the price of imported goods. Given that the price of imported goods will be assumed constant, targeting CPI as opposed to DPI implies that the exchange rate has a direct impact on the interest rates [Cúrdia (2007)].

2.8.1 Simple Interest Rate Rules

The first rule is a simple interest rate rule where the monetary authority adjusts the nominal interest rate based on current inflation. The simple interest rate rule is characterized as

$$\left(1 + i_t^d\right) = \left(1 + r^{ss}\right) \pi_t^{\phi_\pi} \tag{2.8.1}$$

when CPI is the focus for inflation targeting and

$$(1+i_t^d) = (1+r^{ss}) \left[\frac{p_t^d}{p_{t-1}^d}\pi_t\right]^{\phi_{pd}} \tag{2.8.2}$$

when DPI is the focus for inflation targeting[9].

2.8.2 Smoothing Interest Rate Rules

The second rule is smoothing interest rate rule where the monetary authority adjusts the nominal interest rate based on current inflation, and the previous period's interest rate. Thus, under this rule the interest rate adjusts to changes in inflation at a slower pace. The smoothing interest rate rule is characterized as

$$(1+i_t^d) = (1+r^{ss})\,(1+i_{t-1}^d)^{\phi_r} \left[\pi_t^{\phi_\pi}\right]^{1-\phi_r} \tag{2.8.3}$$

when CPI is the focus for inflation targeting and

$$(1+i_t^d) = (1+r^{ss})\,(1+i_{t-1}^d)^{\phi_r} \left[\left[\frac{p_t^d}{p_{t-1}^d}\pi_t\right]^{\phi_{pd}}\right]^{1-\phi_r} \tag{2.8.4}$$

when DPI is the focus for inflation targeting.

2.8.3 Forward-Looking Simple Interest Rate Rule

The third rule is forward-looking simple interest rate rule where the monetary authority adjusts the nominal interest rate based on the expected inflation rate. Note that using forward-looking interest rate rule, the monetary authority responds to the expectations of the real sector. The forward-looking simple interest rate rule is characterized as

$$(1+i_t^d) = (1+r^{ss})\,E_t\left[\pi_{t+1}^{\phi_\pi}\right] \tag{2.8.5}$$

when CPI is the focus for inflation targeting and

$$(1+i_t^d) = (1+r^{ss})\,E_t\left[\left[\frac{p_{t+1}^d}{p_t^d}\pi_{t+1}\right]^{\phi_{pd}}\right] \tag{2.8.6}$$

[9] p_t^d represents the price of domestic good in real terms.

when DPI is the focus for inflation targeting.

2.8.4 Forward-Looking Smoothing Interest Rate Rule

The fourth rule is forward-looking smoothing interest rate rule where the monetary authority adjusts the nominal interest rate based on the expected inflation rate, and the previous period's interest rate. The forward-looking smoothing interest rate rule is characterized as

$$(1+i_t^d) = (1+r^{ss})\,(1+i_{t-1}^d)^{\phi_r}\; E_t\left[\pi_{t+1}^{\phi_\pi}\right]^{1-\phi_r} \tag{2.8.7}$$

when CPI is the focus for inflation targeting and

$$(1+i_t^d) = (1+r^{ss})\,(1+i_{t-1}^d)^{\phi_r}\; E_t\left[\left[\frac{p_{t+1}^d}{p_t^d}\pi_{t+1}\right]^{\phi_{pd}}\right]^{1-\phi_r} \tag{2.8.8}$$

when DPI is the focus for inflation targeting.

3 Model Parameters

During the 1996-1997 Asian crisis, Indonesia and Korea were the two countries which had the most severe balance sheet problems in the corporate sector, with firms having large debt-to-equity ratios and large foreign exchange exposure. Considering that our model focuses on the firm dynamics, i.e. balance-sheet effect, the model parameters are chosen to stay consistent with certain features of the Korean economy in the 1990s. The parameter values are summarized in Table 1.

Preferences: The discount factor, β is chosen as 0.984. The parameter ϑ in the utility function is set to 0.8. The choice of ϑ corresponds to an elasticity of labor supply, $\frac{1}{\vartheta}$ of 1.25. The elasticity of substitution between domestic and foreign consumption goods, ν, set to 1.

During 1990-2002 Korea's average consumption-to-GDP ratio, $\frac{C}{Y}$, was 0.5. Given this value the share of domestic consumption good in consumption composite, γ, is set to 0.5.

Export Demand: During 1990-2002 Korea's average exports-to-GDP ratio, $\frac{X}{Y}$, was 0.4. So at steady state the exports C^{d^*} is taken as 40% of output. The elasticity of export demand, ς, is 1 while the inertia in export demand, ω, is 0.75. These values are taken from Gertler et al. (2006).

Government Expenditure: The steady-state government expenditure-to-output ratio, G/Y is set as 0.2 which also implies that the lump-sum tax revenues at steady state was also 20% of the output.

Wholesale Good Production: During 1990-2001 Korea's average investment-to-GDP ratio, $\frac{I}{Y}$, was 0.35. To match these values, the share of domestic inputs in investment composite, γ_i, and the share of capital in wholesale production, α, are set to 0.5. At steady state, the average labor hours is taken as $\frac{1}{3}$.

Capital Utilization and Depreciation: The parameter values for the depreciation function and capital utilization are taken from Baxter and Farr (2001). The steady state utilization rate is assumed as 1. The quarterly depreciation at the steady state, δ, is 0.025. Finally, the elasticity of marginal depreciation with respect to the utilization rate, ξ is set to 1.

Productivity Shock: The total factor of productivity in the wholesale goods technology, Z_t, follows an autocorrelation process with an AR(1) coefficient of 0.95. On the other hand, the shocks to technological productivity is assumed to follow a normal distribution with mean 0 and variance 1, i.e. $Z_t \sim N(0,1)$.

Entrepreneurs: The entrepreneur's death rate is calculated as 0.0477.The share of entrepreneurial labor in total labor, Ω, is set to 0.01.

The Contracting Problem: The distribution for the idiosyncratic shock to project yield is taken as log normally distributed with variance σ_ω^2 equal to 0.28, so $ln\ (\omega)\ \sim N(-\frac{1}{2}\sigma_\omega^2, \sigma_\omega^2)$. Additionally, the idiosyncratic shocks averaged over wholesale firms, $E[\omega]$, is equal to 1. The fraction of realized payoffs to banks lost in bankruptcy, μ_b, is set to 12%.

Capital Production: The elasticity of substitution between domestic and foreign investment inputs, ν_i is set to 0.25. This value is commonly used in the literature for emerging economies. The share of domestic investment good in the investment composite, γ_i, is set to 0.5.

Retail Sector: The mark-up rates for both the domestic and foreign retail sector, μ and μ^f, are set to 1.2. The elasticity of the price of capital with respect to investment-capital ratio, $\eta_{\frac{i}{k}}$, is taken as 2. The price inertia in the retail sector, ϱ, is set to 0.75. The same value is assumed for the foreign retail sector, ϱ_f.

Risk Premium: The steady state external finance premium and leverage ratio are taken as 3.5 percent. These values are then used to calculate the parameter capturing the rate of firm risk responding to its leverage ratio. Accordingly, the parameter χ equals to 0.05.

Table 1: Parameter Values

β	Discount factor	0.984
ν	Intra-temporal elast. of subst. in C	1
ν_i	Intra-temporal elast. of subst. in I	0.25
γ	Share of domestic goods in C	0.5
ϑ	Elasticity of labor supply	1.25
H	Hours worked relative to total hours available	1/3
ς	Elasticity of export demand	1
$1-\varepsilon$	Weight of inertia in export demand	0.75
α	Capital share	0.5
γ_i	Share of domestic goods in I	0.5
$\frac{C^{d^*}}{Y^d}$	Exports to output ratio	0.4
$\frac{G}{Y^d}$	Government expenditures to output ratio	0.2
Ω	Share of entrepreneurial labor	0.01
$\bar{u}$	Steady-state capital utilization rate	1
$\delta(\bar{u})$	Steady-state quarterly capital depreciation rate	0.025
ξ	Elast. of marginal depreciation wrt u	1
μ	Steady-state mark-up value	1.2
$\eta_{\frac{i}{k}}$	Elast. of q wrt to $\frac{i}{k}$	2
$1-\phi$	Entrepreneur's death rate	0.0477
μ_b	Fraction of realized payoffs lost in bankruptcy	0.12
ϱ	Probability of fixing prices	0.75
σ_ω	Variance of the productivity variable ω	0.28
θ_z	Autoregressive coefficient of the productivity variable z	0.95
θ_Λ	Autoregressive coefficient of the country risk premium Λ	0.95

Monetary Policy: In this paper, the performance of various interest rate rules will be assessed. In this respect, the weight on both inflation targets, CPI or DPI, will take on values of 1.1 and 2.0, and the smoothing factor will take on values 0.45, 0.75 and 0.90, respectively.

4 Results

This section presents both the loss of each policy rule obtained through simulations and their impulse responses to sudden stops.

4.0.5 Simulation Results

The first goal is to find out whether a policy prescription of responding to inflation strongly is beneficial or not. To compute the benefit of the policy rules, a loss function is used. This function is characterized as the average of the variance of the output gap and the variance of inflation.

$$L = \frac{1}{2}\, var\left(ln\left(\frac{Y}{Y^{ss}}\right)\right) + \frac{1}{2}\, var\left(ln(\pi)\right) \tag{4.0.9}$$

Table 2: Simple Interest Rate Rules

Weights	var$\left(ln\left(\frac{Y}{Y^{ss}}\right)\right)$	var$(ln(\pi))$	Loss
$\phi_\pi = 1.1$	0.0021	0.0223	0.0122
$\phi_\pi = 2.0$	0.0054	0.0003	0.0028
$\phi_{pd} = 1.1$	0.0073	0.0064	0.0068
$\phi_{pd} = 2.0$	0.0091	0.0009	0.0050

The simulation results presented in Table 2 suggest that the monetary authority should adopt a strong response to inflation. The results also suggest that the loss incurred by the economy would be less if the monetary authority focuses on CPI for inflation targeting than DPI. Note that when CPI is the inflation target the exchange rate also becomes a determinant in policy response. This enables the monetary authority to reduce the distortion on the return to capital that may arise due to financial market imperfections and high liability dollarization in the economy.

In addition to these, Table 3[10] summarizes the benefits of alternative interest rate rules. Accordingly, forward-looking interest rate rule with first-order smoothing reduces the volatility in the economy substantially owing to reduction in the distortion on the return to capital due to two important factors. With forward-looking interest rate with first-order smoothing, the monetary authority does not allow sudden jumps or drops in the interest rate thus the rental rate on capital remains stable. Moreover, due to forward-looking feature of the policy, the private sector's expectations are incorporated into the monetary authority's policy response thus avoiding distortions that might arise due to abrupt changes in expectations of the private sector.

Table 3: Loss of Interest Rate Rules: CPI

Weights	var$\left(ln\left(\frac{Y}{Y^{ss}}\right)\right)$	var$(ln(\pi))$	Loss
Simple Interest Rate Rule (Benchmark Rule)			
$\phi_\pi = 2.0$	0.0054	0.0003	0.0028
Smoothing Interest Rate Rule, $\phi_r = 0.45$			
$\phi_\pi = 2.0$	0.0049	0.0003	0.0026
Smoothing Interest Rate Rule, $\phi_r = 0.75$			
$\phi_\pi = 2.0$	0.004	0.0004	0.0022
Forward-Looking Simple Interest Rate Rule			
$\phi_\pi = 2.0$	0.0057	0.0004	0.0031
Forward-Looking Smoothing Interest Rate Rule, $\phi_r = 0.45$			
$\phi_\pi = 2.0$	0.0046	0.0004	0.0025
Forward-Looking Smoothing Interest Rate Rule, $\phi_r = 0.75$			
$\phi_\pi = 2.0$	0.0034	0.0006	0.002

4.0.6 Impulse Responses

This section presents the responses of alternative policy rules to a sudden stop incidence. Each period represents a quarter. The sudden stop is triggered by a one-time 500 basis point unantici-

[10] For loss values of alternative interest rate rules where DPI is the focus refer to Table 4. Note that the loss of alternative interest rate rules also suggest that the loss incurred by the economy when DPI is the focus for inflation targeting is higher.

pated increase in the country risk-premium, similar to that of the Korean experience[11]. Note that this paper does not intend to replicate the Korean experience of the 1997-1998 financial crisis but assess how an emerging economy like Korea would come through a sudden stop if it adopted flexible exchange rate system with a strong commitment to inflation using interest rate as the policy instrument.

Korea experienced a sudden stop starting in October 1997, with capital flight accompanied by an increase in the country's bond spreads. The Bank of Korea first defended its currency by increasing the domestic interest rate but then had to abandon the fixed exchange rate regime, after a substantial depletion of its reserves. After the abandonment of the fixed exchange rate regime, the interest rates were reduced gradually throughout 1998. During 1998, Korea experienced a large contraction in output, consumption, investment and employment. It also experienced a large real depreciation of about 40%, which translated into an increase in the inflation rate along with a hike in the interest rates. The depreciation in the exchange rate was the key contribution to the correction in the current account deficit, primarily due to the decline in imports rather than an increase in exports. The recovery of the real sector started at the beginning of 1999 and lasted for a year. By the end of 1999, Korea's output and investment were back to their pre-crisis level. However, the contraction in consumption and employment was more persistent.

The simulation results are depicted in Figures 1-4. Under all policy rules, the pattern of the real activity is similar to those observed in past sudden stop events. A sudden stop in capital flow is followed by an immediate contraction in the output, consumption and investment followed by a recovery. Additionally, the recovery in consumption is slower than the output, i.e. by the time the recovery in output is completed consumption is still below its pre-crisis level. However, there is a difference across rules with respect to the magnitude of contraction during the sudden stop. According to the simulation results, under the forward-looking interest rate rule with a first-order smoothing factor of 0.75[12], the real activity contracts less than under the other rules. This is because the channels through which these rules induce the observed patterns is different. The difference is even more pronounced between the simple rule and the forward-looking smoothing interest rate rule (Figure 5-8).

The unanticipated increase in the foreign interest rate requires an immediate depreciation of the

[11]There are a number of studies that have established the stylized facts of sudden stops in emerging economies. Some of which are Calvo (1998), Tornell and Westermann (2002), Gertler et al. (2006).

[12]The smoothing factor is chosen as 0.75. With a factor 0.45, the dynamics in the economy are almost similar to that of simple interest rate rule. The results suggests that any smoothing factor above 0.45 would generate a smaller contraction and a faster recovery (Figure 10-13).

domestic currency and an upward adjustment of domestic interest rate against inflationary pressures. As opposed to the simple rule, under smoothing interest rate rules the upward adjustment in the domestic interest rate is bounded with the previous period's level. The increase is even more limited under forward-looking smoothing interest rate rule as the shock is unanticipated and the private sector's expectations are still unchanged. Thus, under the forward-looking smoothing rule the increase in the domestic interest rate is lower than under the simple rule and others. In addition to this, the depreciation in the domestic currency is larger under the forward-looking smoothing interest rate rule versus the simple interest rate rule and others. This has three important implications. First, since under the forward-looking smoothing rule the depreciation of the domestic currency is larger, the country becomes more competitive in the world market. This stimulates the foreign demand for domestic goods, i.e. exports of the country. The increased demand for domestic goods stimulates production in the wholesale sector. Second, the larger depreciation of the domestic currency under the smoothing rule would lead to less demand for foreign goods due to the relatively higher price of the foreign good in domestic currency units[13]. This qualitatively replicates the Korean current account adjustment experience. Figure 9 depicts the external balance adjustments under simple and forward-looking smoothing interest rate rule. Finally, since under the forward-looking smoothing interest rate rule the increase in the domestic interest rate is less than under the simple rule and others, the decline in the asset prices and the rental rate on capital will also be the least. This eases the pressure on the firms' financing and encourages investment. Thus, during the sudden stop under the forward-looking smoothing rule the real activity contracts less compared to the other rules. Therefore, under forward-looking smoothing interest rate rule the welfare loss incurred by the economy is the least.

After the sudden stop, i.e. the output reaches its pre-crisis level, the pick up in real activity is faster under the simple rule. This is mainly because unlike the smoothing rule, under the simple rule once the economy enters the recovery period the necessary downward adjustment in the interest rate and corresponding correction in the exchange rate is more rapid. These results suggest that the monetary authority should adopt a regime switching policy, where at the start of a sudden stop the authority adjust the domestic interest rate according to the smoothing rule and, once the economy starts its recovery, the authority switches to using the simple interest rate rule.

[13] See equation 2.1.9 for the motivation behind this.

5 Conclusion

Currently emerging economies are adopting flexible exchange rate regimes with a strong commitment to inflation targeting, by means of interest rate as a policy instrument. Although inflation targeting is known to perform well in tranquil times, its performance during sudden stops has not been adequately explored. Using a modified version of Gertler et al. (2006), i.e. small open economy financial accelerator model, this paper studies the potency of inflation targeting in smoothing sudden stops. The paper introduces four types of interest rate rules, namely a simple and a smoothing interest rate rule, a forward-looking simple and smoothing interest rate rule, respectively. The model is log-linearized and is quantitatively analyzed. The first set of results which consists of the simulated loss of the alternative interest rate rules suggest that in targeting inflation the monetary authority should focus on the dynamics of consumer price index rather than domestic price index. This is mainly because the when consumer price index is the inflation target the exchange rate becomes a determinant in policy response and this enables the monetary authority to reduce the distortion on the return to capital that may arise due to high liability dollarization in the economy. Note that under inflation targeting with a special focus domestic price index the monetary authority completely ignores the changes in exchange rate. This in return amplifies the distortionary on return on capital due to financial market imperfections and high liability dollarization within the real sector. The second set of results which is impulse response simulations of the alternative interest rate rules to a sudden stop suggests that a monetary authority of an emerging economy should adopt a regime switching policy, where at the start of a sudden stop the authority adjust the domestic interest rate according to the forward-looking smoothing interest rate rule and, once the economy returns to its pre-crisis output level, the authority switches to using the simple interest rate rule. Accordingly, during a sudden stop the contraction is less under the forward-looking smoothing rule whereas once the recovery starts the growth in real activity is more rapid under simple rule.

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A Solution Methodology

A.1 System of Equations

Production Function:

$$y_t = z_t \; (u_t k_t)^{\alpha} \; \left(h_t^{e^{\Omega}} \; h_t^{(1-\Omega)} \right)^{(1-\alpha)} \tag{A.1.1}$$

Labor market equilibrium:

$$\theta \; h_t^{(1+\vartheta)} = (1-\alpha)(1-\Omega) \; p_t^w y_t \; \frac{1}{c_t} \tag{A.1.2}$$

Capital stock law of motion[14]:

$$k_{t+1} = (1-\delta(u_t)) \; k_t + \Phi\left(\frac{x_t}{k_t}\right) \; k_t \tag{A.1.3}$$

Exports:

$$c_t^{d^*} = \left(\frac{p_t^d}{s_t}\right)^{-\nu^*} \; y_t^{* \; \nu^*} \, c_{t-1}^{d^* \; (1-\nu^*)} \tag{A.1.4}$$

Entrepreneur's net worth:

$$n_{t+1} = \phi \; \left[\left(1 + r_t^k\right) q_{t-1} k_t - \left(\frac{n_t}{q_{t-1} k_t}\right)^{\rho} \left(1 + r_{t-1}^f\right) \; \frac{s_t}{s_{t-1}} \left(q_{t-1} k_t - n_t\right) \right] - (1-\alpha) \; \Omega y_t \; p_t^w \tag{A.1.5}$$

Feasibility Condition:

$$y_t = c_t^d \; + \; c_t^{d^*} \; + \; i_t^d \; + \; c_t^{e^d} \tag{A.1.6}$$

[14]To avoid notational confusion investments is defined as x_t.

Inflation:

$$\pi_t = \left(\mu \, \frac{p_t^w}{p_t^d}\right)^{\psi} \left(\mu^f \, \frac{s_t \, p_t^{f^*}}{p_t^f}\right)^{\psi^f} \; E_t \left[\pi_{t+1}\right]^{\beta} \tag{A.1.7}$$

Country Interest Rate:

$$(1 + r_t^f) = \Lambda_t \, (1 + r^{rf}) \tag{A.1.8}$$

Euler Equation:

$$1 = \beta \, E_t \left[(1 + r_t^d) \, \left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}\right] \tag{A.1.9}$$

Expected Marginal Return on Capital:

$$E_t \left[1 + r_{t+1}^k\right] = \frac{E_t \left[\alpha \, p_{t+1}^w \, \frac{y_{t+1}}{k_{t+1}} + q_{t+1} - p_{t+1}^i \, \delta(u_{t+1})\right]}{q_t} \tag{A.1.10}$$

Capital Demand:

$$E_t \left[1 + r_{t+1}^k\right] = \left(\frac{n_{t+1}}{q_t \, k_{t+1}}\right)^{\rho} \, E_t \left[(1 + r_t^f) \frac{s_{t+1}}{s_t}\right] \tag{A.1.11}$$

Uncovered Interest Parity:

$$E_t \left[(1 + r_t^d) - (1 + r_t^f) \frac{s_{t+1}}{s_t}\right] = 0 \tag{A.1.12}$$

Q-investment Relation:

$$E_t \left[q_{t+1} \Phi' \left(\frac{x_{t+1}}{k_{t+1}}\right) - p_{t+1}^i\right] = 0 \tag{A.1.13}$$

Domestic Price Inflation:

$$\left(\frac{p_t^d}{p_{t-1}^d}\right) \, \pi_t = \left(\mu \frac{p_t^w}{p_t^d}\right)^{\psi} E_t \left[\frac{p_{t+1}^d}{p_t^d} \, \pi_{t+1}\right]^{\beta} \tag{A.1.14}$$

Household Consumption of Domestic Good:

$$c_t^d = \frac{c_t}{p_t^d} \tag{A.1.15}$$

Domestic Input for Investment Good:

$$x_t^d = \left(\frac{p_t^i}{p_t^d}\right)^{\nu_i} \; x_t \tag{A.1.16}$$

Entrepreneur's Consumption for Domestic Good:

$$c_t^{e^d} = \frac{c_t^e}{p_t^d} \tag{A.1.17}$$

Entrepreneur's Total Consumption:

$$c_t^e = \left(\frac{1-\phi}{\phi}\right) \; [n_{t+1} - (1-\alpha)\, \Omega \, y_t \, p_t^w] \tag{A.1.18}$$

Nominal Domestic Interest Rate:

$$(1 + i_{t-1}^d) = \pi_t \, (1 + r_{t-1}^d) \tag{A.1.19}$$

Monetary Policy Rules:
Simple Interest Rate Rule:

$$(1 + i_t^d) = (1 + r^{ss}) \, \pi_t^{\phi_\pi} \; \left[\frac{p_t^d}{p_{t-1}^d} \pi_t\right]^{\phi_{pd}}$$

Smoothing Interest Rate Rule:

$$(1 + i_t^d) = (1 + r^{ss}) \, (1 + i_{t-1}^d)^{\phi_r} \; \left[\pi_t^{\phi_\pi} \; \left[\frac{p_t^d}{p_{t-1}^d} \pi_t\right]^{\phi_{pd}}\right]^{1-\phi_r}$$

Forward-Looking Simple Interest Rate Rule:

$$(1 + i_t^d) = (1 + r^{ss}) \, E_t \left[\pi_{t+1}^{\phi_\pi} \; \left[\frac{p_{t+1}^d}{p_t^d} \pi_{t+1}\right]^{\phi_{pd}}\right]$$

Forward-Looking Smoothing Interest Rate Rule:

$$(1+i_t^d) = (1+r^{ss})\,(1+i_{t-1}^d)^{\phi_r}\; E_t\left[\pi_{t+1}^{\phi_\pi}\;\left[\frac{p_{t+1}^d}{p_t^d}\pi_{t+1}\right]^{\phi_{pd}}\right]^{1-\phi_r}$$

A.2 Non-Stochastic Steady-State

First, the steady-state inflation and price of capital are normalized at 0% and 1,

$$\pi = 1$$
$$q = 1$$

Due to the capital adjustment cost function, the latter implies that the price of investment good is 1.

$$p_i = 1$$

From (2.4.4) and (2.1.4),

$$p^d = 1$$
$$p^f = 1$$

From (2.5.6) and (2.5.7)

$$p^w = \frac{1}{\mu}$$
$$p^{w^f} = \frac{1}{\mu^f}$$

Assuming that the price of foreign good in foreign currency is 1, the exchange rate at steady-state is also $1/\mu^f$. From (2.1.8) and (2.3.12)

$$R^d = \frac{1}{\beta}$$
$$R^d = R^f$$

From the definition of the external finance premium

$$s = \frac{R^k}{R^f} = \left(\frac{qk}{n}\right)^{\rho}$$

the R^k is found, where ρ and k/n are calibrated.

From (2.3.8) the steady-state capital stock is

$$R^k = \alpha\, p^w\, \frac{y}{k} - \delta(u)$$

Given the capital-net worth ratio k/n the entrepreneur's net worth n is derived. From (2.4.5) the steady-state investment is

$$i = \delta(u)\, k$$

Then the steady-state domestic input for investment good is given as

$$i^d = \gamma_i\, i$$

Given $h = 0.3$ and $z = 1$ the steady-state wholesale output is

$$y^w = z(uk)^{\alpha}(h^{(1-\Omega)})^{(1-\alpha)}$$

From (2.3.15) and (2.3.13), the entrepreneur's consumption and the probability of exit from entrepreneurship are given as

$$c^e = \left(\frac{1-\phi}{\phi}\right)[n - (1-\alpha)\Omega y^w p^w]$$
$$\phi\, R^k = \frac{n + (1-\alpha)\Omega y^w p^w}{n}$$

The steady-state entrepreneur's consumption of domestic good is

$$c^{e^d} = \gamma\, c^e$$

As is mentioned in the text, the fixed cost for retailers, κ is chosen to set the steady-state profit is zero. Thus the steady-state output level is

$$y^d = (1 - \kappa)\, y^w$$

From the labor market equilibrium, (2.1.10) and (2.3.1), the steady-state consumption is found

$$\theta\, h^{(1+\vartheta)} = (1 - \alpha)(1 - \Omega)\, p^w y\, \frac{1}{c}$$

The steady-state consumption of domestic good is given as

$$c^d = \gamma\, c$$

Finally, given the exports-to-output, c^{d^*}/y^d, and the government expenditure-to-output ratio, g/y^d, the feasibility constraint is checked.

$$y^d = c^d + i^d + c^{e^d} + c^{d^*} + g$$

A.3 Log-Linearization

The solution to the model is characterized as:

$$X_t = P\, X_{t-1} + Q\, z_t \tag{A.3.1}$$

where

$$X_t \;=\; \left[\tilde{k}_{t+1}, \tilde{n}_{t+1}, \tilde{h}_t, \tilde{y}_t, \tilde{x}_t, \tilde{x}_t^d, \tilde{c}_t, \tilde{c}_t^d, \tilde{c^e}_t, \tilde{c}_t^{e^d}, \tilde{c}_t^{d^*}, \tilde{p}_t^d, \tilde{p}_t^w, \tilde{\pi}_t, \tilde{r}_t^k, \tilde{q}_t, \tilde{i}_t^d, \tilde{r}_t^d, \tilde{r}_t^f, \tilde{s}_t\right]$$

and

$$Z_t \;=\; \left[\Lambda_t, z_t, y_t^*, p_t^{f^*}\right]$$

Given that $(p^d)^\gamma (p^f)^{1-\gamma} = 1$ and the price of investment good is the composite of p^d and p^f, $\tilde{p}^i_t = 0$ at all times. Therefore, it has been excluded from the log-linearized system.

$$0 = \tilde{y}_t - z_t - \alpha\, \tilde{k}_t - (1-\alpha)\,(1-\Omega)\,\tilde{h}_t \tag{A.3.2}$$

$$0 = \tilde{y}_t + \tilde{p}^w_t - (1+\vartheta)\,\tilde{h}_t - \sigma\,\tilde{c}_t \tag{A.3.3}$$

$$0 = \tilde{k}_{t+1} - x\,\tilde{x}_t - (1-\delta(u))\,k_t - \delta'(u)u\,u_t \tag{A.3.4}$$

$$0 = \tilde{c}^{d^*}_t - \nu^*\tilde{s}_t - \nu^*\tilde{y}^*_t - (1-\nu^*)\tilde{c}^{d^*}_{t-1} + \nu^*\tilde{p}^d_t \tag{A.3.5}$$

$$0 = \begin{bmatrix} n\,\tilde{n}_{t+1} - \phi\, R^k qk\,\tilde{r}^k_t + \left(\phi\, R^k n - \phi\, R^k qk\right)\; r^f_{t-1} \\ + \left(\phi\, R^k n - \phi\, R^k qk\right)[q_{t-1} - k_t] \\ + \left(\rho\left(\phi\, R^k n - \phi R^k qk\right) + R^k n\right)\;\tilde{n}_t \\ + \phi\, R^k\,(n - qk)\;[s_t - s_{t-1}] \\ -(1-\alpha)\Omega y^w p^w\,[\tilde{y}_t + \tilde{p}^w_t] \end{bmatrix} \tag{A.3.6}$$

$$0 = y^d\,\tilde{y}_t - c^d\,\tilde{c}^d_t - i^d\,\tilde{i}^d_t - c^{e^d}\,\tilde{c}^{e^d}_t \tag{A.3.7}$$

$$0 = \tilde{r}^f_t - \tilde{\Lambda}_t \tag{A.3.8}$$

$$0 = \tilde{i}^d_t - \tilde{r}^d_t - \tilde{\pi}_{t+1} \tag{A.3.9}$$

$$0 = \tilde{c}^d_t - \tilde{c}_t + p^d_t \tag{A.3.10}$$

$$0 = \tilde{c}^{e^d}_t - \tilde{c}^e_t + p^d_t \tag{A.3.11}$$

$$0 = \tilde{x}^d_t - \tilde{x}_t + \nu_i\,\tilde{p}^d_t \tag{A.3.12}$$

$$0 = c^e\,\tilde{c}^e_t - \left(\frac{1-\phi}{\phi}\right)[n\,\tilde{n}_t - (1-\alpha)\Omega y^w p^w\,(\tilde{y}_t + \tilde{p}^w_t)] \tag{A.3.13}$$

$$0 = E_t\left[\pi_t - \left(\psi\,\gamma\,\tilde{p}^w_t + \psi^f\,(1-\gamma)\left(s_t + p^{f^*}_t\right)\right) - \beta\,\pi_{t+1}\right] \tag{A.3.14}$$

$$0 = E_t\left[\tilde{r}^d_t + \sigma\,(\tilde{c}_t - \tilde{c}_{t+1})\right] \tag{A.3.15}$$

$$0 = E_t\begin{bmatrix} R^k\,q\;\left[\tilde{r}^k_{t+1} + \tilde{q}_t\right] - \left(\alpha\,p^w\,\dfrac{y^w}{k}\right)\left[\tilde{p}^w_{t+1} + \tilde{y}_{t+1} - \tilde{k}_{t+1}\right] \\ -q\,\tilde{q}_{t+1} \end{bmatrix} \tag{A.3.16}$$

$$0 = E_t\left[\tilde{r}^k_{t+1} - \tilde{r}^f_t - \rho\left[\tilde{n}_{t+1} - \tilde{q}_t - \tilde{k}_{t+1}\right] - \tilde{s}_{t+1} + \tilde{s}_t\right] \tag{A.3.17}$$

$$0 = E_t\left[\tilde{r}^d_t - \tilde{r}^f_t - \tilde{s}_{t+1} + \tilde{s}_t\right] \tag{A.3.18}$$

$$0 = E_t\left[\tilde{q}_{t+1} - \eta^{\frac{i}{k}}(\tilde{x}_{t+1} - \tilde{k}_{t+1})\right] \tag{A.3.19}$$

$$0 = E_t\left[\tilde{\pi}_t + (1+\psi+\beta)\tilde{p}^d_t - \tilde{p}^d_{t-1} - \beta\left[\tilde{p}^d_{t+1} + \tilde{\pi}_{t+1}\right] - \psi\tilde{p}^w_t\right] \tag{A.3.20}$$

Monetary Policy Rules:

Simple Interest Rate Rule:

$$\tilde{i}_t^d - (\phi_\pi + \phi_{pd} + \phi_s)\tilde{\pi}_t - \phi_{pd}[\tilde{p}_t^d - \tilde{p}_{t-1}^d] = 0$$

Smoothing Interest Rate Rule:

$$= \tilde{i}_t^d - \phi_r \; i_{t-1}^d - (1-\phi_r)\left[(\phi_\pi + \phi_{pd} + \phi_s)\right]\tilde{\pi}_t + \phi_{pd}[\tilde{p}_t^d - \tilde{p}_{t-1}^d] = 0$$

Forward-Looking Simple Interest Rate Rule:

$$E_t\left[\tilde{i}_t^d - (\phi_\pi + \phi_{pd} + \phi_s)\tilde{\pi}_{t+1} - \phi_{pd}[\tilde{p}_{t+1}^d - \tilde{p}_t^d]\right] = 0$$

Forward-Looking Smoothing Interest Rate Rule:

$$E_t\left[\tilde{i}_t^d - \phi_r \tilde{i}_{t-1}^d - (1-\phi_r)\left[(\phi_\pi + \phi_{pd} + \phi_s)\tilde{\pi}_{t+1} + \phi_{pd}[\tilde{p}_{t+1}^d - \tilde{p}_t^d]\right]\right] = 0$$

Exogenous Processes:

$$\Lambda_{t+1} = \theta_l \; \Lambda_t + \epsilon_{t+1}^l, \quad \epsilon_{t+1}^l \sim N(0, \sigma_l^2) \tag{A.3.21}$$

$$z_{t+1} = \theta_z \; z_t + \epsilon_{t+1}^z, \quad \epsilon_{t+1}^z \sim N(0, \sigma_z^2) \tag{A.3.22}$$

$$y_{t+1}^* = \theta_{y^*} \; y_t^* + \epsilon_{t+1}^{y^*}, \quad \epsilon_{t+1}^{y^*} \sim N(\mu_{y^*}, \sigma_{y^*}^2) \tag{A.3.23}$$

$$p_{t+1}^{f^*} = \theta_{pf} \; p_t^{f^*} + \epsilon_{t+1}^{pf}, \quad \epsilon_{t+1}^{pf} \sim N(0, \sigma_{pf^*}^2) \tag{A.3.24}$$

Table 4: Loss of Interest Rate Rules: DPI

Weights	var$\left(ln\left(\frac{Y}{Y^{ss}}\right)\right)$	var$(ln(\pi))$	Loss
Simple Interest Rate Rule (Benchmark Rule)			
$\phi_{pd} = 2.0,\ \phi_y = 0.0$	0.0091	0.0009	0.0050
Smoothing Interest Rate Rule, $\phi_r = 0.45$			
$\phi_{pd} = 2.0,\ \phi_y = 0.0$	0.009	0.0008	0.0049
Smoothing Interest Rate Rule, $\phi_r = 0.75$			
$\phi_{pd} = 2.0,\ \phi_y = 0.0$	0.0086	0.0008	0.0047
Forward-Looking Simple Interest Rate Rule			
$\phi_{pd} = 2.0,\ \phi_y = 0.0$	0.0264	0.002	0.0142
Forward-Looking Smoothing Interest Rate Rule, $\phi_r = 0.45$			
$\phi_{pd} = 2.0,\ \phi_y = 0.0$	0.0212	0.0021	0.0116
Forward-Looking Smoothing Interest Rate Rule, $\phi_r = 0.75$			
$\phi_{pd} = 2.0,\ \phi_y = 0.0$	0.0161	0.0017	0.0089

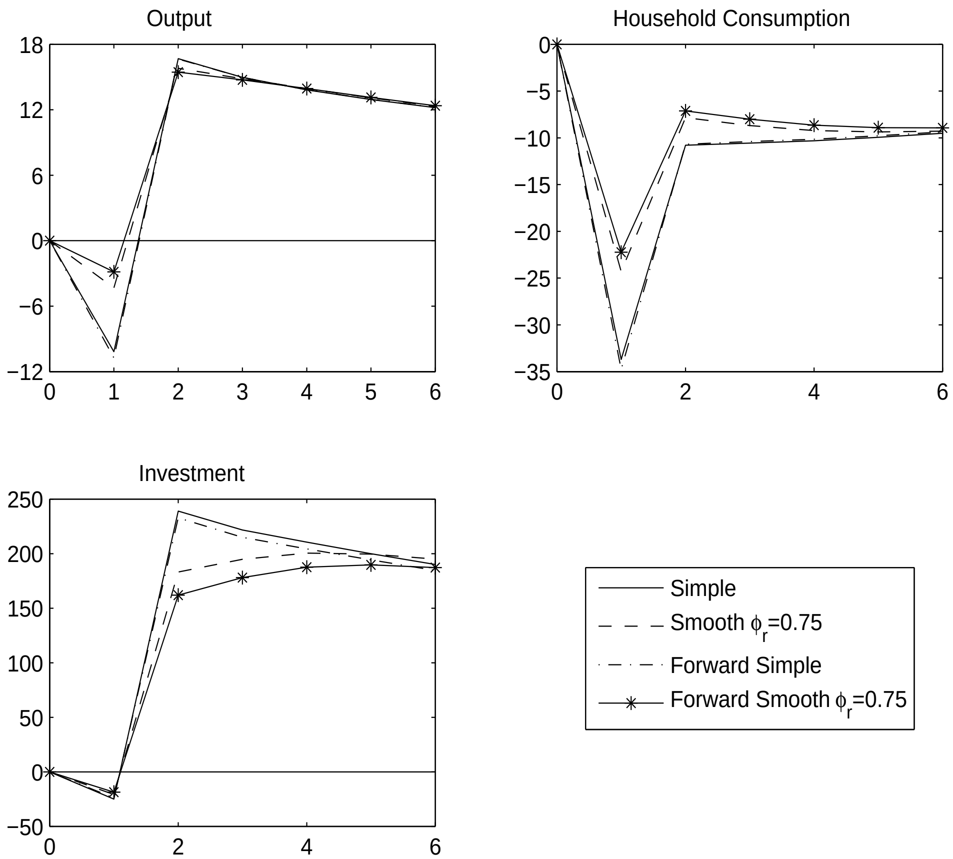

Figure 1: All Interest Rate Rules, CPI I

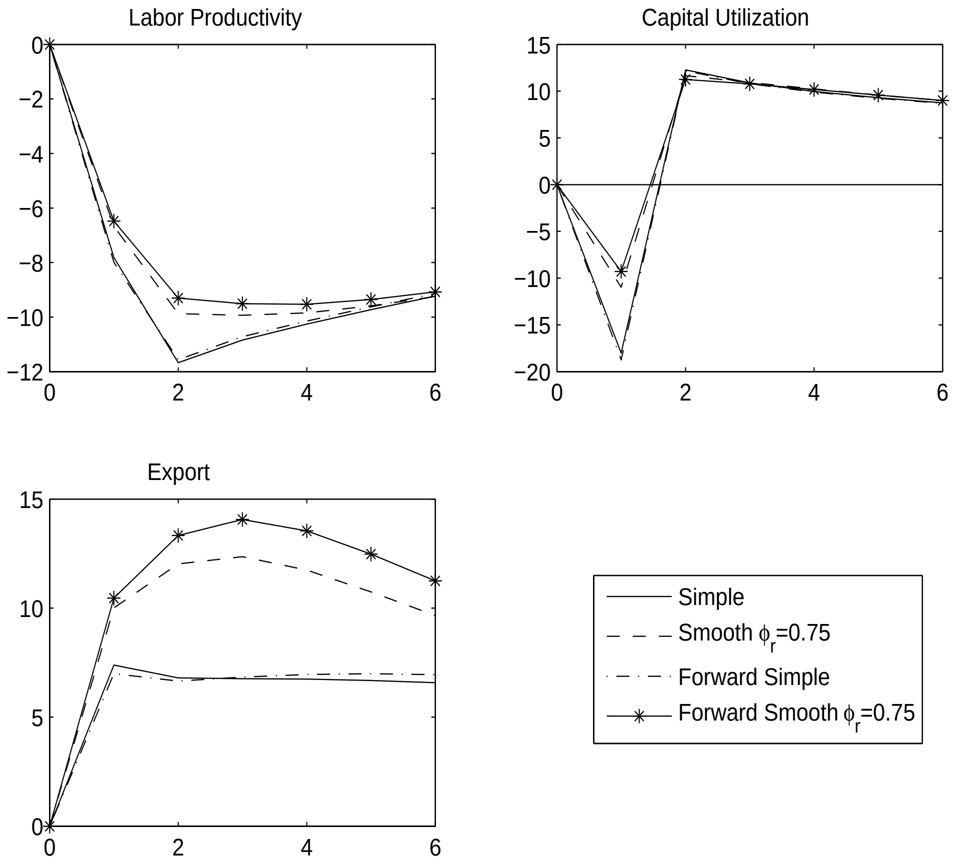

Figure 2: All Interest Rate Rules, CPI II

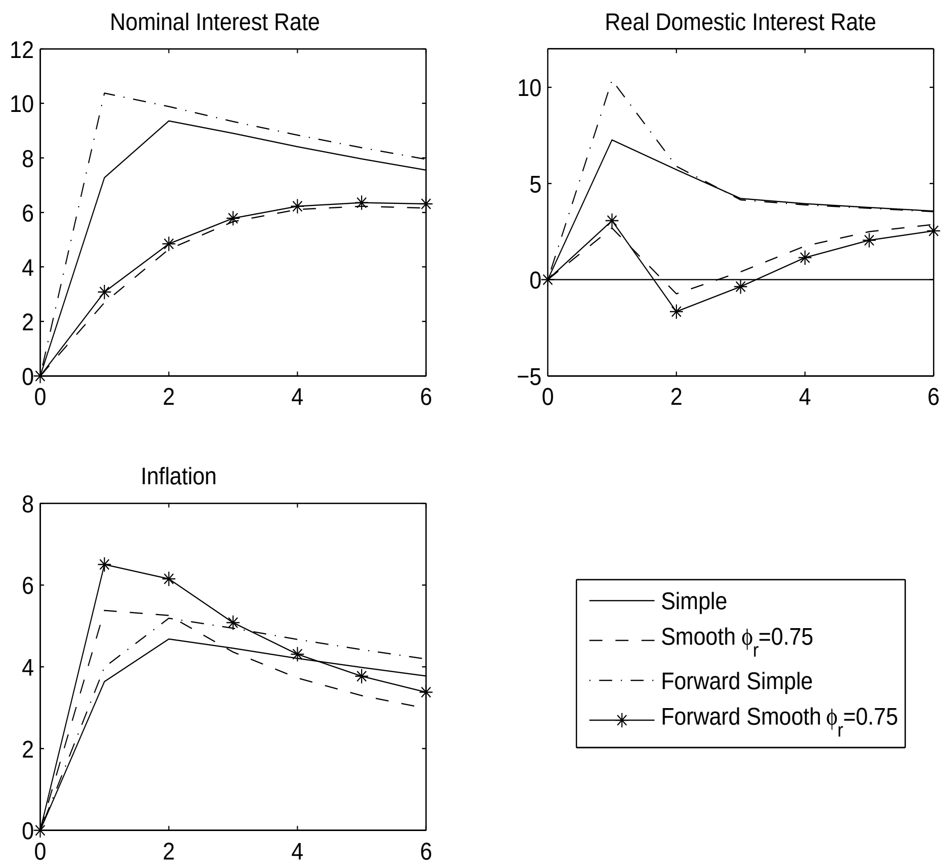

Figure 3: All Interest Rate Rules, CPI III

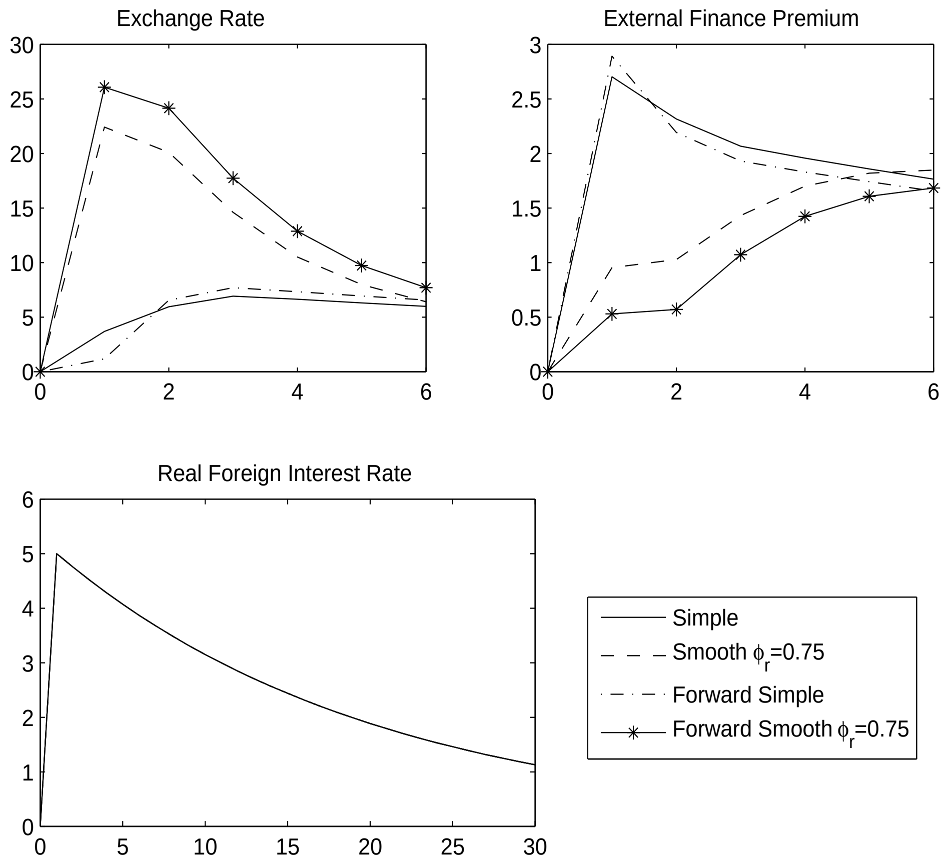

Figure 4: All Interest Rate Rules, CPI IV

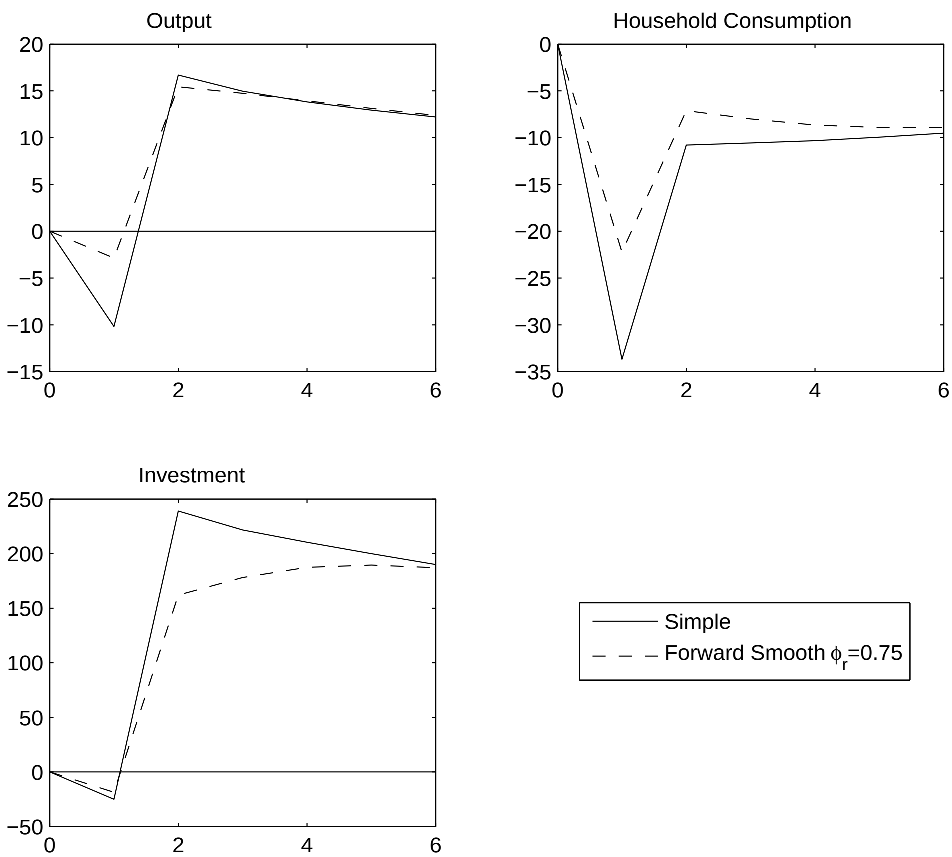

Figure 5: Simple versus Forward-Looking Smoothing Interest Rate Rule, CPI I

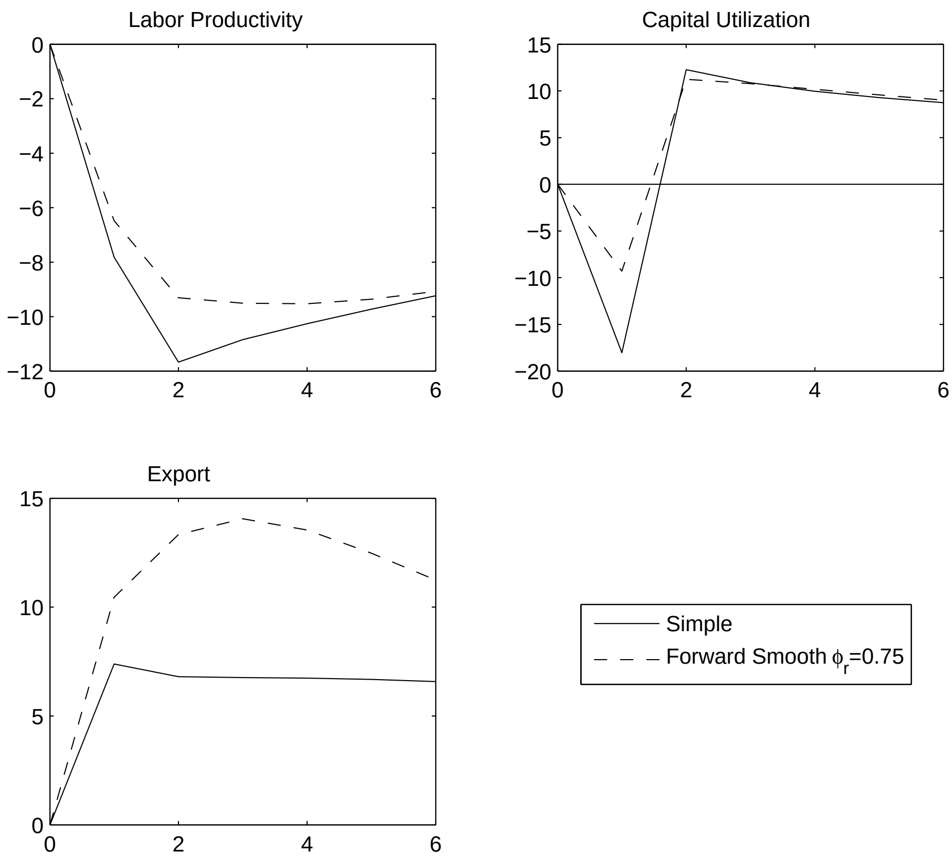

Figure 6: Simple versus Forward-Looking Smoothing Interest Rate Rule, CPI II

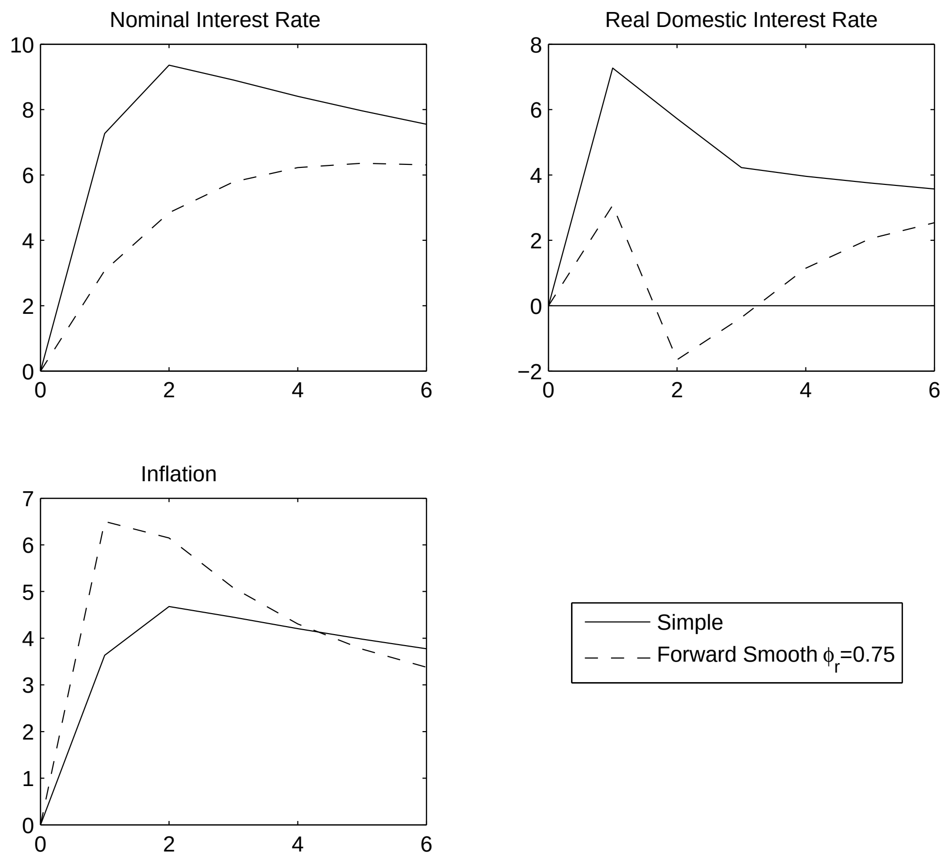

Figure 7: Simple versus Forward-Looking Smoothing Interest Rate Rule, CPI III

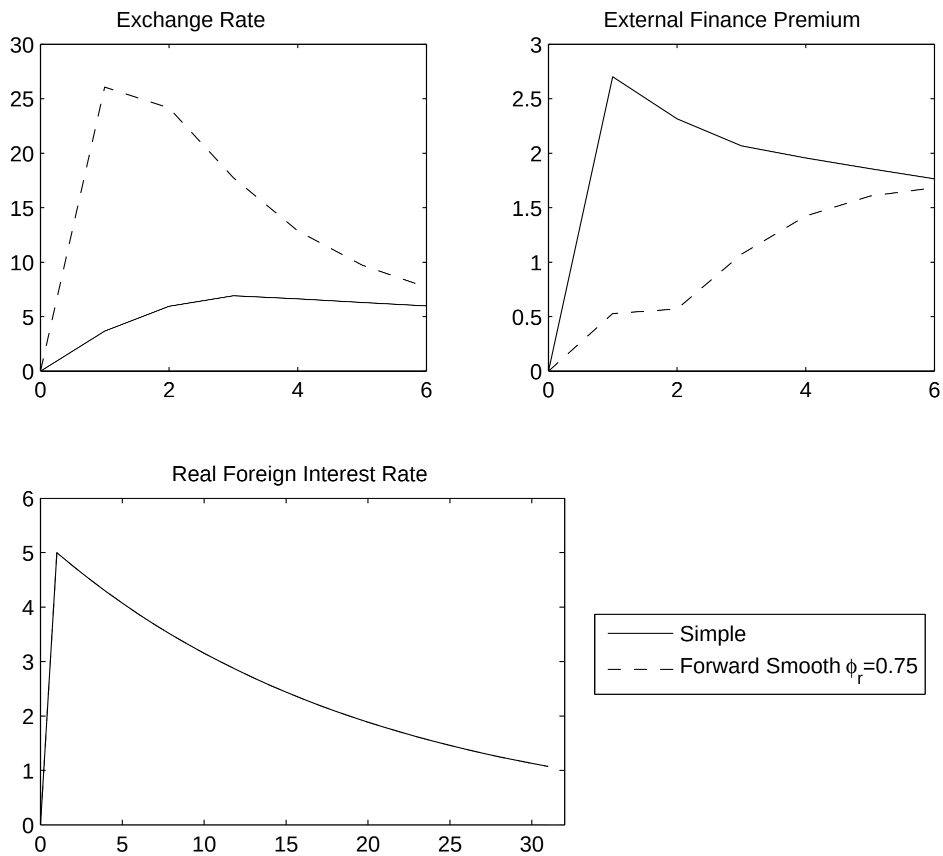

Figure 8: Simple versus Forward-Looking Smoothing Interest Rate Rule, CPI IV

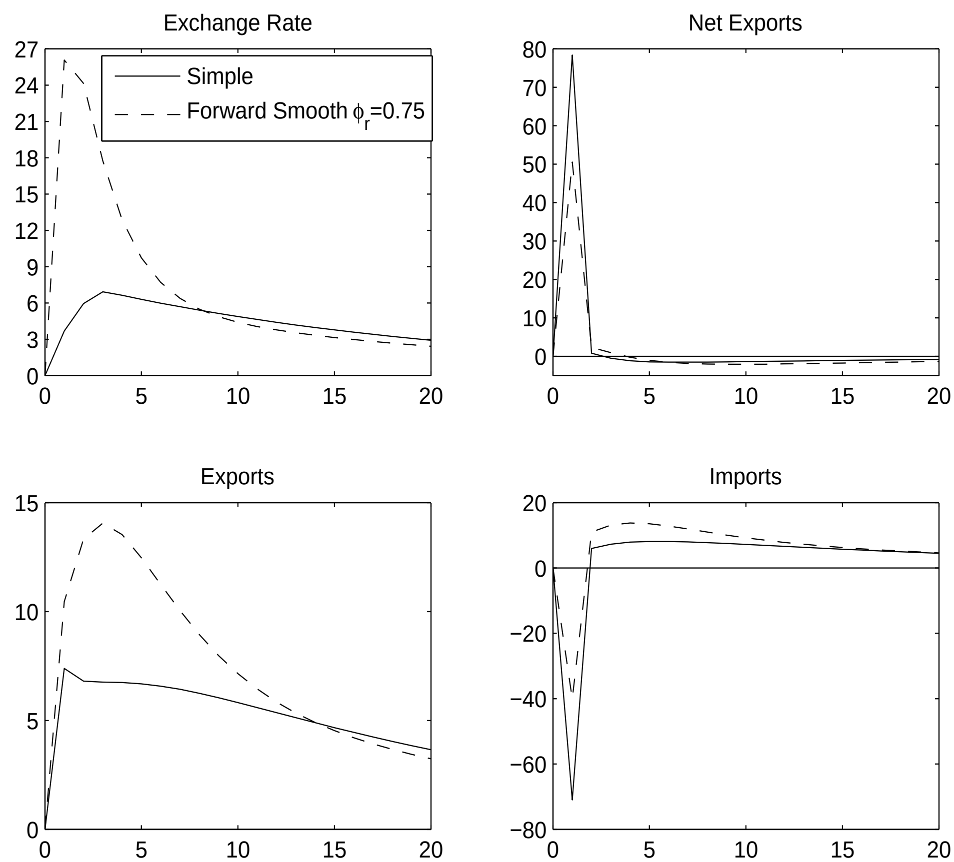

Figure 9: External Balance Adjustments: Simple Rule versus Forward-Looking Smoothing Rule

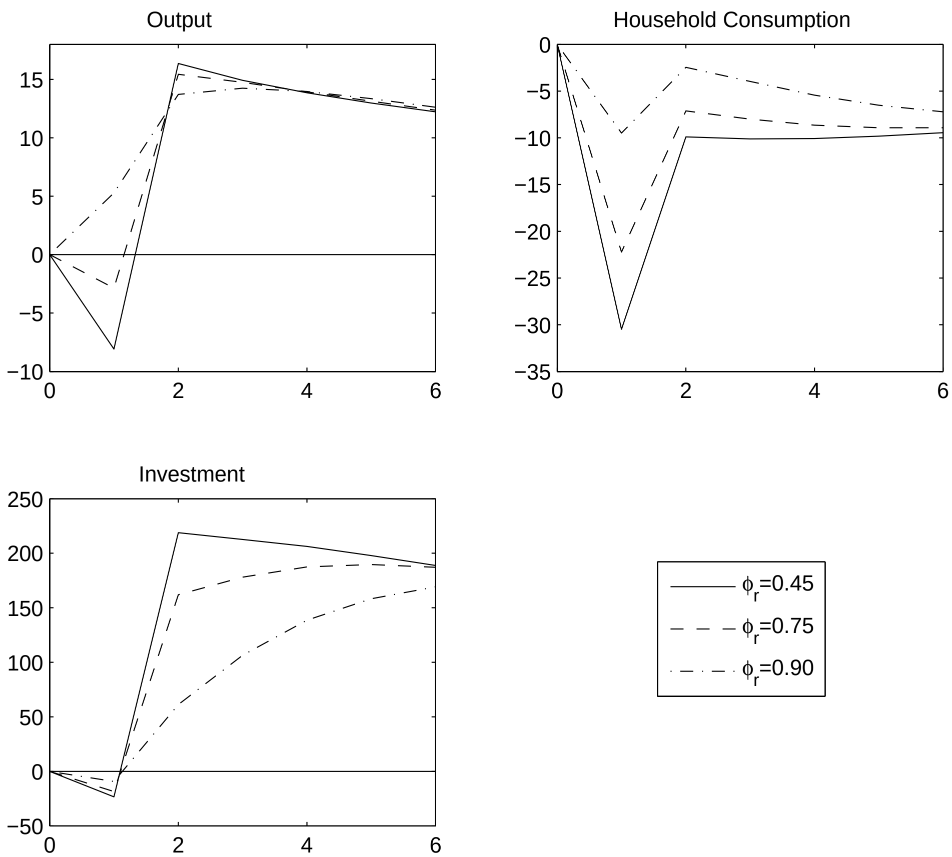

Figure 10: Forward-Looking Smoothing Interest Rate Rule: Different Smoothing Factors, CPI I

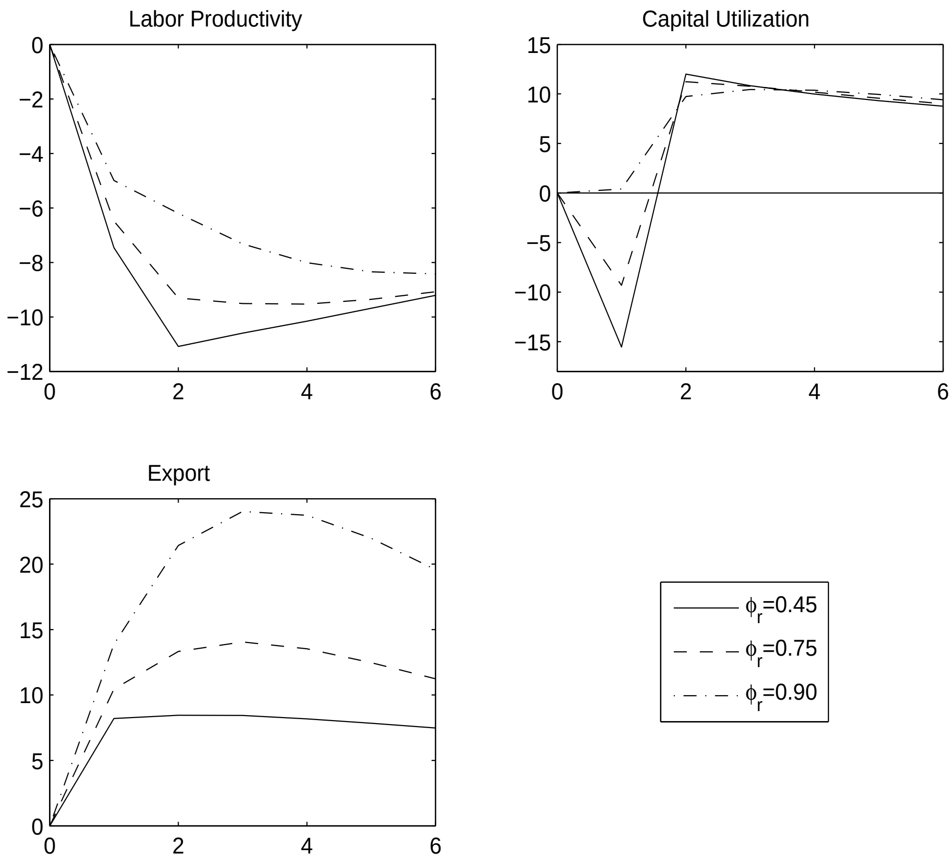

Figure 11: Forward-Looking Smoothing Interest Rate Rule: Different Smoothing Factors, CPI II

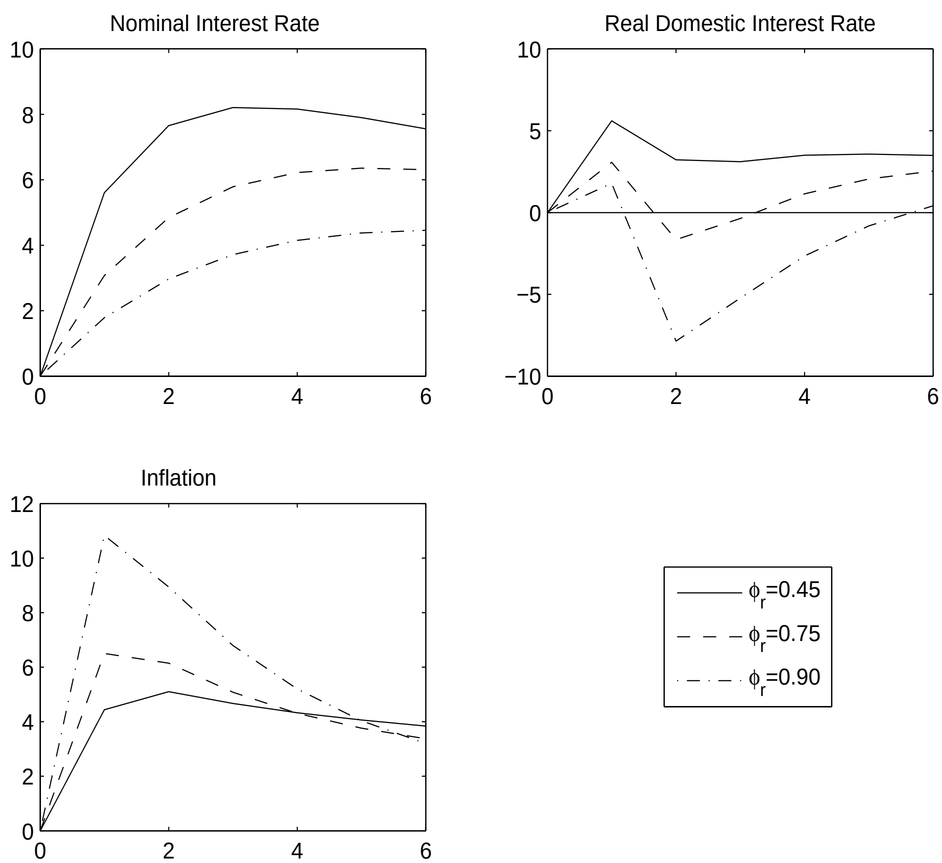

Figure 12: Forward-Looking Smoothing Interest Rate Rule: Different Smoothing Factors, CPI III

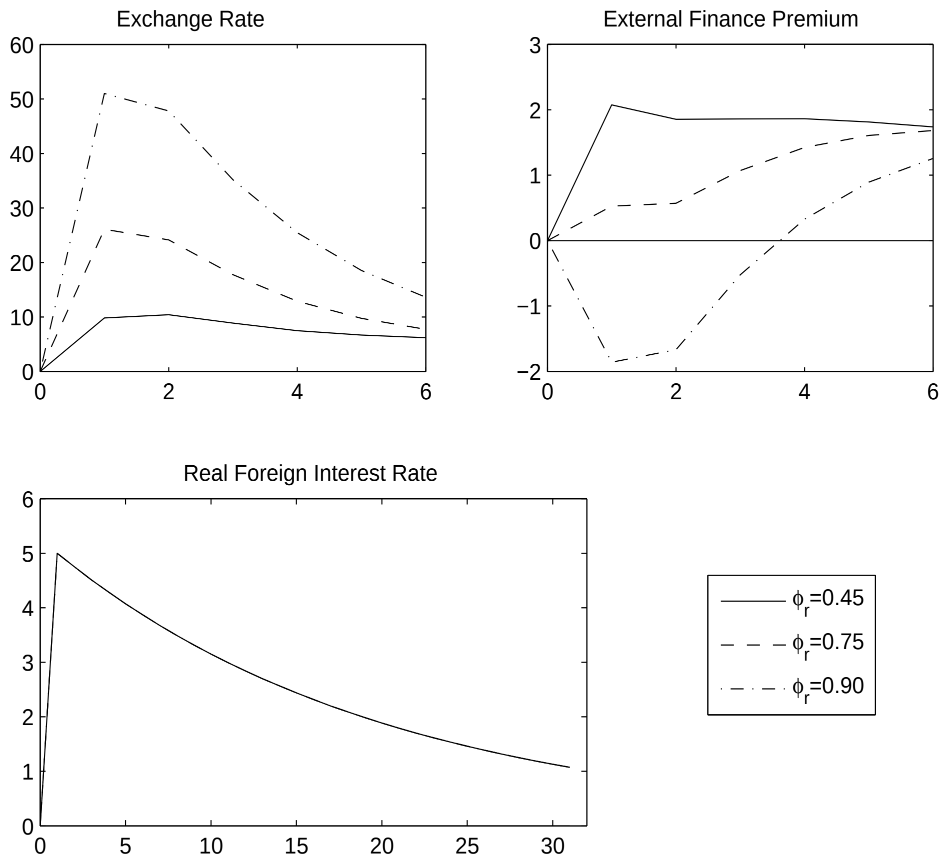

Figure 13: Forward-Looking Smoothing Interest Rate Rule: Different Smoothing Factors, CPI IV