Volume Title: International Dimensions of Monetary Policy

Volume Author/Editor: Jordi Gali and Mark J. Gertler, editors

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-27886-7

Volume URL: http://www.nber.org/books/gert07-1

Conference Date: June 11-13, 2007

Publication Date: February 2010

Chapter Title: Current Account Dynamics and Monetary Policy

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Chapter URL: http://www.nber.org/chapters/c0521

Chapter pages in book: (199 - 244)

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Current Account Dynamics and Monetary Policy

Andrea Ferrero, Mark Gertler, and Lars E. O. Svensson

4.1 Introduction

A salient feature of the global economy is the emergence of significant global imbalances over the past decade, reflected principally by the large current account deficit of the United States, with the rest of the world portrayed in the top panel of figure 4.1. There has been considerable debate over the sources of these imbalances as well as over the implications they may have for future economic behavior. Perhaps most notably, Obstfeld and Rogoff (2005) (henceforth OR) argue that, regardless of origins of the recent U.S. current account deficit, a correction of this imbalance will require a real depreciation of the dollar on the order of 30 percent. While there is far from universal agreement with the OR hypothesis, the slide in the dollar over the past several years (bottom panel of figure 4.1) is certainly consistent with their scenario.

Despite the recent discussions about current account imbalances and exchange rates, much less attention has been paid to the implications for

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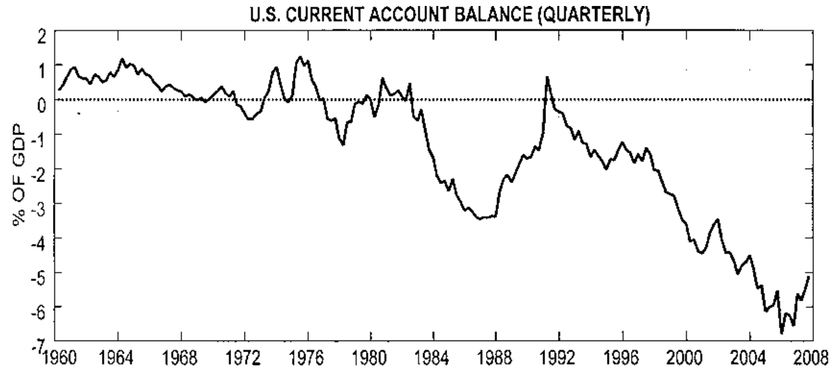
Prepared for the NBER conference on “International Dimensions of Monetary Policy” in Girona (Spain), June 2007. The authors are grateful to Gianluca Benigno, Paul Bergin, Luca Dedola, Maurice Obstfeld, and Paolo Pesenti for their discussions and also to participants at several conferences for helpful comments. Gertler thanks the National Science Foundation (NSF) and the Guggenheim Foundation for financial support. The views expressed in this chapter are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York, the Federal Reserve System, the Sveriges Riksbank, or the National Bureau of Economic Research.



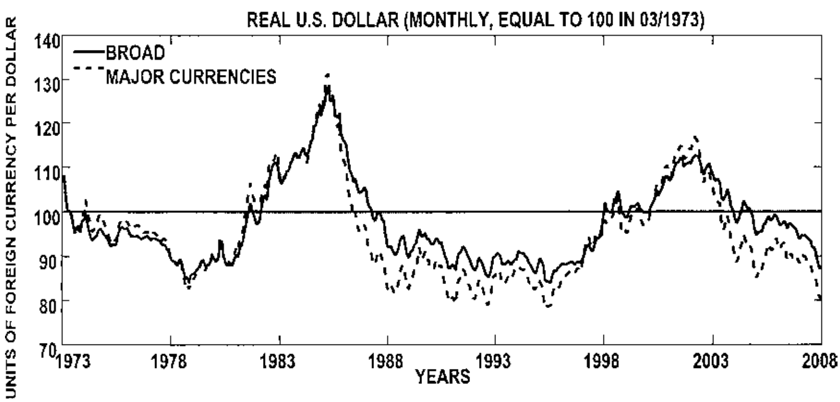


Fig. 4.1 U.S. Current Account and real exchange rate

Source: Bureau of Economic Analysis and Board of Governors of the Federal Reserve System.

monetary policy. At first blush, it may seem that any connection with monetary policy is at best indirect. Given that the U.S. current account deficit ultimately reflects saving/investment differences with the rest of the world, monetary policy management cannot be assigned any direct responsibility. Similarly, the adjustment of real exchange rates to correct these imbalances is beyond the direct province of monetary policy.

Nonetheless, while monetary policy is arguably not the cause of current account deficits and surpluses, there are potentially important implications of these imbalances for the management of monetary policy. For example, to the extent that OR are correct about the adjustment of exchanges rates, the depreciation of the dollar is potentially a source of inflationary pressure. To be sure, in the long run inflation is ultimately a monetary phenomenon and even in a global environment, the Federal Reserve retains full control over its monetary policy. Nonetheless, as Rogoff (2007) has suggested, movements in international relative prices may influence short-run inflation dynamics.

In the case of current account adjustment, any associated depreciation may force the central bank into choosing between maintaining price stability or output at potential. That is, even if the current account adjustment plays out smoothly, the depreciation of the dollar may induce extra pressure on consumer price index (CPI) inflation for a period of time that can only be offset by tightening of monetary policy, with potential repercussions for real activity.

Further, even if unlikely, it is not inconceivable that there might be a quick reversal of the U.S. current account, perhaps in response to some adverse news about the long-run growth prospects of the U.S. economy relative to the rest of the world. Under this "sudden stop" scenario, there would likely be a rapid depreciation of the dollar along with a sharp contraction in domestic spending required to bring the current account into line. These rapid and large adjustments could potentially create a complex balancing act for the Federal Reserve. Even if such a circumstance is remote, it is certainly worth exploring policy options under this kind of worst-case scenario.

In this chapter, accordingly, we explore the implications of current account imbalances for monetary policy. To do so, we develop a simple two-country monetary dynamic stochastic general equilibrium (DSGE) model. The framework nests the static endowment world economy that OR used to study the link between the current account and exchange rates. To this framework, we add explicit dynamics and consider production decisions under nominal rigidities. The end product is a framework where the current account, exchange rates, and both output and inflation within each country are determined endogenously. The behavior of each economy, further, depends on the monetary policy decisions of each country. We then use the model to study how different monetary policies affect aggregate economic behavior in light of current account developments.

We model the current account imbalance as the product of cross-country differences in expected productivity growth as well as differences in saving propensities, the two main factors typically cited as underlying the recent situation.[1] We initialize the model to approximately match the recent U.S. current account deficit, which is roughly 5 percent of gross domestic product (GDP). The expected depreciation the model predicts is then very close to the 30 percent estimate of OR. This is not entirely surprising since the way we calibrate our model is very consistent with OR's approach. In this regard, we stress that our goal is not to establish whether or not OR's forecast is correct. Rather, it is to consider various monetary policy strategies in an environment where current imbalances do exert pressures on the domestic

1. To be clear, we model differences in consumption/saving propensities as preferences shocks that are meant to be a catch-all for factors that could cause differences in national savings rates such as fiscal policies, demographics, and capital market frictions. For recent analyses of current account behavior, see, for example, Engel and Rogers (2006); Backus et al. (2006); Caballero, Fahri, and Gourinchas (2007); Ferrero (2007), Faruquee et al. (2005); and Mendoza, Quadrini, and Rios-Rull (2007).

economy of the type OR envision. Put differently, what we are engaged in should be regarded as "war-gaming" different scenarios that could prove challenging for monetary policy.

We consider two main scenarios. The first we refer to as the "slow burn." In this case the current account adjustment plays out slowly and smoothly. There are no major shocks along the way. Nonetheless, the steady depreciation of the dollar places persistent pressures on CPI inflation. In the second scenario, "the fast burn," there is a reversal of the current account deficit that plays out over the course of a year. We model the reversal as a revision in beliefs about future productivity growth in the home country relative to the foreign country. Under each scenario, we consider the implications of different monetary policies for the home and foreign countries.

There has been other work that examines monetary policies under different scenarios for current account adjustment. Several authors, for example, have employed the large scale Global Economy Model (GEM) developed by the International Monetary Fund (IMF) exactly for this purpose (e.g., Faruquee et al. 2005).[2] We differ by restricting attention to a small scale model, with the aim of developing a set of qualitative results. Thus, we abstract from many of the frictions present in the GEM framework that help tightly fit the data. Instead, we incorporate a relatively minimal set of frictions with the aim of a balance between facilitating qualitative analysis and at the same time permitting the model to generate quantitative predictions that are "in the ball park."

In section 4.2 we develop the basic model. It is a variation of the monetary two-country DSGE model with nominal rigidities developed by Obstfeld and Rogoff (2002), Clarida, Galí, and Gertler (2002), Corsetti and Pesenti (2005), Benigno and Benigno (2006), and others. The key differences involve (a) introducing incomplete international capital markets in order to study international lending and borrowing and (b) allowing for both tradable and nontradable goods in order to nest the OR model of the current account and real exchanges rates. We finish this section by analyzing the relation between our model and OR's specification. Section 4.3 presents the log-linear model and characterizes the monetary transmission mechanism in this kind of environment. Section 4.4 then discusses our numerical simulations under different scenarios for current account adjustment and explores the implications of different monetary rules. Our baseline case presumes perfect pass-through of exchange rates to import prices. Section 4.5 considers the implications of imperfect pass-through. Concluding remarks are in section 4.6.

4.2 The Model

We begin this section with a brief overview of the model, then present the details of the production sectors, and close with a description of the equilibrium.

2. For related work, see the references in the *IMF World Economic Outlook,* April 2007.

4.2.1 Overview

The framework is a variation of OR's model of current account adjustment and the exchange rate. Whereas OR studied a simple two-country endowment economy, we add production, nominal price rigidities, and monetary policy. In addition, while OR performed the static experiment of examining the response of the exchange rate to closure of the current account deficit, we examine the dynamic adjustment path. Our interest is to explore the implications of different adjustment scenarios for the appropriate course of monetary policy.

There are two countries: home (H) and foreign (F). Each country has one representative household that is assumed to behave competitively.[3] Within each country, the household consumes tradable and nontradable consumption goods. Tradable goods, further, consist of both home- and foreign-produced goods. For simplicity, there are no capital goods.

Each household consists of a continuum of workers of measure unity. Each member of the household consumes the same amount. Hence, there is perfect risk-sharing within each country. Each worker works in a particular firm in the country that produces intermediate tradable or nontradable goods. Therefore, there is a continuum of intermediate goods firms of measure unity. Because we want to allow for some real rigidity in price setting, we introduce local labor markets for each intermediate-goods firm (see, for instance, Woodford [2003]). A fraction of the workers work in the nontradable goods sector, while the rest work in the tradable goods sector.

Hence, there are two production sectors within each country: one for nontradable goods and one for a domestic tradable good. Within each sector, there are final and intermediate goods firms. Within each sector, competitive final goods firms produce a single homogenous good with a constant elasticity of substitution (CES) technology that combines differentiated intermediate goods. Intermediate goods firms are monopolistic competitors and set prices on a staggered basis.

Because we wish to study current account dynamics, we allow for incomplete financial markets at the international level. There is a single bond that is traded internationally and is denominated in units of home currency.[4] Foreign country citizens may also hold a bond denominated in units of foreign currency, but this bond is not traded internationally.[5]

3. We could alternatively consider a continuum of measure unity of identical households in each country.

4. The denomination of the international asset in U.S. currency is the only source of valuation effects in our model. If the dollar depreciates, the real value of U.S. foreign liabilities reduces, hence generating a capital gain. Cavallo and Tille (2006) discuss in detail how this mechanism can affect the rebalancing of the U.S. current account deficit in the context of the OR model. Bems and Dedola (2006) investigate the role of cross-country equity holdings and find that this channel can smooth the current account adjustment by increasing risk-sharing.

5. Since there is complete risk-sharing within a country, this bond is redundant. We simply add it to derive an uncovered interest parity condition.

While we allow for nominal price rigidities in both the nontradable and tradable sectors, for simplicity, we assume in our baseline case that across borders there is perfect exchange rate pass-through. Hence, the law of one price holds for tradable goods. There is of course considerable evidence of imperfect pass-through from exchange rates to import prices (see, for instance, Campa and Goldberg [2006]). Nonetheless, we think there are several reasons why in our baseline case it may be reasonable to abstract from this consideration. First, evidence that firms adjust prices sluggishly to "normal" exchange movements may not be relevant to situations where there are sudden large exchange rate movements, as could happen in a current account reversal. Second, under the baseline calibration, our model is broadly consistent with the evidence on low pass-through of exchange rates to final consumer prices. We obtain low pass-through to consumer prices because the calibrated import share is low, as is consistent with the evidence.[6] Nonetheless, it can be argued that the model with perfect pass-through misses out on some of the very high frequency dynamics between exchange rates, import prices, and final consumer prices. We accordingly extend the baseline model to allow for imperfect pass-through in section 4.6.

We next present the details of the model. We characterize the equations for the home country. Unless stated otherwise, there is a symmetric condition for the foreign country.

4.2.2 The Household

Let C_t be the following composite of tradable and nontradable consumption goods, C_{Tt} and C_{Nt}, respectively:

$$C_t \equiv \frac{C_{Tt}^{\gamma} C_{Nt}^{1-\gamma}}{\gamma(1-\gamma)}. \tag{1}$$

We employ the Cobb-Douglas specification to maintain analytical tractability. The implied elasticity of substitution of unity between tradables and nontradables, however, is not unreasonable from a quantitative standpoint and corresponds to the baseline case of OR.[7]

Tradable consumption goods, in turn, are the following composite of home tradables C_{Ht} and foreign tradables, C_{Ft}:

$$C_{Tt} \equiv [\alpha^{1/\eta}(C_{Ht})^{(\eta-1)/\eta} + (1-\alpha)^{1/\eta}(C_{Ft})^{(\eta-1)/\eta}]^{\eta/(\eta-1)}. \tag{2}$$

Following OR, we allow for home bias in tradables, that is, $\alpha > 0.5$. We use a CES specification as opposed to Cobb-Douglas, given that the elasticity of

6. Campa and Goldberg (2006) estimate an exchange rate pass-through elasticity to consumer prices of 0.08, which is close to the analogous value in our model. In our framework, the low value obtains because imports in the consumption bundle have small weight relative to nontraded goods and home tradables.

7. Model simulations suggest that varying this elasticity from 0.5 to 2.0 (the range considered by OR) does not have a major effect on the quantitative results.

substitution among tradables is likely to be higher than across tradables and nontradables. Further, as we will demonstrate, the departure from Cobb-Douglas permits the terms of trade to have a direct effect on the trade balance.

Given that the household minimizes expenditure costs given (1) and (2), the index for the nominal price of the consumption composite, P_t, is given by the following function of the price of tradables P_{Tt} and the price non-tradables P_{Nt}:

$$P_t = P_{Tt}^{\gamma} P_{Nt}^{1-\gamma}. \tag{3}$$

Similarly, from cost minimization, we may express P_{Tt} as the following function of the price of home tradables P_{Ht}, and the (domestic currency) price of foreign tradables, P_{Ft}:

$$P_{Tt} = [\alpha P_{Ht}^{1-\eta} + (1-\alpha) P_{Ft}^{1-\eta}]^{1/(1-\eta)}. \tag{4}$$

We assume that the law of one price holds for tradables. Let ε_t be the nominal exchange rate and let the superscript * denote the corresponding variable for the foreign country. Then, we have:

$$P_{jt} = \varepsilon_t P_{jt}^{*}$$

for $j = H, F$.

The household in each country consists of a continuum of workers who consume and supply labor. Within the household, a fraction γ of workers work in the tradable goods sector, while a fraction $1-\gamma$ work in the nontradable goods sector. As we noted earlier, within each sector, labor markets are local, and we assume that each worker works in a particular firm within the sector.[8] Let $f \in (0, 1)$ index the intermediate goods firms, and let $f \in [0, \gamma)$ denote firms in the tradable goods sector and let $f \in (\gamma, 1)$ denote firms in the nontradable goods sector. Then we also let $f \in (0, 1)$ index workers in the household. Let $L_{kt}(f)$ denote hours worked by worker f in sector $k = H$, N (where $f \in [0, \gamma)$ for $k = H$ and $f \in (\gamma, 1)$ for $k = N$). Finally, let θ_t be the household's subjective discount factor. The preferences for the household in period t are then given by

$$U_t \equiv E_t \sum_{s=0}^{\infty} \theta_{t+s-1} u_{t+s}, \tag{5}$$

where the period utility u_t is given by

$$u_t \equiv \log C_t - \left[\int_0^{\gamma} \frac{L_{Ht}(f)^{1+\varphi}}{1+\varphi} df + \int_{\gamma}^{1} \frac{L_{Nt}(f)^{1+\varphi}}{1+\varphi} df \right].$$

The discount factor θ_t is endogenous and is defined by the recursion

8. To be clear, the household decides labor supply for each individual worker.

(6) $$\theta_t = \beta_t \theta_{t-1}$$

with

$$\beta_t \equiv \frac{e^{\varsigma t}}{1 + \psi(\log \overline{C}_t - \vartheta)},$$

where $\overline{C}_t$ is detrended consumption, treated as exogenous by the household, and hence, corresponding to an average across households in case we replace the representative household by an explicit continuum of identical households. Following Uzawa (1968), we make the discount factor endogenous to ensure a determinate steady state in the presence of incomplete markets and international lending and borrowing.[9] In particular, we choose the constant ψ to pin down the steady-state discount factor to the desired value and we choose the constant ϑ to ensure $\psi > 0$, which guarantees that the discount factor is decreasing in the level of average consumption.[10] Intuitively, under this formulation, there is a positive spillover from average consumption to individual consumption. Higher consumption within the community induces individuals to want to consume more today relative to the future; that is, β_t decreases. As in Uzawa (1968), indebtedness reduces borrowers' consumption, which raises their discount factor, thus inducing them to save, and vice versa. We stress, however, that this formulation is simply a technical fix. We parametrize the model so that the endogenous discount factor has only a negligible effect on the medium term dynamics by picking ψ to be sufficiently small.

Finally, the variable ς_t is a preference shock that follows a first-order autoregressive process with i.i.d. normal innovations

(7) $$\varsigma_t = \rho_\varsigma \varsigma_{t-1} + u_{\varsigma t}, \quad u_{\varsigma t} \sim \text{i.i.d. } N(0, \sigma_\varsigma^2).$$

The preferences for the foreign household are defined similarly.

Let B_t represent the nominal holdings at the beginning of period $t + 1$ of an internationally traded one-period riskless bond nominated in home currency. Let $W_{kt}(f)$ be the nominal wage in sector $k = H, N$ that worker $f \in [0, 1]$ faces. Finally, let Υ_t be dividends net of lump sum taxes. Then the household's budget constraint is given by

(8) $$P_t C_t + B_t = I_{t-1} B_{t-1} + \int_0^\gamma W_{Ht}(f) L_{Ht}(f) df + \int_\gamma^1 W_{Nt}(f) L_{Nt}(f) df + \Upsilon_t,$$

where I_{t-1} denotes the gross nominal domestic currency interest rate between period $t - 1$ and t.

9. For a recent survey of different approaches to introducing a determinate steady state with incomplete international financial markets, see Bodenstein (2006).

10. Nothing would change significantly if the discount factor depended on utility (perceived as exogenous) instead of consumption. We opt for consumption since it leads to a simpler dynamic relation for the discount factor. The effect on the quantitative performance of the model is negligible.

The household maximizes the utility function given by equation (5) subject to the budget constraint given by equation (8), as well as the definitions of the various composites, given by equations (1) and (2). The first-order necessary conditions of the household's problem are all reasonably conventional.

The allocation between tradables and nontradables is

$$C_{Tt} = \gamma\left(\frac{P_{Tt}}{P_t}\right)^{-1} C_t, \quad C_{Nt} = (1-\gamma)\left(\frac{P_{Nt}}{P_t}\right)^{-1} C_t. \tag{9}$$

The allocation between home and foreign tradables is

$$C_{Ht} = \alpha\left(\frac{P_{Ht}}{P_{Tt}}\right)^{-\eta} C_{Tt}, \quad C_{Ft} = (1-\alpha)\left(\frac{P_{Ft}}{P_{Tt}}\right)^{-\eta} C_{Tt}. \tag{10}$$

The consumption saving decisions depend upon a standard Euler equation,

$$\mathrm{E}_t\left[\beta_t I_t \frac{P_t}{P_{t+1}}\left(\frac{C_{t+1}}{C_t}\right)^{-1}\right] = 1. \tag{11}$$

Finally, the sectoral labor supply equations are

$$\frac{W_{kt}(f)}{P_t}\frac{1}{C_t} = L_{kt}(f)^{\varphi}. \tag{12}$$

We assume that the structure of the foreign country is similar, but with two differences. First, the realizations of the country specific shocks may differ across countries. Second, we assume that the foreign country bond is not traded internationally. Thus, while citizens of H trade only in domestic bonds, citizens of F may hold either domestic or foreign country bonds.

Accordingly, given that foreign country citizens must be indifferent between holding domestic and foreign bonds, we obtain the following uncovered interest parity condition:

$$E_t\left\{I_t \frac{\varepsilon_t P_t^*}{\varepsilon_{t+1} P_{t+1}^*}\left(\frac{C_{t+1}^*}{C_t^*}\right)^{-1}\right\} = E_t\left\{I_t^* \frac{P_t^*}{P_{t+1}^*}\left(\frac{C_{t+1}^*}{C_t^*}\right)^{-1}\right\}. \tag{13}$$

Note that, since there is only one representative household in country F, the foreign bond will be in zero net supply in equilibrium.

4.2.3 Firms

Final Goods Firms

As mentioned, $f \in [0, \gamma)$ and $f \in (\gamma, 1)$ denote intermediate goods firms in the tradable goods and nontradable goods sector, respectively. Within sector $k = \{H, N\}$, competitive final goods firms package together intermediate products to produce output, according to the following CES technology:

$$(14)\quad Y_{Ht} \equiv [\gamma^{-1/\sigma}\int_0^{\gamma} Y_{Ht}(f)^{(\sigma-1)/\sigma}df]^{\sigma/(\sigma-1)},$$
$$Y_{Nt} \equiv [(1-\gamma)^{-1/\sigma}\int_{\gamma}^{1} Y_{Nt}(f)^{(\sigma-1)/\sigma}\,df]^{\sigma/(\sigma-1)}.$$

The parameter σ is the elasticity of substitution among intermediate goods. We assume $\sigma > 1$.

From cost minimization:

$$(15)\quad Y_{Ht}(f) = \gamma^{-1}\left[\frac{P_{Ht}(f)}{P_{Ht}}\right]^{-\sigma} Y_{Ht}, \quad Y_{Nt}(f) = (1-\gamma)^{-1}\left[\frac{P_{Nt}(f)}{P_{Nt}}\right]^{-\sigma} Y_{Nt}.$$

Accordingly, the price index is:

$$(16)\quad P_{Ht} = [\gamma^{-1}\int_0^{\gamma} P_{Ht}(f)^{1-\sigma}df]^{1/(1-\sigma)}, \quad P_{Nt} = [(1-\gamma)^{-1}\int_{\gamma}^{1} P_{Nt}(f)^{1-\sigma}df]^{1/(1-\sigma)}.$$

Intermediate Goods Firms

Each intermediate goods firm produces output using only labor input. Let $Y_{kt}(f)$ be the output of intermediate goods firm f in sector k. Let $L_{kt}(f)$ be total input from the firm's local labor market (supplied by worker f) and let A_t be a productivity factor that is common within the country.[11] We assume that production is linear in labor inputs as follows:

$$(17)\quad Y_{kt}(f) = A_t L_{kt}(f).$$

Let Z_t be trend productivity and e^{a_t} be the cyclical component. Then A_t obeys

$$(18)\quad A_t = Z_t e^{a_t}$$

with

$$\frac{Z_t}{Z_{t-1}} = 1 + g,$$

where g is the trend productivity growth rate. We defer a full description of the cyclical component e^{a_t} to section 4.4.1, other than saying that this component is stationary.

Assuming that the firm acts competitively in the local labor market, cost minimization yields the following expression for the nominal marginal cost of firm f in sector k:

$$(19)\quad MC_{kt}(f) = \frac{W_{kt}(f)}{A_t}.$$

Firms set prices on a staggered basis. Each period a fraction ξ of firms do not adjust their price. These firms produce output to meet demand, assuming the price does not fall below marginal cost. For the fraction $1 - \xi$ that are able to change price, the objective is given by:

11. It is straightforward to allow for sector-specific productivity shocks as well.

$$\text{(20)} \qquad E_t \sum_{s=0}^{\infty} \xi^s \Lambda_{t,t+s}[P_{kt}(f) - MC_{k,t+s}(f)]Y_{k,t+s}(f),$$

where $\Lambda_{t,t+s} = \beta_{t+s}(C_{t+s}/C_t)^{-1}(P_t/P_{t+s})$ is the stochastic discount factor between t and $t + s$.

The firm maximizes the objective (20), given the demand for its product (15) and its production function (17). The first-order condition for the optimal reset price P^o_{kt} is given by (21)

$$\text{(21)} \qquad E_t\left\{\sum_{s=0}^{\infty} \xi^s \Lambda_{t,t+s}[P^o_{kt} - (1 + \mu)MC_{k,t+s}(f)]Y_{k,t+s}(f)\right\} = 0,$$

where $\mu \equiv (\sigma - 1)^{-1}$.

Finally, from the law of large numbers, the price index in each sector evolves according to

$$\text{(22)} \qquad P_{kt} = [\xi P^{1-\sigma}_{k,t-1} + (1 - \xi)(P^o_{kt})^{1-\sigma}]^{1/(1-\sigma)}.$$

4.2.4 Current Account Dynamics and the Real Exchange Rate

Total nominal domestic bond holdings, B_t, evolve according to

$$\text{(23)} \qquad \frac{B_t}{P_t} = \frac{I_{t-1}B_{t-1}}{P_t} + NX_t,$$

where NX_t is the real value of net exports, given by:

$$\text{(24)} \qquad NX_t \equiv \frac{P_{Ht}Y_{Ht} - P_{Tt}C_{Tt}}{P_t}.$$

The current account reflects the net change in real bond holdings:

$$\text{(25)} \qquad CA_t \equiv \frac{B_t - B_{t-1}}{P_t}.$$

Finally, we define the real exchange rate as

$$\text{(26)} \qquad Q_t \equiv \frac{\varepsilon_t P^*_t}{P_t}.$$

4.2.5 Monetary Policy

In our benchmark framework we suppose that monetary policy obeys the following simple interest rate rule with partial adjustment:

$$\text{(27)} \qquad I_t = I^{\rho}_{t-1}\tilde{I}^{1-\rho}_t$$

where $\tilde{I}_t$ is the "full adjustment" nominal rate, which depends on the steady-state natural rate of interest in the frictionless zero inflation equilibrium, I, and on the gross inflation rate P_t/P_{t-1}

$$\text{(28)} \qquad \tilde{I}_t = I\left(\frac{P_t}{P_{t-1}}\right)^{\phi_\pi}.$$

We begin with this kind of rule as a benchmark because it provides the simplest empirical characterization of monetary policy by the major central banks over the past twenty years (see, for instance, Clarida, Galí, and Gertler [1998]). We will experiment with other rules, however, including targeting rules.

4.2.6 Equilibrium

For both home and foreign tradables, production must equal demand:

$$Y_{Nt} = C_{Nt}, \quad Y^*_{Nt} = C^*_{Nt}. \tag{29}$$

The production of home tradables must equal the sum of the demand from domestic and foreign residents:

$$Y_{Ht} = C_{Ht} + C^*_{Ht}, \tag{30}$$

where C^*_{Ht} denotes the demand for home tradable by the foreign household.

International financial markets must clear:

$$B_t + B^*_t = 0, \tag{31}$$

where B^*_t represents the nominal holdings of the domestic bond by the foreign household. Conditions (31) and (23) imply that the foreign trade balance in units of home consumption, $Q_t\mathrm{NX}^*_t$, must equal the negative of the home trade balance, $-\mathrm{NX}_t$.

Finally, if all these conditions are satisfied, by Walras' Law, the production of foreign tradables equals demand.

This completes the description of the model. There are two special cases to note. First, in the polar case where the probability that a price remains fixed is zero (i.e., $\xi = 0$), the economy converges to a flexible-price equilibrium. Second, with $\xi = 0$ and the Frisch elasticity of labor supply equal to zero (i.e., $\varphi = \infty$), the model converges to the dynamic version of the endowment economy in OR.

Because it will eventually prove convenient in characterizing the full log-linear model, before proceeding further we define aggregate domestic real output, $P_{Yt}Y_t/P_t$ as the sum of the value of the sectoral outputs:

$$\frac{P_{Yt}Y_t}{P_t} = \frac{P_{Ht}Y_{Ht} + P_{Nt}Y_{Nt}}{P_t}, \tag{32}$$

where P_{Yt} is the nominal domestic producer price index. In general, P_{Yt} may differ from P_t since domestic consumption may differ from domestic output. In steady state, however, the trade balance is zero, implying $P_{Yt} = P_t$ is the long-run equilibrium. Outside steady state, no arbitrage requires that P_{Yt} equals the output share weighted sum of the sectoral nominal prices.

4.2.7 International Relative Prices and Current Account: A Comparison with OR

In this section we present some intuition about the workings of our model. To do so, we first describe how our model nests OR's model of current accounts and exchange rates. We then outline how our modifications will influence the general equilibrium.

It is first convenient to define the following set of relative prices. Let $X_t \equiv P_{Nt}/P_{Tt}$ and $X_t^* \equiv P_{Nt}^*/P_{Tt}^*$ be the relative prices of nontradables to tradables in the home and foreign countries, respectively, and let $\mathcal{T}_t \equiv P_{Ft}/P_{Ht}$ be the terms of trade. After making use of the relevant price indexes and the definition of the real exchange rate, the real exchange rate may then be expressed as a function of these three relative prices:

$$Q_t = \left[\frac{\alpha\mathcal{T}_t^{1-\eta} + (1-\alpha)}{\alpha + (1-\alpha)\mathcal{T}_t^{1-\eta}}\right]^{1/(1-\eta)}\left(\frac{X_t^*}{X_t}\right)^{1-\gamma}. \tag{33}$$

Given home bias ($\alpha > 0.5$), the real exchange rate is increasing in $\mathcal{T}_t$. It is also increasing in X_t^* and decreasing in X_t.

We now turn the link between international relative prices and the current account. Substituting the demand functions for home tradables into the respective market-clearing condition yields:

$$\begin{aligned} Y_{Ht} = {} & \alpha[\alpha + (1-\alpha)\mathcal{T}_t^{1-\eta}]^{\eta/(1-\eta)}C_{Tt} \\ & + (1-\alpha)[\alpha\mathcal{T}_t^{1-\eta} + (1-\alpha)]^{\eta/(1-\eta)}C_{Tt}^*. \end{aligned} \tag{34}$$

Equating demand and supply in the home and foreign markets for nontradables yields:

$$Y_{Nt} = \frac{1-\gamma}{\gamma}(X_t)^{-1}C_{Tt}, \quad Y_{Nt}^* = \frac{1-\gamma}{\gamma}(X_t^*)^{-1}C_{Tt}^*. \tag{35}$$

Given that the international bond market clears, the trade balance in each country may be expressed as:

$$\mathrm{NX}_t = (X_t)^{\gamma-1}\{[\alpha + (1-\alpha)\mathcal{T}_t^{1-\eta}]^{1/(\eta-1)}Y_{Ht} - C_{Tt}\}, \tag{36}$$

$$-\frac{\mathrm{NX}_t}{Q_t} = (X_t^*)^{\gamma-1}\{[\alpha + (1-\alpha)\mathcal{T}_t^{\eta-1}]^{1/(\eta-1)}Y_{Ft}^* - C_{Tt}^*\}. \tag{37}$$

Finally, the current account may be expressed as:

$$\mathrm{CA}_t = (I_{t-1} - 1)\frac{B_{t-1}}{P_t} + \mathrm{NX}_t. \tag{38}$$

Obstfeld and Rogoff pursue the following strategy. They take as given the current account, CA_t, net interest payments, $(I_{t-1} - 1)B_{t-1}/P_t$, and the sectoral outputs in the home and foreign country, Y_{Ht}, Y_{Nt}, Y_{Ft}, and Y_{Nt}. Then, the six equations (33) through (38) determine net exports, NX_t, tradable consumption in the home and foreign countries, C_{Tt} and C^*_{Tt}, along with the four relative prices, $\mathcal{T}_t$, X_t, X^*_t, and Q_t.

Next, OR consider a set of comparative static exercises where the current account adjusts from a deficit to zero. Holding constant international relative prices and all the sectoral outputs, an improvement in the current account requires a decrease in domestic tradable consumption and a roughly offsetting increase in foreign tradable consumption. With home bias, the relative decrease in home tradable consumption causes a deterioration in the terms of trade; that is, an increase in $\mathcal{T}$. In addition, the drop in home tradable consumption required to bring the current account into balance reduces the demand for nontradables, causing a fall in the relative price of nontradables to tradables X. Conversely, the rise of tradable consumption in the foreign country pushes up the relative price of nontradables, X^*. The adjustment in each of the relative prices works to generate a depreciation of the home country's real exchange rate. Under their baseline calibration, for example, OR find that closing the current account from its current level would require a depreciation of the real exchange rate of about 30 percent. Of course, their results depend on the elasticities of substitution between nontradables and tradables and between home and foreign tradables, and require that sectoral outputs are fixed.

Our framework builds on OR and endogenizes the movement of the current account and sectoral outputs in the two countries. The current account is connected to aggregate activity in part through the impact of aggregate consumption on tradable consumption demand within each country:

$$C_T = \gamma(X_t)^{1-\gamma} C_t, \quad C^*_T = \gamma(X^*_t)^{1-\gamma} C^*_t. \tag{39}$$

Everything else equal, accordingly, a rise in aggregate consumption within a country raises the demand for tradable consumption, thus causing a deterioration in the trade balance.

The production of tradables and nontradables will of course also depend on aggregate economic activity. Within the flexible-price version of the model, labor demand and supply along the production technology within each sector determine sectoral outputs. Aggregate consumption and real interest rates within each country depend upon the respective economy-wide resource constraints and the respective consumption Euler equations. The relative pattern of real interest rates across countries and the real exchange rate, in turn, depend on the uncovered interest parity condition.

Within the sticky-price version of the model, for firms not adjusting price in a given period, output adjusts to meet demand so long as the markup is nonnegative. Given staggered price setting, the price index within each sector adjusts sluggishly to deviations of the markup from desired levels. As a consequence, there is stickiness in the movement of the overall index of domestic prices and also in the relative price of nontradables to tradables. The nominal stickiness, of course, implies that monetary policy influences the joint dynamics of output and inflation. There are potentially several extra complications from this open economy setup. Monetary policy can influence not only short-term real interest rates but also the real exchange rate. In addition, both domestic output and inflation depend on foreign economic behavior. Finally, stickiness in the movement of the relative price of nontradables to tradables may distort the efficient adjustments of the two sectors to international disturbances. In the numerical exercises that follow we illustrate these various phenomena.

We now turn to the log-linear model.

4.3 The Log-Linear Model

We consider a log-linear approximation of the model around a deterministic steady state. We first characterize the steady state and then turn to the complete log-linear model. Fortunately, the model is small enough so that the key mechanisms of current account and exchange rate determination as well as monetary policy transmission become quite transparent.

4.3.1 Steady State

The steady state is very simple. In the symmetric long-run equilibrium, each country grows at the steady-state productivity growth rate g. Both the trade balance and the stock of foreign debt are zero:

$$\mathrm{NX} = B = 0.$$

It is then straightforward to show these restrictions imply that in the symmetric deterministic steady state, all the relevant relative prices are unity:

$$\mathcal{T} = X = Q = 1.$$

In addition, for each country there are a simple set of relations that characterize the behavior of the real quantities. Given that the trade balance is zero, national output simply equals national consumption:

$$Y_t = C_t.$$

Next, since relative prices are unity, expenditures shares depend simply on preference parameters:

$$C_{Ht} = \alpha\gamma C_t, \quad C_{Ft} = (1 - \alpha)\gamma C_t, \quad C_{Nt} = (1 - \gamma)C_t.$$

Market clearing for output in each sector requires:

$$Y_{Ht} = C_{Ht} + C^*_{Ht}, \quad Y_{Nt} = C_{Nt}.$$

Similarly, market clearing for labor in each sector along with the respective production technologies pins down steady-state output with each sector

$$\frac{Y_{Ht}}{Z_t} = \gamma(1+\varphi)^{1/(1+\varphi)}, \quad \frac{Y_{Nt}}{Z_t} = (1-\gamma)(1+\varphi)^{1/(1+\varphi)},$$

where Z_t is trend productivity. Finally, the steady real interest rate, I^o, is given by:

$$I^o = \frac{1+g}{\beta},$$

where $1 + g$ is the gross growth rate of technology.

4.3.2 Log-Linear Model

We now characterize the log-linear system for the home country. A symmetric set of equations that we do not list here applies for the foreign country. Lowercase variables denote log deviations from a deterministic steady state, except as noted otherwise.[12]

We begin by expressing domestic real output as a linear combination of home tradable and nontradable output:

$$y_t = \gamma y_{Ht} + (1-\gamma)y_{Nt}. \tag{40}$$

The demand for home tradables depends positively on the terms of trade and on both relative prices of nontradables as well as on aggregate consumption in both countries:

$$y_{Ht} = 2\alpha(1-\alpha)\eta\tau_t + (1-\gamma)[\alpha x_t + (1-\alpha)x_t^*] + \alpha c_t + (1-\alpha)c_t^*. \tag{41}$$

In turn, the demand for nontradables may be expressed as:

$$y_{Nt} = -\gamma x_t + c_t, \tag{42}$$

where $x_t \equiv p_{Nt} - p_{Tt}$. The demand for home nontradables depends negatively on the relative price of nontradables and positively on aggregate consumption.

From the log-linear intertemporal Euler equation, consumption depends positively on expected future consumption, and inversely on the real interest rate and the time varying discount factor:

$$c_t = \mathrm{E}_t c_{t+1} - (i_t - \mathrm{E}_t \pi_{t+1}) - \hat{\beta} t, \tag{43}$$

where $\hat{\beta}_t$ denotes the percent deviation of β_t from steady state. The endogenous discount factor depends negatively on consumption according to

$$\hat{\beta}_t = \varsigma_t - \psi\beta c_t, \tag{44}$$

12. The approximation is performed about the steady state in which quantities are constant; that is, expressed relative to trend productivity Z_t.

where ς_t, the exogenous shock to the discount factor, obeys the autoregressive process given by equation (7). The presence of c_t reflects the consumption externality on the discount rate that ensure determinate model dynamics. As noted earlier, we pick ψ to be tiny to ensure that this feature has only a negligible effect on medium term dynamics.

One can view equations (40), (41), (42), (43), and (44) as determining aggregate demand for output, conditional on the real interest rate and international relative prices. Given nominal rigidities, of course, the real interest rate will depend on monetary policy. By adjusting the short-term interest rate, the central bank can also influence the terms of trade, as we show explicitly in the following.

Given that there is nominal inertia on both the tradable and nontradable sectors, τ_t and x_t evolve as follows:

$$\tau_t = \tau_{t-1} + (\Delta q_t + \pi^*_{Ft} - \pi^*_t) - (\pi_{Ht} - \pi_t), \tag{45}$$

$$x_t = x_{t-1} + \pi_{Nt} - \pi_{Ht} - \gamma(1 - \alpha)\Delta\tau_t. \tag{46}$$

Note, however, that because there is perfect pass-through in the tradable sector, there is an immediate effect of exchange rate adjustments on the terms of trade.

Let the superscript ^{o} denote the flexible-price equilibrium value of a variable. Then inflation in the tradable goods and nontradable goods sectors may be expressed as:

$$\pi_{Ht} = \kappa\left[(y_{Ht} - y^o_{Ht}) - \frac{1}{1+\varphi}(nx_t - nx^o_t)\right] + \beta E_t\pi_{H,t+1}, \tag{47}$$

$$\pi_{Nt} = \kappa(y_{Nt} - y^o_{Nt}) + \beta E_t\pi_{N,t+1}, \tag{48}$$

with $y^o_{Ht} = a_t + (1+\varphi)^{-1}nx^o_t$, $y^o_{Nt} = a_t$, and $\kappa = (1-\xi)(1-\beta\xi)(1+\varphi)/[\xi(1+\sigma\varphi)]$. Inflation in the nontradable sector depends on the current output gap within the sector and on anticipated future nontradable inflation, in analogy to the standard new-Keynesian Phillips curve (see, for instance, Woodford 2003). For the tradable goods sector, the "trade balance gap" matters as well. Roughly speaking, a higher trade deficit relative to the flexible-price equilibrium value is associated with higher marginal cost in the tradable goods sector resulting from this imbalance.

Overall CPI inflation depends not only on domestic inflation but also on the evolution of the price of imported goods:

$$\pi_t = \gamma\pi_{Ht} + (1-\gamma)\pi_{Nt} + \gamma(1-\alpha)\Delta\tau_t. \tag{49}$$

We next turn to interest rates and exchange rates. In the baseline case, the nominal interest rate follows a simple feedback rule with interest rate smoothing:

$$i_t = \rho i_{t-1} + (1-\rho)\phi_\pi\pi_t. \tag{50}$$

Uncovered interest rate parity implies the following link between real interest rates and real exchange rates:

$$(51) \qquad (i_t - E_t\pi_{t+1}) - (i_t^* - E_t\pi_{t+1}^*) = E_t q_{t+1} - q_t.$$

Finally, we turn to the trade balance and the evolution of net foreign indebtedness. Net exports depend inversely on the terms of trade and positively on the current and expected path of the discount factor shock:

$$(52) \qquad nx_t = \delta(\eta - 1)\tau_t + \sum_{s=0}^{\infty} (1 - \alpha)E_t\hat{\beta}_{Rt+s},$$

with $\delta = 2\alpha(1-\alpha) > 0$, and where $\tau_t \equiv p_{Ft} - p_{Ht}$ and $\hat{\beta}_{Rt}$ is the difference between the home and foreign time varying discount factors. Since the steady-state value of net exports is zero, nx_t is net exports as a fraction of steady-state output. Equation (52) is obtained by combining the resource constraint, the market-clearing condition for home tradables, and the uncovered interest parity condition, along with the consumption Euler equations for the two countries.[13] Note that in the log case ($\eta = 1$), the trade balance is driven purely by the exogenous preference shock. In this instance, as emphasized by Cole and Obstfeld (1991) and others, the terms of trade adjusts to offset any impact on the trade balance of disturbances (other than shifts in consumption/saving preferences). This result also depends on having a unit elasticity of substitution between tradables and nontradables, as we have here.

Finally, the net foreign indebtedness evolves as follows:

$$(53) \qquad b_t = \frac{1}{\beta} b_{t-1} + nx_t,$$

where b_t is debt normalized by trend output.

The system thus far consists of fourteen equations that determine fourteen variables, $\{i_t, c_t, \hat{\beta}_t, y_t, y_{Ht}, y_{Nt}, x_t, \pi_t, \pi_{Ht}, \pi_{Nt}, q_t, nx_t, \tau_t, b_t\}$, conditional on the foreign economy and conditional on the exogenous shocks ς_t and a_t and the values of the predetermined variables b_{t-1}, τ_{t-1}, and x_{t-1}. The complete model consists of these equations plus nine more that help determine the foreign variables $\{i_t^*, c_t^*, \hat{\beta}_t^*0, y_t^*, y_{Ft}^*, y_{Nt}^*, x_t^*, \pi_t^*, \pi_{Ft}^*, \pi_{Nt}^*\}$, along with two foreign predetermined variables, τ_{t-1}^*, and x_{t-1}^*. These nine equations are the foreign counterparts of equations (41), (43), (44), (42), (46), (47), (48), (49), and (50). In addition, given the evolution of debt determined by the model, we may express the current account as:

$$(54) \qquad \mathrm{ca}_t = b_t - \frac{1}{1+g} b_{t-1},$$

13. From combining equations one obtains

$$nx_t = (1 - \alpha)\hat{\beta}_{R,t} - \delta(\eta - 1)E_t\Delta\tau_{t+1} + E_t nx_{t+1}.$$

Given that $\hat{\beta}_{R,t}$ is stationary about a zero mean, one can iterate this relation forward to obtain equation (52).

where ca_t is the current account normalized by steady-state output.

The model is not small, but it is parsimonious (we think), given its objectives. In particular, it captures the link between international relative prices and the current account stressed by OR. Given our goal of studying the role of monetary policy, it goes beyond OR by endogenizing the determination of these variables within a two-country monetary general equilibrium framework.

The way monetary policy influences international relative prices and the current account further is fairly clear. Given that prices are sticky, an increase in the nominal interest rate causes an appreciation of the real exchange rate (holding constant expectations of the future) as the uncovered interest parity condition (51) makes clear. The appreciation of the exchange rate improves the terms of trade (i.e., τ_t falls), as equation (45) suggests. This in turn leads to a deterioration of the trade balance and hence, of the current account. The evolution of the current account and international relative prices will have implications for the behavior of output and inflation within each country and thus, implications for the appropriate course of monetary policy. It should also be clear that the monetary policy of one country has implications for the other.

We next employ the model to explore the implications of current account behavior for monetary policy.

4.4 Current Account Dynamics and Monetary Policy

We first describe how we calibrate the model. We then explore the behavior of the model economy in our benchmark case, where each country's central bank sets the short-term interest rate according to a Taylor rule with partial adjustment, as described by equation (50). We choose this formulation of monetary policy for our benchmark case because the evidence suggests it provides a reasonable way to describe the behavior of the major central banks during the past twenty-five years. We then proceed to consider alternative policy environments. For each policy environment, we consider two scenarios for current account adjustment. In the "slow burn" scenario, the adjustment is smooth and drawn out over time. In the "fast burn" scenario, instead, the current account is subject to a sharp reversal.

4.4.1 Calibration

We have in mind the United States as the home country and the rest of the world as the foreign country. This is somewhat problematic since the countries in the model are symmetric in size while the U.S. output is only about a quarter of world GDP. It is not hard to extend the model to allow for differences in country size, though at the cost of notational complexity. Thus, for this chapter, we stick with the simpler setup at the cost of some quantitative realism.

The model is quarterly. The three parameters that govern the open economy dimension of the model are the preference share parameter for tradables (γ), the preference share parameter for home tradables (α), and the elasticity of substitution between home and foreign tradables (η). Based on the evidence and arguments in OR, we set $\gamma = 0.25$, $\alpha = 0.7$, and $\eta = 2.0$. Note that our consumption composite imposes a unit elasticity of substitution between tradables and nontradables. This number is within the range of plausible values suggested by OR and is actually the benchmark case in their study.

There are five additional preference parameters, three of which are standard: the steady-state discount factor (β), the inverse of the Frisch elasticity of labor supply (φ), and the elasticity of substitution between intermediate inputs (σ). We set $\beta = 0.99$ and $\varphi = 2.0$. The latter implies a Frisch elasticity of labor supply of 0.5, which is squarely in the range of estimates from microdata. We set $\sigma = 11$ to deliver a 10 percent steady-state price markup in both the tradable- and nontradable-goods sectors. The other two preference parameters, ψ and ϑ, govern the spillover effect of aggregate consumption on the discount factor. We fix ψ consistently with our choice of β and we adjust ϑ so that ψ is small but positive. In particular, we arbitrarily set $\vartheta = -1{,}000$ and obtain $\psi = 7.2361 \cdot 10^{-6}$. Implicitly, we are simply ensuring that the endogeneity of the discount factor does not significantly influence medium term dynamics.

Next, we set the probability that a price does not adjust (ξ) at 0.66. This implies a mean duration that a price is fixed of 3 quarters, which is consistent with the micro evidence.

The two parameters of the policy rule are the feedback coefficient ϕ_π and the smoothing parameter ρ. Based on the evidence in Clarida, Galí, and Gertler (1998) and elsewhere, we set $\phi_\pi = 2.0$ and $\rho = 0.75$.

Finally, we turn to the parameters that govern the preference shock ς_t and the cyclical productivity shock a_t. As we discussed earlier, ς_τ is meant to be a simple way to capture structural factors that influence differences in consumption/saving propensities across countries, such as fiscal policy, demographics, and capital market development. In this regard, it is an object that is likely to persist over time. We thus set the serial correlation parameter that governs this process (ρ_ς) at 0.97.

We assume that trend productivity grows at a 2 percent annual rate (corresponding to $g = 0.5$ percent). Because we would like cyclical differences in productivity growth to contribute to current account dynamics, we model the cyclical component of technology, allowing for persistent forecastable periods of productivity movement away from trend that may vary over time. In particular, a_t is a combination of two processes, u_t and v_t, as follows:

$$a_t = u_t - v_t \tag{55}$$

with

$$u_t = \rho_u u_{t-1} + \varepsilon_t + \varepsilon_{ut}$$

$$v_t = \rho_v v_{t-1} + \varepsilon_t,$$

where $\rho_u = 0.999 > \rho_v$, and where ε_t and ε_{ut} are zero mean i.i.d. shocks.

The assumption that u_t is "near" unit root allows us to partition the shocks, roughly speaking, into one (ε_{ut}) that primarily affects the current level of productivity and another (ε_t) that affects its expected growth rate. Suppose we start at a steady state with $u_{t-1} = v_{t-1} = 0$. A positive innovation in ε_t has no direct effect on a_t in the first period. However, since $\rho_u > \rho_v$, a_t will grow steadily for a period of time. Because ρ_u is close to unity and greater than ρ_v, this period can be quite long. Thus, innovations in ε_t can induce growth cycles. By contrast, a shock to ε_{ut} has a direct affect on a_t but only generates a one-period blip in the growth rate since ρ_u is near unity. We can allow for ε_t and ε_{ut} to be correlated in any arbitrary fashion.

Similar to OR, we initialize the model to match roughly the current international situation; that is, a current account deficit for the home country (i.e., the United States) of approximately 5 percent of GDP (or equivalently 20 percent of tradable output) along with a stock of foreign debt approximately equal to 20 percent of GDP annualized (equivalent to 80 percent of tradable output).[14] We start with the flexible-price model and set the predetermined value of foreign indebtedness at its value in the data. We then adjust ε_t for the home country and ρ_v so that domestic productivity growth is expected to be roughly half percent above trend for the next decade. We adjust ε_t^* exactly in the opposite direction and set $\rho_v = \rho_v^*$. We fix the differential in expected productivity growth between the two countries at 1 percent based on the evidence from the G7 ex the United States over the past decade. It turns out that this accounts for roughly one-third of the U.S. current account deficit. We then add in a preference shock for both the home and foreign countries to explain the difference. Again, this preference shock is meant to account for factors that lead to different consumption/saving propensities across countries.

We then turn to the sticky-price model. We initialize the predetermined variables in the sticky-price model, τ_{t-1} and x_{t-1}, to match the values that arose in the first period of the flexible-price model. We then feed in the same size shocks as before to see whether we matched the current account evidence. If not, we adjust proportionately the sizes of all the shocks. We found that in all cases, only very tiny adjustments were necessary.

4.4.2 Baseline Case

We now analyze our baseline case where monetary policy in each country is given by a Taylor rule with partial adjustment, as described by equation

14. The recent current account deficit is more on the order of 6 percent of GDP, but we stick with the 5 percent number to maintain comparability with OR.

(50). We characterize the response of the home country economy in both the slow and fast burn scenarios. For the most part, we do not show the foreign country variables because to a first approximation their movement is of equal magnitude and is the opposite sign to those of the home country variables. This mirrored response arises because: (a) the countries are of equal size; (b) the shocks we feed in are of similar magnitude and opposite signs; and (c) for our baseline case, the two countries follow the same policy rule. It is true that one country is a debtor and the other a creditor. While this introduces a small difference in the low-frequency behavior of aggregate consumption across countries, it does not introduce any major differences in the comparative dynamics.

The Slow Burn Scenario

We start with the slow burn scenario. The top panel of figure 4.2 plots the response of a variety of "international" variables for this case, while the bottom panel of figure 4.2 plots mostly "domestic" variables. In each plot, the solid line presents the response of the model with nominal price rigidities. To provide a benchmark, the dotted line presents the response of the flexible-price model. The horizontal axis measures time in quarters from the initial period while, for the quantity variables and relative prices, the vertical axis measures the percent deviation from steady state. Inflation and interest rates are measured in annualized basis points.

To organize the discussion, it is useful to first describe the flexible-price case. As we noted earlier, we initialize the model with a current account deficit of 20 percent of tradable output. As the top panel of figure 4.2 shows, in the slow burn scenario the half life for adjustment of the current account is about seven years.[15] In the absence of any further shocks, after ten years the current account has closed by about 60 percent. The protracted current account deficit produces a sustained increase in net foreign indebtedness that does not level off until far in the future. Associated with the large current account deficit is a consumption boom in the home country (along with a consumption bust in the foreign country). Consumption is more than 3.5 percent above steady state in the home country, with the reverse being true in the foreign country. The sustained upward movement in consumption in the home country is due to the fact that for a sustained period productivity growth in the home country is above trend. Note in figure 4.2 that the upward movement in domestic output in percentage terms is nearly three times that of home country consumption. This differential helps account for why the current account is closing steadily over this period, despite the growth in consumption.

As figure 4.2 also shows, the current account imbalance implies an

15. Interestingly, this prediction is very close to that of the GEM model. See Faruqee et al. (2005).

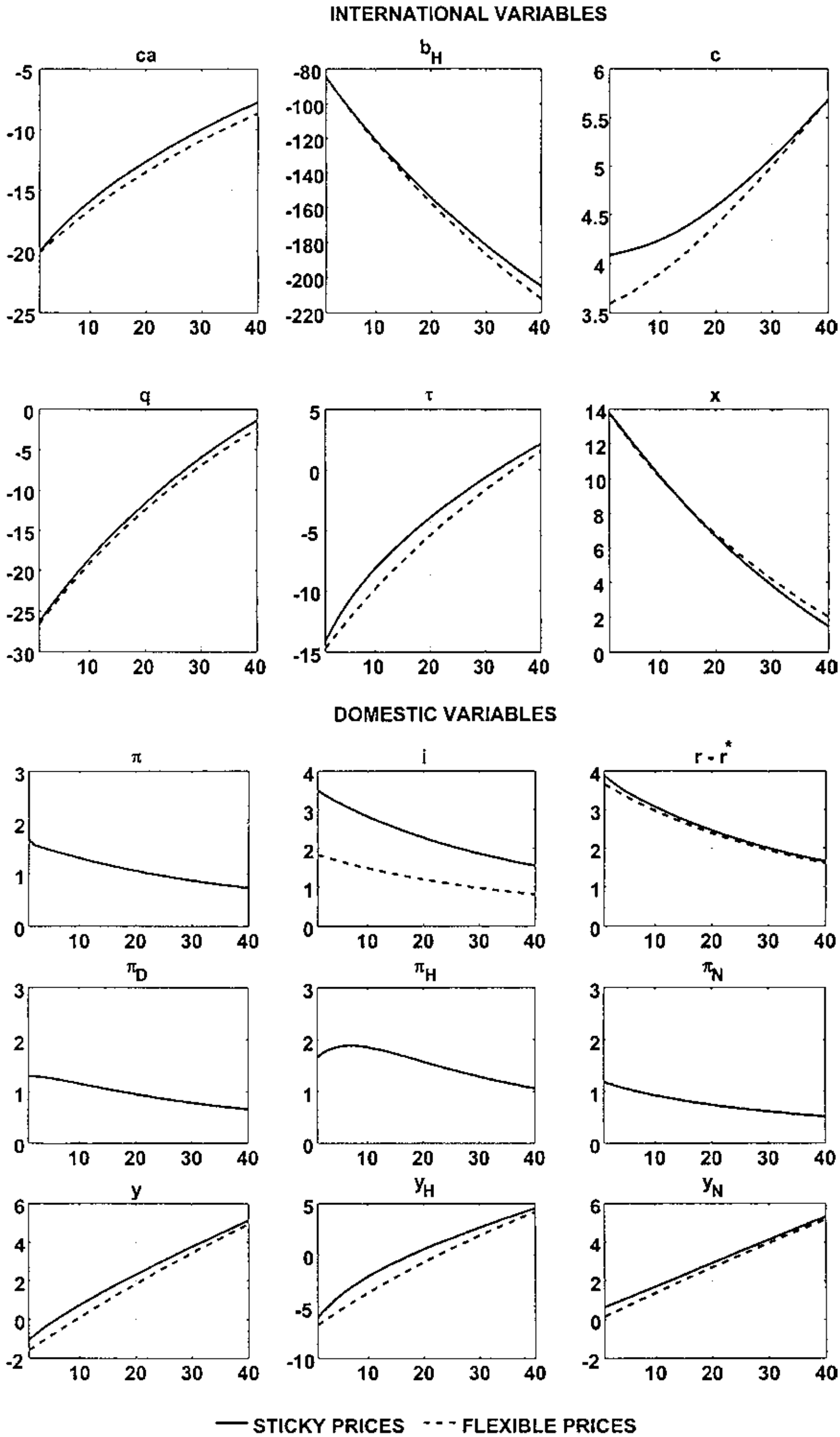


Fig. 4.2 Baseline Taylor rule: Slow burn scenario

expected depreciation of almost 30 percent, in line with the estimates of OR. Under the slow burn scenario, the half life of this adjustment is roughly five years. The total expected exchange rate depreciation is accounted for by a 15 percent depreciation of the terms of trade and an expected decline in the relative price of nontradables to tradables of 14 percent, along with a symmetric increase in the foreign relative price of nontradables to tradables.[16] This decomposition is also in line with OR. Again, this correspondence is not that surprising since we are using a similar calibration of the international sector. Where we differ from OR is by providing a model of the dynamic adjustment path.

One other result worth noting for this case involves the real interest rate differential between the home and foreign country. As the bottom panel in figure 4.2 shows, in the initial period, the real interest rate for the flexible-price model is roughly two hundred basis points above steady state. It then steadily converges back to steady state. The foreign country interest rate is the mirror image, implying an initial real interest rate differential of roughly four hundred basic that erodes steadily over time. The source of these interest rate dynamics is the expected movement in the real exchange rate. Given that uncovered interest parity holds (at least in the model!), the home real interest must be sufficiently greater than the foreign real rate to compensate for the expected real depreciation of the home country currency. Of course, there is considerable evidence against uncovered interest parity. At the same time, the associated expected decline in the home country's short-term real interest rate suggests an inverted yield curve for the home country, everything else equal. Conversely, the expected rise in the foreign country suggests an upward sloping yield curve for this region. While certainly a host of other factors are at work, it is possible that these considerations may help account for the recent yield curve inversion in the United States, a phenomenon that has been largely specific to this country. In any event, as we discuss, the fact that current account adjustment influences the path of the natural rate of interest has potentially important implications for monetary policy.

We now turn to the sticky-price case. The first point we emphasize is that the behavior of the international variables does not differ dramatically from the flexible-price model. Put differently, in this baseline case, current account and real exchange rate behavior appear to depend mainly on real as opposed to monetary factors. Though there are some small differences, current account and real exchange rate dynamics are very similar across the sticky- and flexible-price models.

16. Given the calibrated elasticities of substitution, the relative price of nontradables explains about two-thirds of the overall movement of the real exchange rate. This is partly inconsistent with the last dollar depreciation episode (late 1980s) when the adjustment occurred mostly through the terms of trade. Relative to twenty years ago, however, the nontradable sector today represents a much larger share of the economy (Buera and Kaboski 2007). Therefore, it is not unlikely that the importance of the relative price of nontradables may increase significantly.

Under our baseline Taylor rule however, demand in the home country is high relative to the flexible-price equilibrium. In particular, both consumption and the current account are above their respective flexible-price equilibrium values (where the latter is driven primarily by the trade balance). Contributing to the positive current account gap is a systematic positive difference between the terms of trade and its flexible-price equilibrium value. In this respect, the terms-of-trade gap is another indicator that monetary policy is not sufficiently tight to curb excess demand in the baseline case. As figure 4.2 illustrates, the result is persistent inflation that averages almost a percent and a half (above target) over the first five years. There is also persistent inflation in both sectors, though it is nearly double in the tradable goods sector, due to the relative effect on demand in this sector stemming from the terms of trade gap. Finally, note the consumer price inflation is roughly thirty to forty basis points above domestic inflation, due to the added effect of the depreciation on import prices.

Note that persistent inflation emerges even though the central bank is aggressively adjusting interest rates in response to inflation (the Taylor rule coefficient is 2.0). A key reason that a conventional Taylor rule does not perform well in this environment is that it does not directly respond to the movement in the short-term natural rate of interest induced by the current account imbalance. At zero inflation, the rule fixes the nominal rate at its steady-state value. However, the current imbalance pushes up the short-term real rate, implying a monetary policy that is too expansionary in this instance. It is straightforward to show that allowing the target interest rate to also depend on an intercept equal to the natural rate of interest greatly improves the central bank's ability to contain inflation. The problem, of course, is that the natural rate is not directly observable. Later we present a rule based on observables that accomplishes much the same as a natural rate of interest augmented rule. In the meantime, we simply emphasize the general point that the current account imbalance may have implications for the natural rate of interest that must be factored into central bank policy, one way or another.

The Fast Burn Scenario

We now turn to the fast burn scenario. As we noted in the introduction, the probability does not seem high that the United States would suffer the kind of sudden current account reversal that many emerging market economies have experienced over the last twenty years. Given its well-developed financial markets, it does not seem likely that the United States would face rapid capital outflows and sharp increases in country risk spreads, as has been endured by a number of East Asian or South American countries. In this regard, if we are to imagine such a crisis arising, we think the most likely scenario is one where there is a sudden reversal of fortune in the growth prospects of the United States relative to the rest of the world.

In particular, we suppose that expected productivity growth in the home country over the next decade declines by an average of 0.75 percent and that the opposite happens in the foreign country. Thus, the initial 1.0 percent advantage in medium term productivity growth drops to a 0.5 disadvantage. Think of the productivity boom coming to a sudden end in the United States and at the same time picking up steam quickly abroad.[17] Because this is unlikely to happen instantly, we let the process play out over the course of the year. The shocks that reduce productivity growth in the home country and raise it in the foreign one are spaced out evenly over the course of four quarters.

Figure 4.3 portrays this scenario, both for the sticky- and flexible-price models. The hard landing begins in quarter 8 and plays out through quarter 12. For both models, the revision in expectations of relative productivity growth results in a current account reversal of roughly 70 percent in the year of the "crisis." The trade balance nearly closes, implying that most of the remaining current account deficit is due to interest payments. The real exchange rate drops nearly 20 percent in the flexible-price model. It drops by only three quarters of this amount, or 15 percent, in the sticky-price model. The somewhat smaller drop in the sticky-price model is due to the inertia in the movement of the relative price of nontradables to tradables in each country that is induced by the staggered nominal price setting within each sector. At the same time, there is a larger depreciation in the terms of trade in the sticky-price model relative to the flex price case, owing to a depreciation of the nominal exchange rate that outpaces the depreciation of the real exchange rate. This relative behavior of the terms of trade accounts for why at the end of the sharp reversal in expectations, the current account deficit is smaller by a modest margin in the sticky-price case.

How does the fast burn impact the domestic variables? In the flexible-price model domestic output actually continues to increase for a period. This somewhat perverse behavior arises because expectations of lower productivity growth reduce current domestic consumption, which in turn induces a positive wealth effect on labor supply. Thus, as emphasized in the recent literature on "news driven" business cycles, within a flexible-price model with standard preferences and technologies, shifts in expected productivity growth tend to move current output in the opposite direction.[18] Within our open economy framework, though, there is also a significant compositional effect, owing to the sharp depreciation of the real exchange rate. As a consequence, the modest rise in total output is accounted for by a sharp increase

17. For simplicity, we assume that the shift in relative productivity growth is the product of shifts within each country that are of equal absolute value but opposite sign. We would obtain virtually the same results if most or all of the shift in productivity growth occurs in one country.

18. See Beaudry and Portier (2004) and Jaimovich and Rebelo (2006) for recent analyses of news-driven business cycles within a flexible price neoclassical framework.

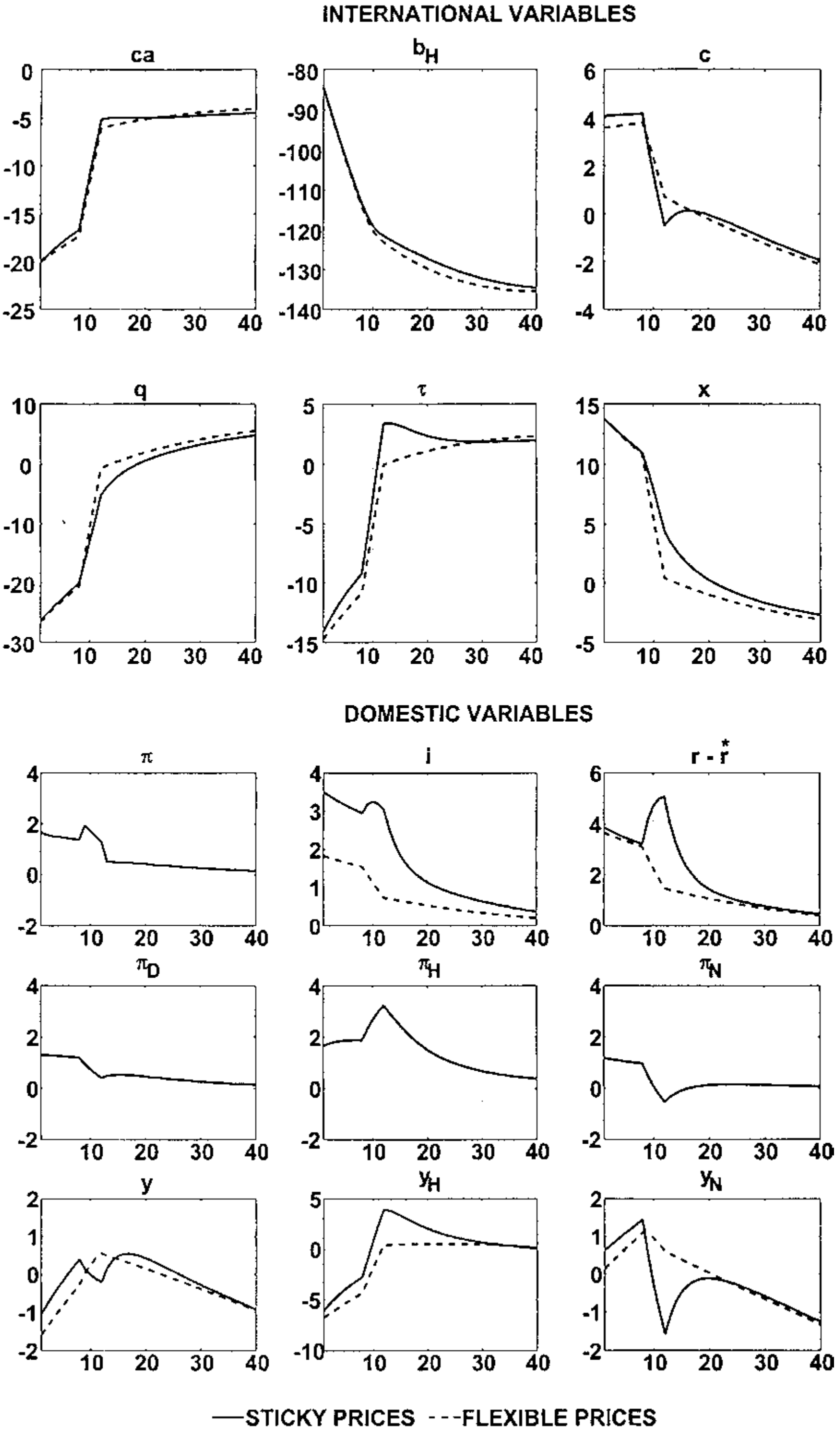


Fig. 4.3 Baseline Taylor rule: Fast burn scenario

in tradable goods output. In contrast, nontradable output begins a steady decline at the onset of the revision in growth expectations.

In the sticky-price model, the fast burn produces a drop in output, albeit a modest one, roughly 0.5 percent over the year. Accompanying the output decline is a rise in inflation of roughly 50 basis points that stems from the exchange rate depreciation.

The small drop in aggregate output, however, masks a significant compositional effect. There is a major contraction in nontradable output, which drops more than 2.5 percent over the year. This sharp contraction opens up a gap with the potential level of nontradable output of more than 2.0 percent at the trough. What accounts for the modest decline in aggregate output is a sharp increase in tradable goods output, which jumps roughly 7.5 percent, nearly 3.0 percentage points larger than the rise in its potential value. The overreaction in the sectoral adjustment, of course, is a product of the stickiness in the relative price of nontradables and tradables. Thus, the modest decline in overall output relative to its potential level hides the efficiency losses stemming from the extra large sectoral adjustments.

There are, of course, a number of reasons why our baseline model likely understates the impact of the fast burn on aggregate output. Chief among these is that the model permits adjustment of the exchange rate to have an instantaneous effect on the demand and production of tradables. Adding factors that either slow down this adjustment or introduce a stronger complementarity with nontradable output will mute the ability of the tradable goods sector to soften the effect of the current account reversal on output. Indeed, in section 4.6 we illustrate how, under certain monetary policy rules, imperfect exchange rate pass-through can inhibit any stabilizing adjustment of the tradable goods sector.

Another consideration is that we abstract from any movement in risk premia. As we noted, owing to a more advanced financial structure, we would not expect a country risk premium for the United States to emerge that could come anywhere near to the levels reached in emerging market crises. Nonetheless, it is possible that some kind of premium could emerge that could have the effect of enhancing the crises. Modeling the movement of this premium in a satisfactory way, however, is beyond the scope of the chapter. Though we do not report the results here, we experimented, allowing the U.S. country risk premium to rise exogenously at the onset of a sudden stop. For increases in spread up to 200 basis points, the results we obtain are qualitatively very similar to our baseline case. The rise in the risk premium, of course, amplifies a bit the responses of all variables.

Finally, we note that the monetary policy rule is a key factor. The evidence suggests that countries that have experienced significant output drops typically have tied monetary policy to an exchange rate peg.[19] As a consequence, during the initial phase of the current account reversal, the central banks

19. See, for example, Gertler, Gilchrist, and Natalucci (2007) and Curdia (2007).

of these countries have usually raised short-term rates sharply in order to defend the peg. Large contractions in output have followed these large increases in short-term rates. By contrast, the baseline Taylor rule in our model economy induces only a tiny rise in current short-term rates, followed by a reasonably sharp decline in future short-term rates. This anticipated decline in short rates helps moderate the drop in aggregate output at the expense of a relatively modest increase in inflation. To illustrate the significance of the monetary policy rule on the overall output drop, following we provide two examples of monetary policy regimes that indeed produced a major contraction in aggregate economic activity.

4.4.3 Alternatives to the Baseline Case

We now explore the implications of some alternative monetary policy regimes. We first consider domestic producer inflation targeting as an example of a policy that works reasonably well in our framework. We next consider two policies that do not work well, at least in a fast burn scenario: consumer price inflation targeting and exchange rate targeting. As we show, under either of these policies, the fast burn produces a significant drop in aggregate output. Finally, we consider a case where monetary policy is asymmetric across the two countries: the home central bank follows a Taylor rule while the foreign central bank (for instance, the Bank of China) follows a strict peg.

Domestic Producer Inflation Targeting

We first consider a scenario where the central bank targets domestic producer inflation.[20] We do so for two reasons. First, as we noted in the previous section, the simple Taylor rule may not adequately account for shifts in the potential rate of interest generated by the current account imbalance. In contrast, the targeting rule requires that the central bank adjust its instrument to compensate for any impact that shifts in the natural interest rate may have on inflation. Second, as received wisdom suggests, it is desirable to stabilize prices in the sectors where prices are stickiest (see, for instance, Aoki [2001] and Benigno [2004]). Efficiency losses from relative price dispersion induced by inflation are greatest in these sectors.[21] In addition, by letting prices float

20. See Svensson (1999) for a discussion of inflation targeting as a monetary policy rule and Svensson and Woodford (2005) for a more detailed discussion of targeting rules and instrument rules.

21. It is possible to derive an explicit utility-based loss function to measure the welfare implications of different monetary policy rules by using the methods in Woodford (2003). In our case, the result is quite complicated due to the existence of two sectors in each country. We thus do not report it here. However, such an approach reveals that in this kind of framework it is producer inflation that is costly as opposed to consumer inflation, due to the costs of the associated relative price dispersion on production efficiency. Strictly speaking though, welfare losses depend on distortions at the sectoral level. Efficiency costs depend on squared deviations of output from its natural level in each sector as well as on squared deviations of inflation in each sector from zero. There is also a term that reflects the loss from incomplete international financial markets.

in flexible-price sectors, the central bank avoids costly output adjustments in the sticky-price sectors that may be required to stabilize an overall price index. For each country within our framework, domestic home tradable and nontradables constitute the sticky-price sectors. By contrast, due to perfect exchange rate pass-through, import prices are perfectly flexible. What this suggests is that within our framework, a domestic inflation target may be preferable to a consumer price inflation target. In this section and the next, we verify this conjecture.

We thus replace the simple Taylor rule for each country with the targeting rule for domestic producer inflation, π_{Dt}, given by

$$\pi_{Dt} = \gamma\pi_{Ht} + (1 - \gamma)\pi_{Nt} = 0. \tag{56}$$

The top panel of figure 4.4 reports the response of the model economy to a slow burn adjustment under this monetary rule. As we would expect, the rule is more effective than the simple Taylor rule in offsetting the inflationary impact of the current account deficit. In contrast to the previous case, there is only a very modest increase in consumer price inflation. The targeting rule fixes domestic producer inflation (which we do not report) at zero. This essentially coincides with fixing the larger component of consumer price inflation, given that the steady-state import share of consumer expenditures is only 7.5 percent under our baseline calibration. Thus, the only effective source of overall consumer price inflation is the terms of trade depreciation that boosts import prices. However, since the import share is small, the impact on overall consumer inflation is small, though tangible. The current account imbalance adds an average of 20 basis points to inflation over the first five years. Again, the aggregate statistics hide sectoral imbalances. The excess demand for tradable goods pushes up inflation in this sector by an average of 50 basis points. This effect is offset by a modest deflation in the nontradables goods sector.

In the fast burn scenario, the targeting rule eliminates the drop in aggregate output, as the bottom left panel of figure 4.4 shows. Under this rule, the nominal interest drops immediately through the course of the current account reversal, which works to offset any decline in aggregate demand. At the same time, though, the sharp depreciation induces a rise in consumer price inflation of roughly 1 percentage point over the course of the year.

While the rule moderates the aggregate impact of the fast burn, there remains a significant distortion of the sectoral reallocation. Though it is slightly more moderate than in the baseline case, nontradable goods output contracts roughly 2 percentage points over the course of the current account reversal. There is similarly a significant movement in tradable output above its potential level, which, if anything, is somewhat larger than in the baseline case.

Of course, some qualifications are in order. As in the baseline case, tradable goods output responds immediately and the crisis has no effect on the

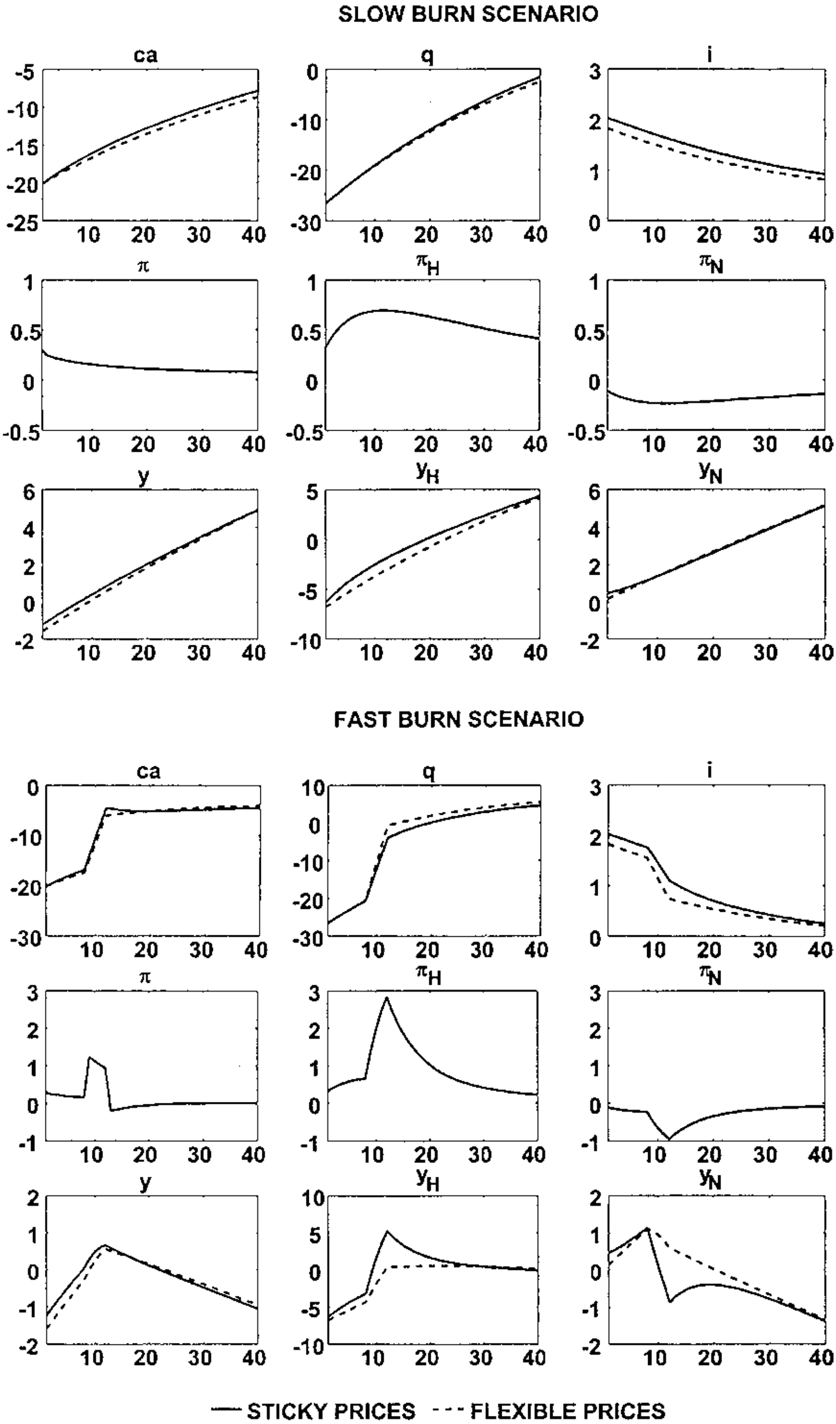


Fig. 4.4 Domestic inflation targeting

home country risk premium. As before, both these factors likely moderate the impact of the fast burn. It is also relevant that frictions introducing persistence in inflation such as wage rigidity or backward-looking price indexing are absent. Adding these frictions would likely make a rule that permitted inflation to deviate from target in response to movements in capacity utilization preferable to the strict inflation targeting rule that we have explored. At the same time, it is still likely to be the case that focusing on some measure of domestic inflation is preferable to incorporating overall consumer price inflation in the targeting rule. We elaborate on this point in the next section.

In the context of our model, we note that domestic producer inflation targeting corresponds to GDP deflator targeting. In making the leap to the real world, the issue may be more complex, since capital goods prices, which are absent in our model, enter the measure of the latter. To the extent that capital goods prices are roughly as sticky as those of consumer goods and services, it may suffice to use the GDP deflator as the appropriate index of producer prices to target. An alternative might be to develop a consumer price index that measures the prices of domestic goods exclusively. While in principle it is possible to construct such an index, doing so might involve considerable measurement error, especially given the need to account for complex input/output relationships.

Two Rules to Avoid in a Fast Burn: CPI and Exchange Rate Targeting

As we noted earlier, the effects on aggregate output of a fast burn depend critically on the monetary policy rule that is in act. We now give two examples of monetary policy regimes where the fast burn indeed generates a significant output contraction. In the first regime, the central bank targets overall consumer inflation as opposed to a measure of domestic inflation. In the second, it follows a Taylor rule that responds to exchange rate movements as well as inflation.

We begin with CPI targeting. We now suppose that a rule that fixes consumer price inflation at zero replaces our baseline Taylor rule. In particular, the "strict" CPI targeting rule is given by

$$\pi_t = \gamma\pi_{Ht} + (1 - \gamma)\pi_{Nt} + \gamma(1 - \alpha)\Delta\tau_t = 0. \tag{57}$$

It should be clear that stabilizing consumer price inflation in the presence of a terms-of-trade depreciation requires generating a deflation of domestic producer prices. Given that these prices are sticky, this deflation can occur only via an output contraction in at least one of the sectors. Indeed, this is exactly what happens in the fast burn scenario under this monetary policy regime.

As the top panel of figure 4.5 shows, under CPI targeting, the hard landing induces an output contraction on the order of 3 percent at the trough. In contrast to the case of domestic producer inflation targeting, the central bank immediately raises the short-term interest rate over 300 basis points, which

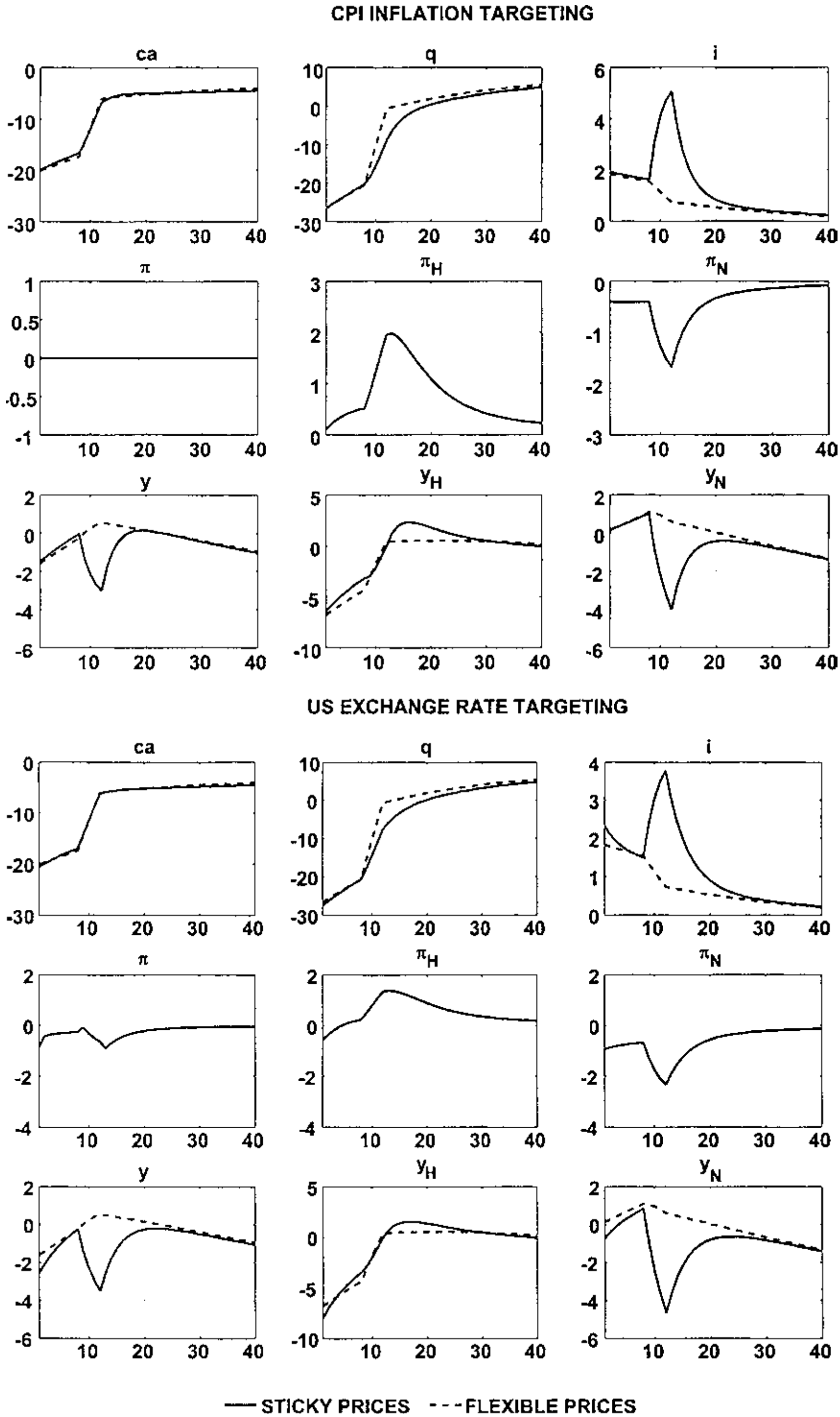


Fig. 4.5 Fast burn scenario under two different policy rules

enhances the contraction. In addition, the sectoral distortions intensify, many due to a nearly 4.5 percent contraction in nontradable goods output.

It thus appears that targeting a measure of domestic inflation is superior to targeting overall CPI inflation; though, as we noted earlier, coming up with a measure of the former that is appropriately distinct from the latter may not be a trivial undertaking.

We next turn to exchange rate targeting. As we noted, the emerging market economies that suffered large output contractions during current reversals typically had central banks that were following an exchange rate peg. For the Federal Reserve, of course, exchange rate considerations have played virtually no role in interest rate setting, at least in recent times. It is hard to say, however, whether or not during the kind of current account reversal we have been considering, pressures might mount for the central bank to respond even modestly to the depreciation.

In this spirit, we consider a variation of our baseline rule that permits the central bank to also respond to the exchange rate depreciation. Suppose the modified interest rate rule is given by

$$i_t = \bar{\imath}_t + \chi \Delta e_t \tag{58}$$

with

$$\bar{\imath}_t = \rho \bar{\imath}_{t-1} + (1 - \rho)\phi_\pi \pi_t.$$

Here, $\bar{\imath}_t$ is the rate the central bank would choose if it were to follow the baseline Taylor rule. The actual rate it sets is augmented by a factor that reflects the policy adjustment to the depreciation. We set $\chi = 0.1$, which suggests that a 10 percent exchange rate depreciation over the quarter would have the central bank increase the nominal interest rate by 100 basis points. Relative to a strict peg, the response of the policy rate to exchange rate movements is relatively modest.

The bottom panel of figure 4.5 portrays the hard landing scenario for this case. The drop in aggregate output is nearly 3.0 percent, as in the case of pure CPI targeting. Again, the reason for the contraction is that the policy rule forces a rise in short-term interest rates throughout the course of the current account reversal. Similarly, the nontradable goods sector is hit particularly hard. Output in this sector contracts nearly 5.0 percent.

Overall, policy regimes that produce large interest rate increases in response to the reversal can generate large output contractions. Even in the absences of large aggregate effects, though, there can be significant sectoral misallocations, with large positive output gaps opening up in the nontradable goods sectors and large negative ones in the tradable goods sectors.

A Foreign Exchange Rate Peg

We now return to our baseline case but assume that the foreign central bank abandons the Taylor rule and instead pegs its currency to that of the home country. We do this for two reasons. The first is to explore the implications of foreign monetary policy on current account adjustment. In our baseline case, the Taylor rule had the foreign central bank adjust interest rates in the opposite direction of the home central bank. During the fast burn experiment, the foreign interest rate behaved as the mirror image of the home country rate: it declined initially by a modest amount and then began a steady upward trajectory, enhancing the overall terms-of-trade depreciation for the home country. To what degree was this "cooperative" foreign monetary policy helpful in mitigating the impact of the fast burn on home country output? One way to get at the issue is to consider the case where the foreign central bank does not cooperate at all with exchange rate adjustment and simply follows a peg to the home country currency. A second consideration involves the impact of a foreign peg on current account dynamics. It has been widely speculated that by pegging its exchange rate to the dollar, China has been contributing to the U.S. current account deficits. While the other country in our model is meant to capture the rest of the world and not simply China, we can nonetheless shed some light on the issue by adopting the extreme assumption that the foreign country central bank adopts a peg.[22]

We accordingly return to the baseline case and, for foreign monetary policy, substitute a nominal exchange rate peg for the Taylor rule. From the uncovered interest parity condition, a pure nominal exchange rate peg simply requires that the foreign central bank sets its nominal rate equal to the home country rate:

$$i_t^* = i_t. \tag{59}$$

The top panel of figure 4.6 illustrates the response of a small set of domestic, foreign, and international variables for the case of the slow burn. Again, the dotted line reflects the flexible-price equilibrium. As a comparison of figures 4.2 and 4.6 suggests, the foreign country peg has virtually no impact on current account or real exchange rate dynamics. How can this be if the foreign country is fixing the nominal exchange rate? What causes the real exchange rate to adjust is a rapid increase in the foreign price level relative to the domestic level. By not letting its nominal exchange rate appreciate, the foreign country encourages excess demand in its tradable sector, which spills over to its nontradable sector. The end product is rapid domestic inflation, which provides the source of the exchange rate depreciation and the current account adjustment. In addition to the current account and the real exchange rate, the home country economy is also not affected much by the foreign country peg. Indeed, it is the foreign country economy that largely bears the brunt.

In a broad sense, the Chinese economy has behaved consistently with the model predictions. As figure 4.7 shows, output growth has climbed steadily since 2002, rising from 7 percent to almost 12 percent in 2007. Moreover,

22. Besides China, a number of oil producing countries, which, in recent years, have also substantially contributed to finance the U.S. current account deficit, peg their currency to the dollar, too.

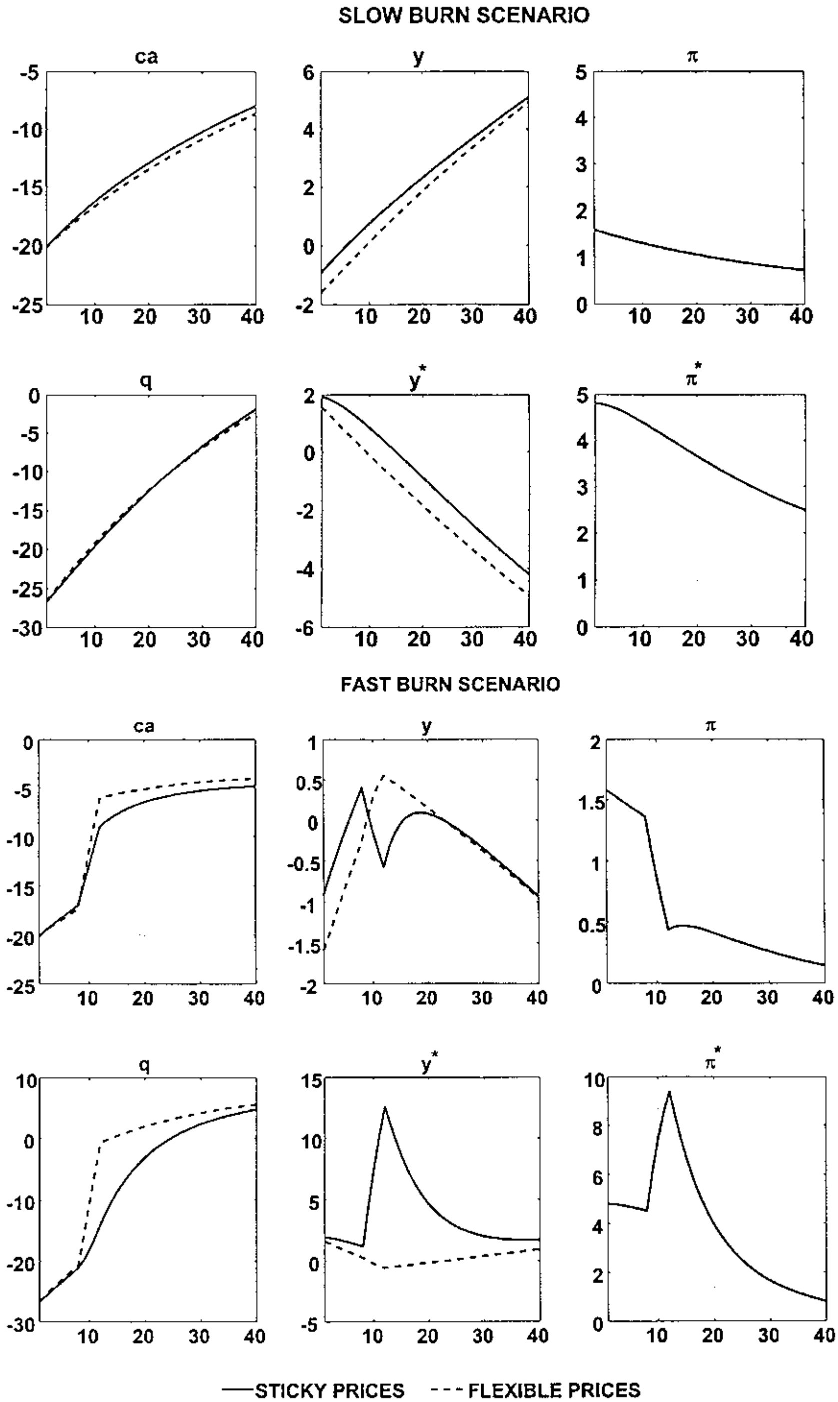


Fig. 4.6 Foreign exchange rate peg

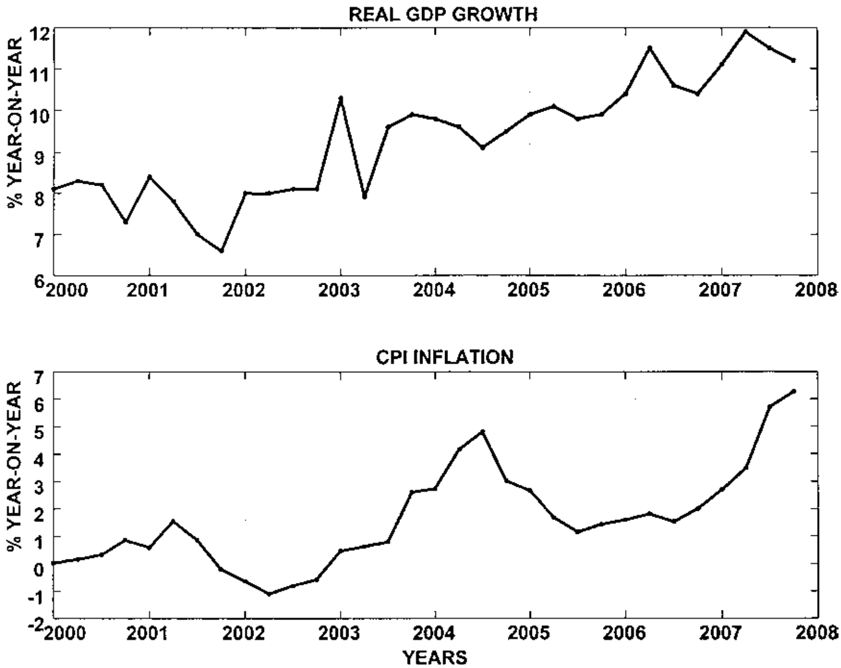


Fig. 4.7 China: Recent trends in GDP growth and inflation
Source: DLX/Haver Analytics.

there also has been a recent increase in CPI inflation from 1 to 6 percent in the last two years. Of course, there are a variety of factors such as price and capital controls that one would need to take into account before applying the model literally to China. In addition, since China only accounts for roughly one quarter of the U.S. current account deficit, we would need to appropriately adjust the calibration, which would likely work to dampen the predicted boom. Thus, the point to take away is that at least in our baseline slow burn scenario, the effect of a foreign peg is felt mainly by the foreign economy. There is little impact on the current account, the real exchange rate, or the home country economy.

Finally, the bottom panel of figure 4.6 portrays the fast burn scenario. Here there is a more significant impact of the foreign country peg. Intuitively, the sluggishness in nominal price adjustment becomes more significant when disturbances are sudden and large. During the crisis (quarters 8 to 12), the real exchange rate depreciates only by one-fourth as much as it did in the baseline case. Most of the adjustment occurs over the subsequent two years. The delayed response of the real exchange (and the terms of trade) leads to the current account closing only about 70 percent of the amount it did in the baseline case. The inertia in the real exchange rate leads to a larger

Table 4.1 Imperfect pass-through on import prices: 1992 ERM crises

	3 Quarters (%)	4 Quarters (%)	6 Quarters (%)	8 Quarters (%)
Italy	49	81	66	69
Sweden	66	53	68	72
United Kingdom	55	78	84	72

drop in aggregate domestic output than in the baseline case: a drop of 1.0 percent instead of 0.5 percent. At the same time, the main effect is felt by the foreign country through an enormous boom in output.

Again, it is important to keep in mind that our example is extreme in that we are assuming that the rest of the world is following a peg. We also abstract from some of the key frictions that may be relevant to an emerging market economy like China. Nonetheless, at least in our canonical framework, the main effects of the foreign peg are felt by the foreign economy, whether in the slow or fast burn scenarios.

4.5 Imperfect Exchange Rate Pass-Through

Our baseline model assumes perfect pass-through of exchange rate movements to import prices, but is calibrated to match the evidence on pass-through to the CPI. Much of this evidence, however, is based on an annual frequency, while our model is quarterly. In this respect, the baseline model may miss the quarterly link between exchange rate movements, import prices, and the CPI. For the slow burn scenario, this may not be problem, since the exchange rate depreciation plays out smoothly over a long period of time. However, it could be relevant to a situation where there is an abrupt large movement in the exchange rate, as for example would be likely to arise under a sudden stop.

To get a feel for how import prices respond to sharp exchange rate depreciations, we examine data from three countries—Italy, Sweden, and the United Kingdom—in the wake of the European Monetary System (EMS) crisis of 1992. Table 4.1 reports the degree of pass-through on import prices from three to eight quarters after the initial depreciation for the three countries in our sample. We conclude from the table that pass-through in response to a large depreciation is high, but delayed.[23]

In the model, we add imperfect pass-through following Monacelli (2005).

23. To the extent that importers face any distribution and/or transportation costs, we should expect any long-run exchange rate pass-through to be less than 100 percent. We abstract from distribution costs directly. However, we indirectly take account of how distribution costs may affect the link between exchange rates and final goods prices by adjusting the size of the non-traded goods sector.

We introduce monopolistically competitive retailers who import foreign tradables and sell them to domestic residents. The law of one price holds at the dock but not at the consumer level because local retailers set the price of imported goods in domestic currency on a staggered basis. Each period a fraction $\tilde{\xi}$ of retailers hold their price constant while the remaining fraction $1 - \tilde{\xi}$ solve an optimal dynamic pricing problem. In particular, those importers who change their price in period t choose P_{Ft} to maximize

$$(60) \qquad E_t \sum_{s=0}^{\infty} \tilde{\xi}^s \Lambda_{t,t+s}(P_{Ft} - \varepsilon_{t+s} P^*_{F,t+s}) C_{F,t+s},$$

subject to the demand equation (10). The first-order condition for this problem is

$$(61) \qquad E_t \left\{ \sum_{s=0}^{\infty} \tilde{\xi}^s \Lambda_{t,t+s}[P_{Ft} - (1 + \tilde{\mu})\varepsilon_{t+s} P^*_{F,t+s})] C_{F,t+s} \right\} = 0,$$

where $\tilde{\mu} \equiv (\eta - 1)^{-1}$. The law of large numbers implies that the price index for imported goods becomes

$$(62) \qquad P_{Ft} = \tilde{\xi} P_{F,t-1} + (1 - \tilde{\xi}) P^o_{Ft}.$$

Given the departure from the law of one price at the consumer level, it is useful to define the price gap as the ratio between the foreign price in domestic currency and the domestic price (also in domestic currency)

$$(63) \qquad \Psi_{Ft} \equiv \frac{\varepsilon_t P^*_{Ft}}{P_{Ft}}.$$

With perfect pass-through, Ψ_{Ft} equals unity.

Next we note that with imperfect pass-through, the terms of trade differs across countries. We keep the definition of the terms of trade from the perspective of the home country consistent with our baseline specification: $T_{Ht} = P_{Ft}/P_{Ht}$. Conversely, we define the foreign country terms of trade as $T_{Ft} \equiv P^*_{Ht}/P^*_{Ft}$.

In the loglinear model, the market demand for home tradables now accounts for the difference in the two countries' terms of trade

$$(64) \qquad y_{Ht} = \alpha(1 - \alpha)\eta(\tau_{Ht} - \tau_{Ft}) + (1 - \gamma)[\alpha x_t + (1 - \alpha)x^*_t] + \alpha c_t + (1 - \alpha)c^*_t.$$

The real exchange rate similarly accounts for the differences in country-specific terms of trade:

$$(65) \qquad q_t = \psi_{F,t} + \alpha\tau_{H,t} + (1 - \alpha)\tau_{F,t} + (1 - \gamma)(x^*_t - x_t).$$

Next, with imperfect pass-through, imported goods inflation is characterized by the following Phillips curve relation:

$$(66) \qquad \pi_{Ft} = \tilde{\kappa}\psi_{Ft} + \beta E_t \pi_{F,t+1},$$

where ψ_{Ft} is the log-linear deviation of the law of one price gap in (63) from its steady-state value (equal to one) and $\tilde{\kappa} \equiv (1-\tilde{\xi})(1-\beta\tilde{\xi})/\tilde{\xi}$.[24] The evolution of the law of one price gap depends on the depreciation of the nominal exchange rate as well as on the inflation rate differentials in the two countries

$$\Delta\psi_{Ft} = \Delta e_t + \pi^*_{F,t} - \pi_{F,t}. \tag{67}$$

As before, the percent change in the terms of trade depends on import inflation minus the inflation of domestic tradables. The difference in this case is that the relation for import inflation, equation (66), is based on imperfect exchange rate pass-through. There are an analogous set of relations that determine the evolution of the terms of trade for the foreign country. Keeping in mind the new country-specific definitions of the terms of trade, the remaining equations of the model are unchanged.

There is only one new parameter that we need to calibrate—the degree of price stickiness for importers, $1-\tilde{\xi}$. We set this parameter at 0.66, the same value we used for domestic producers.

Figure 4.8 presents a comparison of imperfect versus perfect pass-through for the baseline case where each central bank obeys a simple Taylor rule. In each instance, the solid line reflects imperfect pass-through, while the dotted line reflects perfect pass-through. The top set of panels reflects the slow burn scenario. As we conjectured, the behavior of both the domestic and international variables is very similar across the two cases. As one might expect, inflation is a bit lower under imperfect pass-through since the impact of the exchange rate on the domestic price of imports is muted in this case. Though we do not report the results here, for the slow burn scenario imperfect pass-through does not have much effect on the behavior of any of the economic variables under the full set of policy experiments we considered for the benchmark model.

Imperfect pass-through is more relevant under the fast burn scenario. The bottom set of panels in figure 4.8 presents this case. Note first that current account is much slower to adjust under imperfect pass-through. In this instance the depreciation of the home currency has a much smaller effect on domestic exports. As a further consequence, there is a much sharper contraction in output relative to the case of perfect pass-through. In this latter case, the depreciation produces an export boom that softens the overall contraction in output. With imperfect pass-through, however, the export response is muted, which enhances the overall contraction in output.

As a check on our formulation of imperfect pass-through, we examine how the model captures the dynamics of exchange rates and import prices as compared to the experience of the Exchange Rate Mechanism (ERM)

24. For the same amount of nominal rigidities, the absence of labor inputs (and hence, of real rigidities) in the distribution sector implies that the slope of the imported goods Phillips curve is higher than for domestically produced goods.

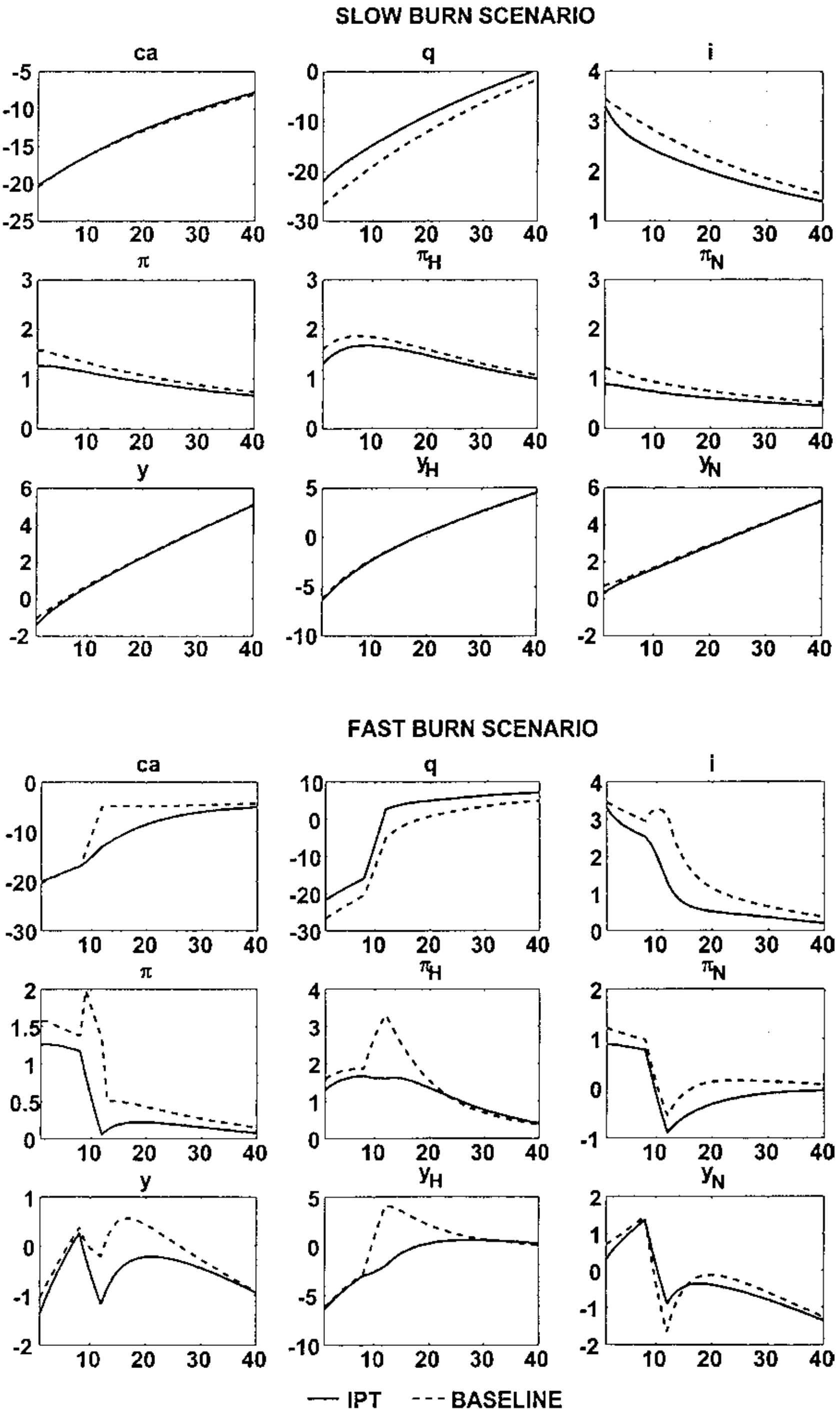


Fig. 4.8 Imperfect pass-through (Baseline Taylor rule)

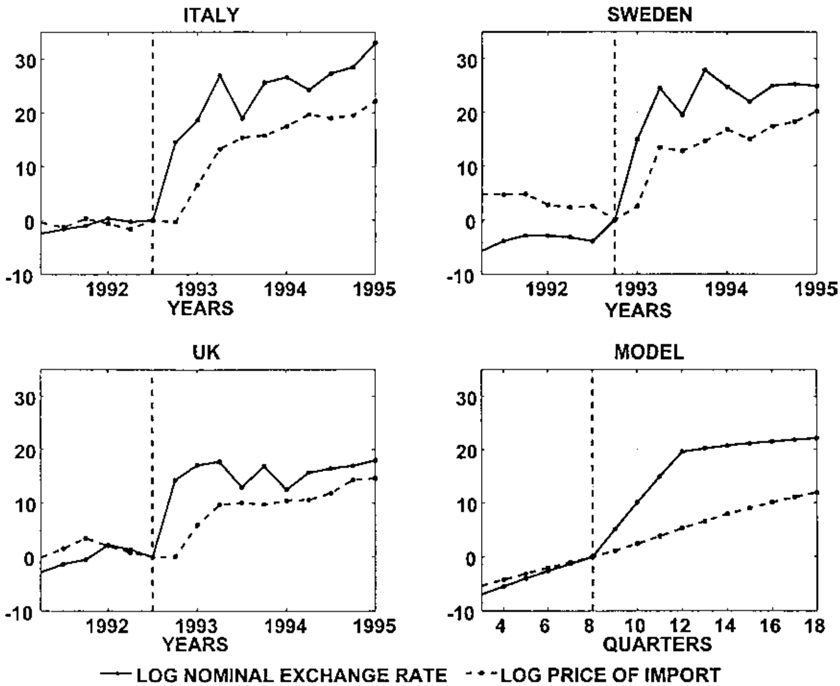


Fig. 4.9 Imperfect pass-through (1992 ERM crisis and model)
Source: IMF International Financial Statistics

crisis. The first three panels in figure 4.9 report the movement of the nominal exchange rate (the solid line) and import prices (the dotted line) for this period in the data. The vertical line shows the beginning of the crisis for each country. Both variables are normalized at zero at the start of the crisis. By construction, the exchange rate depreciations all begin in the first quarter following the start of the crisis. In each case, there is a delay of another quarter before import prices begin to move significantly. Though it varies a bit in each case, on average after a year or so, import prices increase by more than two-thirds of the exchange rate movement. The fourth panel displays the behavior of the correspondent variables in the model, given the appropriate normalization. Overall, the model is roughly consistent with the data.

Finally, as under perfect pass-through, domestic inflation targeting is reasonably effective in insulating the economy from the harmful effects of a sudden stop. As the solid line in the bottom left panel of figure 4.10 shows, under domestic inflation targeting there is no output drop under the sudden stop and only a mild increase in inflation. One difference from the case of perfect pass-through, however, is that CPI targeting is not as harmful. As the dotted line in the panel shows, there is a larger output drop under CPI target-

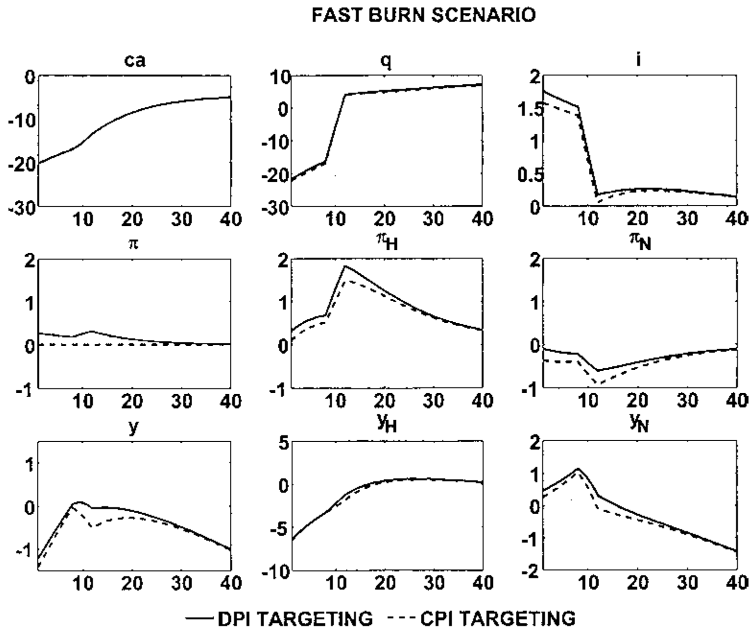


Fig. 4.10 Imperfect pass-through: DPI vs. CPI inflation targeting

ing relative to domestic inflation targeting, but the difference is not nearly as dramatic as under perfect pass-through. With imperfect pass-through the depreciation has less impact on CPI inflation, permitting a less aggressive increase in interest rates to maintain the inflation target.

4.6 Concluding Remarks

We have developed a simple two-country monetary DSGE model that is useful for analyzing the interplay between monetary policy and current account adjustment. We proceeded to use the framework to study the effects of different monetary policy regimes under two different adjustment scenarios: a "slow burn," where adjustment is smooth and plays out over a long period of time, and a "fast burn," where a sudden revision of the relative growth prospects of the home versus foreign country leads to a sharp current account reversal.

Our main finding is that the monetary policy regime has important consequences for the behavior of domestic variables (for instance, output and inflation), but much less so for international variables (for instance, the current account and real exchange rates). Among the policy rules we have examined, the policy rule that seems to work best overall has the central bank focus on targeting domestic (producer) inflation. This policy has the central bank accept the impact of the currency depreciation on import price inflation and instead focus on adjusting interest rates to keep producer prices stable. As a consequence, during the slow burn, inflation is very modest overall (since the import share of consumption is small) and aggregate output roughly equals its potential value. During the fast burn, the rule has each central bank adjust its policy rate rapidly to offset the sudden reallocation of demand across countries. This serves to dampen significantly the effect on aggregate output and inflation. One important caveat, though, is that the moderate aggregate behavior masks an inefficiently large sectoral reallocation. Due to the nominal rigidities, nontradable output falls significantly below its potential level, while the reverse happens in the tradable goods sector.

By contrast, two kinds of monetary regimes work very poorly during a current account reversal: targeting consumer price inflation and targeting the exchange rate. Each of the policies induces the home central bank to raise interest rates sharply to fend off a currency depreciation. This sharp increase in interest rates, in turn, leads to a major contraction in aggregate economic activity within the home country. The contraction is particularly severe in the nontradable goods sector, enhancing the inefficient sectoral reallocation.

While the response of domestic variables tends to be quite sensitive to the monetary policy regime, the same is not true of international variables. In most instances, the behavior of the current account and the real exchange rates does not vary significantly from what a flexible-price model would predict. Indeed, this is largely true even in an extreme case where the foreign country implements an exchange rate peg. In this case, the effect of the peg is largely absorbed by the foreign economy.

Our benchmark model allows for perfect pass-through of exchange rates to import prices but is calibrated to match pass-through to final consumer prices at the annual frequency. We show, however, that the main results are robust to allow for imperfect pass-through to capture the quarterly dynamics of exchange rates and import prices. Under the slow burn scenario, the degree of pass-through has little impact on economic behavior. Under the sudden stop, however, current account adjustment is much slower with imperfect pass-through and the output contraction is much steeper in the baseline case where each central bank obeys a simple Taylor rule. As in the case of perfect pass-through, however, domestic inflation targeting appears to have desirable stabilizing properties in the event of a current account crisis. Consumer price inflation targeting, though, is not as harmful as under perfect pass-through.

Finally, our model is designed to be sufficiently simple to afford qualitative insights, but at the same time to be sufficiently rich to give "ballpark" quantitative predictions. Next on the agenda is adding features that will improve the quantitative dimension.

References

Aoki, K. 2001. Optimal monetary policy response to relative price changes. *Journal of Monetary Economics* 48 (1): 55–80.

Backus, D., E. Henriksen, F. Lambert, and C. Telmer. 2006. Current account fact and fiction. Society for Economic Dynamics 2005 Meeting Paper no. 115.

Bems, R., and L. Dedola. 2006. Current account reversals and capital markets integration: The adjustment of the U.S. external position revisited. International Monetary Fund (IMF). Unpublished Manuscript.

Benigno, G., and P. Benigno. 2006. Designing targeting rules for international monetary policy coordination. *Journal of Monetary Economics* 53: 473–506.

Beaudry, P., and F. Portier. 2004. An exploration into Pigou's theory of cycles. *Journal of Monetary Economics* 51 (6): 1183–1216.

Benigno, P. 2004. Optimal monetary policy in a currency area. *Journal of International Economics* 63 (2): 293–320.

Bodenstein, M. 2006. Closing open economy models. International Finance Discussion Papers no. 867, Board of Governors of the Federal Reserve System.

Buera, F., and J. Kaboski. 2007. The rise of the service economy. Society for Economic Dynamics 2006 Meeting Paper no. 496.

Caballero, R., E. Farhi, and P.-O. Gourinchas. 2008. An equilibrium model of "Global Imbalances" and low interest rates. *American Economic Review* 98 (1): 358–93.

Campa, J., and L. Goldberg. 2006. Distribution margins, imported inputs, and the sensitivity of the CPI to exchange rates. NBER Working Paper no. 12121. Cambridge, MA: National Bureau of Economic Research, March.

Cavallo, M., and C. Tille. 2006. Current account adjustment with high financial integration: A scenario analysis. *Federal Reserve Bank of San Francisco Economic Review:* 31–46.

Clarida, R., J. Galí, and M. Gertler. 1998. Monetary policy rules in practice: Some international evidence. *European Economic Review* 42 (6): 1033–67.

———. 2002. A simple framework for international monetary policy analysis. *Journal of Monetary Economics* 49 (5): 879–904.

Cole, H., and M. Obstfeld. 1991. Commodity trade and international risk sharing: How much do financial markets matter? *Journal of Monetary Economics* 28 (1): 3–24.

Corsetti, G., and P. Pesenti. 2005. International dimensions of optimal monetary policy. *Journal of Monetary Economics* 52 (2): 281–305.

Curdia, V. 2007. Optimal monetary policy under sudden stop. Federal Reserve Bank of New York. Unpublished Manuscript.

Engel, C., and J. H. Rogers. 2006. The U.S. current account deficit and the expected share of world output. *Journal of Monetary Economics* 53: 1063–93.

Faruquee, H., D. Laxton, D. Muir, and P. Pesenti. 2005. Smooth landing or crash? Model-based scenarios of global current account rebalancing. In *G7 current account imbalances: Sustainability and adjustment,* ed. R. Clarida, 377–456. Chicago: University of Chicago Press.

Ferrero, A. 2007. The long-run determinants of the U.S. external imbalances. Federal Reserve Bank of New York Staff Reports no. 295.

Gertler, M., S. Gilchrist, and F. Natalucci. 2007. External constraints on monetary policy and the financial accelerator. *Journal of Money, Credit, and Banking* 39 (2–3): 295–330.

Jaimovich, N., and S. Rebelo. 2006. Can news about the future drive the business cycle. Stanford University. Unpublished Manuscript.

Mendoza, E., V. Quadrini, and V. Rios-Rull. 2007. Financial integration, financial deepness and global imbalances. University of Maryland. Unpublished Manuscript.
Monacelli, T. 2005. Monetary policy in a low pass-through environment. *Journal of Money Credit and Banking* 37 (December): 1047–66.
Obstfeld, M., and K. Rogoff. 2002. Global implications of self-oriented national monetary rules. *Quarterly Journal of Economics* 117 (2): 503–36.
———. 2005. The unsustainable U.S. current account position revisited. In *G7 current account imbalances: Sustainability and adjustment,* ed. Richard Clarida, 339–376. Chicago: University of Chicago Press.
Rogoff, K. 2007. Impact of globalization on monetary policy. In *The new economic geography: Effects and policy implications,* ed. Federal Reserve Bank of Kansas City, Kansas City: Federal Reserve Bank of Kansas City.
Svensson, L. E. O. 1999. Inflation targeting as a monetary policy rule. *Journal of Monetary Economics* 43 (3): 607–54.
Svensson, L. E. O., and M. Woodford. 2005. Implementing optimal policy through inflation-forecast targeting. In *The inflation-targeting debate,* ed. B. S. Bernanke and M. Woodford, 19–83. Chicago: University of Chicago Press.
Uzawa, H. 1968. Time preference, the consumption function and optimum asset holdings. In *Value, capital and growth: Papers in honor of Sir John Hicks,* ed. James Wolfe, Edinburgh, Scotland: University of Edinburgh Press.
Woodford, M. 2003. *Interest and prices.* Princeton, NJ: Princeton University Press.

Comment Paolo Pesenti

Arguably, the interaction between interest rate stance and current account imbalances is nowadays—and has been for quite a while—the key international dimension of monetary policy from the vantage point of the United States and its main trading partners. The point is not whether monetary policy can contribute significantly to closing the imbalances. The relevant question is rather what is the most suitable monetary response to sizable movements in global net saving. In the recent past, when U.S. interest rates were raised at the moderate and predictable pace of 25 basis points every Federal Open Market Committee (FOMC) cycle, a hotly debated issue among policy analysts was whether the path for the policy rate—other things equal—could have been steeper or looser because of considerations related to trade imbalances. Today, in light of highly differentiated patterns of net saving in the global economy, it remains highly relevant to investigate whether monetary policy in the United States and abroad is appropriately designed to deal with the macroeconomic implications of trade imbalances.

The answers to these broad questions, and to their more nuanced variants, are not obvious. In fact, it is possible to articulate a number of antithetical

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