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MACROECONOMIC EFFECTS OF NOMINAL EXCHANGE RATE REGIMES: NEW INSIGHTS INTO THE ROLE OF PRICE DYNAMICS

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ABSTRACT

Macroeconomic Effects of Nominal Exchange Rate Regimes: New Insights into the Role of Price Dynamics*

This Paper analyses the effects of pegged and floating exchange rates using a two-country dynamic general equilibrium model that is calibrated to the US and a European aggregate. The model assumes shocks to money, productivity and the interest parity condition. It captures the fact that the sharp increase in nominal exchange rate volatility after the abandonment of the Bretton Woods (BW) system was accompanied by a commensurate rise in real exchange rate volatility, but had no pronounced effect on the volatility of US and European output. This holds irrespective of whether flexible or sticky prices are assumed – which casts doubt on the widespread view that the roughly equal rise in nominal and real exchange rate volatility reflects price stickiness. Flex-prices variants of the model capture better the fact that the correlation between US and European output has been higher in the floating-rate era.

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1. Introduction

The macroeconomic effect of the nominal exchange rate regime is a key question in economics. The volatility of nominal and real exchange rates between the major currency blocs (U.S., Europe, Japan) rose sharply after the end of the Bretton Woods (BW) pegged-exchange rate system. By contrast, the volatility of real GDP showed little change after the end of BW, but the cross-region correlation of GDP increased markedly.

For example, the standard deviation of Hodrick-Prescott filtered log quarterly nominal and real exchange rates between the U.S. and an aggregate of the three largest continental European economies (EU3: Germany, France, Italy) rose from less than 1% under BW to about 8% in the post-BW era. The standard deviation of U.S. and EU3 GDP was between 1% and 2%, in both eras; the U.S.-EU3 GDP correlation rose from -0.18 (BW) to 0.48 (post-BW).

This paper analyzes these facts using a quantitative two-country dynamic general equilibrium (DGE) model. Interest centers on what light these facts shed on a central and controversial issue in macroeconomics: the relevance of price stickiness for explaining international macroeconomic data. The rise in real exchange rate volatility that accompanied the rise in nominal exchange rate volatility after the end of the BW system, is widely viewed as reflecting price stickiness--and used to justify (Keynesian) sticky-prices macro models, see; e.g., Mussa (1986, 1990), Dornbusch and Giovannini (1990), Caves et al. (1993), and Obstfeld and Rogoff (1996).

The results presented in this paper cast doubt on this view. A flexible-prices variant of the model here--that features shocks to the interest parity condition, see discussion below--can capture the key facts discussed in the first and second paragraph. A sticky-prices variant can capture the post-BW rise in nominal and real exchange rate volatility, but fails to explain the rise in the cross-country output correlation. Thus, the simultaneous rise in nominal and real exchange rate volatility after the end of the BW system cannot be interpreted as evidence for price stickiness (flex- and sticky-prices variants both capture this phenomenon).

The widespread view discussed above seems to be based on the assumption that monetary shocks are the main source of exchange rate fluctuations (standard theory predicts that money shocks have no effect on the real exchange rate under price flexibility, but induce real exchange rate movements that closely track the nominal exchange rate when prices are (sufficiently) sticky). However, econometric attempts to predict post-BW short-run exchange rate movements from changes in money and other macroeconomic fundamentals (productivity, fiscal policy) have so far had little success (Meese and Rogoff (1983), Rogoff (2000)). Also, structural economic models driven by these fundamentals tend to generate predicted exchange rate variability that is much smaller than that seen in the post-BW data. This applies both to flex-prices models in the Real Business Cycle (RBC) tradition, as well as to sticky-prices models. [1]

In order to generate more realistic exchange rate volatility, this paper considers an additional type of shock: a stationary shock to the uncovered interest parity (UIP) condition ("UIP shock", henceforth). This is motivated by the well-documented strong and persistent empirical departures from UIP in floating exchange rate regimes (e.g., Lewis (1995)). The UIP shock can be interpreted as reflecting distorted exchange rate forecasts (Frankel and Froot (1989), i.a., document biases in exchange rate forecasts).

Variants of the model that assume a pegged and a floating exchange rate are calibrated to the U.S. and the EU3. I show that UIP shocks were much larger in the post-BW era than under BW. Estimates of the time series process of UIP shocks in the BW era [post-BW era] are used to calibrate the pegged-rate [floating-rate] variant of the model. A flex-prices version of the model

[1] E.g., the Backus et al. (1995) RBC model captures only about one tenth of the standard deviation of post-BW real exchange rates. Sticky-prices models may generate more volatile exchange rates than RBC models (possibility of Dornbusch-style exchange rate overshooting) but require unrealistically long price adjustment lags to match post-BW volatility (Kollmann (2001a,b), Chari et al. (2002)).

and a sticky prices version are considered. The latter assumes staggered price setting à la Calvo (1983); the average duration between price changes is set at 4 quarters--as often assumed in Keynesian models.

Simulations of the floating rate variant suggest that UIP shocks are a powerful source of nominal and real exchange rate fluctuations--much more than money and productivity shocks. The floating-rate variant (with post-BW UIP shocks) captures about 80% of the standard deviations of post-BW nominal and real U.S.-EU3 exchange rates. Predicted *real* exchange rate volatility is markedly higher in the floating-rate variant than in the pegged-rate variant (due to bigger UIP shocks under float). The model predicts that nominal exchange rate movements induced by UIP shocks have only a limited effect on national price levels (due to the small volume of U.S.-EU3 trade, relative to GDP—under 2%); thus, these movements are accompanied by (roughly) equiproportional variations of the real exchange rate; also, these exchange rate movements only have a weak effect on aggregate output. The model captures the fact that the sharp rise in dollar exchange rate volatility after the end of BW did not greatly affect the volatility of U.S. and EU3 output. These results hold irrespective of whether sticky or flexible prices are assumed.

By contrast, flex- and sticky-prices versions yield sharply differing predictions regarding the effect of the exchange rate regime on the cross-country output correlation. Monetary policy affects output under sticky prices, but is neutral under flexible prices. As a pegged exchange rate regime requires international synchronization of monetary policy, the sticky-prices variant predicts that the cross-country output correlation is higher in a pegged-rate regime than in a floating-rate regime. That prediction is inconsistent with the fact that the U.S.-EU3 output correlation was lower (and actually negative) under BW. Flex-prices variants of the model, by contrast, capture that fact, provided one allows for asymmetric country-specific productivity shocks during the BW era (empirically, innovations to total factor productivity were negatively correlated across the U.S. and the EU3, during the BW era).

The work here is related to the Keynesian literature of the 1960s and 1970s that provided theoretical analyses of fixed and floating exchange rate regimes, under the assumption that prices (or wages) are sticky (e.g., Mundell (1968), Dornbusch (1980)); that literature predicts that the exchange rate regime affects macroeconomic behavior, but provides only limited quantitative/empirical results. Moreover, that literature lacks the explicit micro-foundations that characterize modern macro models (based on DGE approach).

The recent open economy DGE literature (see surveys by Obstfeld and Rogoff (1996), Lane (2001) and Sarno (2001)) typically assumes a floating exchange rate. Exceptions include Obstfeld and Rogoff (2000), Devereux and Engel (2003), Bacchetta and van Wincoop (2000), Parrado and Velasco (2001) and Tille (2003) who compare pegs and floats, using highly stylized sticky-prices models, for which closed form solutions can be derived; these authors focus on the welfare consequences of the exchange rate regime. In contrast, the paper here considers a richer business cycle model that is solved numerically and used to analyze key features of BW and post-BW data.[2] Dedola and Leduc (2001), Duarte (2003), Monacelli (2004) and Sopraseuth (2003) also use calibrated DGE models to compare floats and pegs.[3] Those papers discuss model predictions for a smaller set of business cycle statistics (than the paper here), and claim that price stickiness is necessary for explaining BW vs. post-BW exchange rate facts. However, the models used by these authors underpredict sharply the high volatility of exchange rates observed during the post-BW period.[4] This casts doubts on the relevance of those models for analyzing a floating-rate regime.

[2] Several other recent papers discuss quantitative open economy, sticky-prices DGE models; however, these papers focus solely on the post-Bretton Woods era. See, for example, Benigno (2004), Bergin (2003), Chari et al. (2002), Collard and Dellas (2002), Faia (2001), Ghironi and Rebucci (2001), Kollmann (2001a,b; 2002; 2004), Laxton and Pesenti (2002), Lubik (2000), McCallum and Nelson (1999, 2000) and Smets and Wouters (2002).

[3] I received these papers after the basic framework here had been developed (see Kollmann (1996)).

[4] In fact, with the exception of models by McCallum and Nelson (1999,2000) and Kollmann (2002, 2004)--who like the paper here assume interest rate parity shocks—all previous calibrated DGE models (which I know) underpredict markedly post-BW exchange rate volatility.

Section 2 discusses the model. Sect. 3 reports macroeconomic stylized facts for the BW and post-BW periods. Sect. 4 presents simulation results. Sect. 5 concludes.

2. The Model

A world with two countries, called Home and Foreign, is considered. In each country there are firms, a representative household and a government that issues a national currency. Each country produces a single non-tradable final good and a continuum of tradable intermediate goods indexed by $s \in [0,1]$. Each country's final good is produced by perfectly competitive firms that use local and imported intermediate goods as inputs; it can be consumed or used for investment. There is monopolistic competition in the markets for intermediate goods--each intermediate good is produced by a single firm. Intermediate goods producers use domestic capital and domestic labor as inputs--capital and labor are immobile internationally. Each country's household owns all domestic firms and the domestic capital stock, which it rents to firms; it also supplies labor to firms. The markets for rental capital and labor market are competitive.

The following description focuses on the Home country. The Foreign country is a mirror image of the Home country (preferences and technologies are symmetric across countries). Foreign variables are denoted by an asterisk.

2.1. Final good production

The Home final good is produced using the aggregate technology

$$Q_t = \{(\alpha^d)^{1/\vartheta}(Q_t^d)^{(\vartheta-1)/\vartheta} + (\alpha^m)^{1/\vartheta}(Q_t^m)^{(\vartheta-1)/\vartheta}\}^{\vartheta/(\vartheta-1)}, \tag{1}$$

with $\alpha^d, \alpha^m > 0$, $\alpha^d + \alpha^m = 1$, $\vartheta > 0$. Q_t is Home final good output at date t. Q_t^d, Q_t^m are quantity indexes of Home and Foreign produced intermediate goods, respectively: $Q_t^i = \{\int_0^1 q_t^i(s)^{(\nu-1)/\nu} ds\}^{\nu/(\nu-1)}$, with $\nu > 1$, for $i = d, m$ where $q_t^d(s)$ and $q_t^m(s)$ are quantities of the Home and Foreign produced type 's' intermediate goods. Let $p_t^d(s)$ and $p_t^m(s)$ be the prices of these goods, in Home currency. Cost minimization in Home final good production implies:

$$q_t^i(s) = (p_t^i(s)/P_t^i)^{-\nu} Q_t^i, \quad Q_t^i = \alpha^i (P_t^i/P_t)^{-\vartheta} Q_t, \text{ for } i = d, m, \tag{2}$$

with $P_t^i = \{\int_0^1 p_t^i(s)^{1-\nu} ds\}^{1/(1-\nu)}$, $P_t = \{\alpha^d (P_t^d)^{1-\vartheta} + \alpha^m (P_t^m)^{1-\vartheta}\}^{1/(1-\vartheta)}$. P_t^d [P_t^m] is the price index for Home [Foreign] intermediate goods. Perfect competition in the final good market implies that the good's price equals P_t (its marginal cost is: $\{\alpha^d (P_t^d)^{1-\vartheta} + \alpha^m (P_t^m)^{1-\vartheta}\}^{1/(1-\vartheta)}$).

2.2. Intermediate goods producers

The technology of the firm that produces Home intermediate good 's' is:

$$y_t(s) = \theta_t (\mathscr{K}_t(s))^{\psi} (\mathscr{L}_t(s))^{1-\psi}, \qquad 0 < \psi < 1. \tag{3}$$

$y_t(s)$ is the firm's output at date t. θ_t is an exogenous productivity parameter that is common to all Home intermediate goods producers. $\mathscr{K}_t(s)$ and $\mathscr{L}_t(s)$ are the amounts of capital and labor used by the firm.

Let R_t and W_t be the Home rental rate of capital and wage rate. Cost minimization implies: $\mathscr{L}_t(s)/\mathscr{K}_t(s) = \psi^{-1}(1-\psi)R_t/W_t$. The firm's marginal cost is: $MC_t = (1/\theta_t) R_t^{\psi} W_t^{1-\psi} \psi^{-\psi}(1-\psi)^{\psi-1}$. The firm's good is sold in the domestic market and exported: $y_t(s) = q_t^d(s) + q_t^{m*}(s)$, where $q_t^d(s)$ [$q_t^{m*}(s)$] is Home [Foreign] demand. The Foreign demand function is analogous to the Home demand function (2): $q_t^{m*}(s) = (p_t^{m*}(s)/P_t^{m*})^{-\nu} Q_t^{m*}$, where $p_t^{m*}(s)$ is the firm's export price, in Foreign currency, and $P_t^{m*} \equiv \{\int_0^1 (p_t^{m*}(s))^{1-\nu} ds\}^{1/(1-\nu)}$.

The firm's profit, π_t, is:

$$\pi_t(p_t^d(s), p_t^{m*}(s)) = (p_t^d(s) - MC_t)(p_t^d(s)/P_t^d)^{-\nu} Q_t^d + (e_t p_t^{m*}(s) - MC_t)(p_t^{m*}(s)/P_t^{m*})^{-\nu} Q_t^{m*},$$

where e_t is the nominal exchange rate, expressed as the Home currency price of Foreign currency.

Intermediate good producers can price discriminate between the domestic market and the export market: $p_t^d(s) \neq e_t p_t^{m*}(s)$ is possible. Open economy models with sticky prices typically assume price setting in buyer currency ("pricing-to-market", PTM); see, e.g., Betts and Devereux (2000), Kollmann (2001a,b). The sticky-prices version of the model here likewise postulates PTM; it assumes that that intermediate goods prices are set in a staggered fashion, à la Calvo (1983), in buyer currency: firms cannot change prices (in buyer currency), unless they receive a random "price-change signal". The probability of receiving this signal in any particular period is $1-\vartheta$, a constant. Thus, the mean price-change-interval is $1/(1-\vartheta)$. Firms are assumed to meet all demand at posted price.

Consider a Home intermediate good producer that, at t, sets a new price in the Home market, $p_{t,t}^d$ and in the Foreign market, $p_{t,t}^{m*}$. With probability ϑ^τ, these prices are still in force at $t+\tau$. The firm sets

$$\{p_{t,t}^d, p_{t,t}^m\} = \underset{\mathit{pd},\mathit{pm}}{Arg\,Max} \sum_{\tau=0}^{\tau=\infty} \vartheta^\tau E_t\{\rho_{t,t+\tau}\, \pi_{t+\tau}(\mathit{pd},\mathit{pm})/P_{t+\tau}\},$$

where $\rho_{t,t+\tau}$ is a pricing kernel for valuing date $t+\tau$ pay-offs (expressed in units of the Home final good) that equals the Home household's marginal rate of substitution between consumption: $\rho_{t,t+\tau} = \beta^\tau U_{C,t+\tau}/U_{C,t}$, where $U_{C,t}$ is the household's marginal utility of consumption at t (household preferences are described in Section 2.3).

The solution of the firm's decision problem regarding $p_{t,t}^d$, $p_{t,t}^{m*}$ is:

$$p_{t,t}^d = (\nu/(\nu-1))\left\{\sum_{\tau=0}^{\infty} \vartheta^\tau E_t \Xi_{t,t+\tau}^d MC_{t+\tau}\right\} \Big/ \left\{\sum_{\tau=0}^{\infty} \vartheta^\tau E_t \Xi_{t,t+\tau}^d\right\},$$

$$p_{t,t}^{m*} = (\nu/(\nu-1))\left\{\sum_{\tau=0}^{\infty} \vartheta^\tau E_t \Xi_{t,t+\tau}^{m*} MC_{t+\tau}\right\} \Big/ \left\{\sum_{\tau=0}^{\infty} \vartheta^\tau E_t \Xi_{t,t+\tau}^{m*} e_{t+\tau}\right\},$$

with $\Xi_{t,t+\tau}^d = \rho_{t,t+\tau}(P_t/P_{t+\tau})Q_{t+\tau}^d(P_{t+\tau}^d)^\nu$, $\Xi_{t,t+\tau}^{m*} = \rho_{t,t+\tau}(P_t/P_{t+\tau})Q_{t+\tau}^{m*}(P_{t+\tau}^{m*})^\nu$. These expressions imply that, up to a certainty equivalent approximation, prices set at t equal a weighted average of current and expected marginal costs, multiplied by the markup factor $\nu/(\nu-1) > 1$.

The price indices P_t^d and P_t^{m*} evolve according to:

$$(P_t^d)^{1-\nu} = \vartheta(P_{t-1}^d)^{1-\nu} + (1-\vartheta)(p_{t,t}^d)^{1-\nu}; \quad (P_t^{m*})^{1-\nu} = \vartheta(P_{t-1}^{m*})^{1-\nu} + (1-\vartheta)(p_{t,t}^{m*})^{1-\nu}.$$

2.3. The representative household

The preferences of the Home household are described by:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, \mathcal{M}_t/P_t, L_t)\ . \tag{4}$$

E_t denotes the mathematical expectation conditional upon complete information pertaining to period *t* and earlier. C_t and L_t are period *t* consumption and labor effort. $\mathcal{M}_t$ is the household's stock of Home money at the end of period t. U is a utility function of the following form:

$$U(C, M/P, L) = \ln\{[C^\sigma + \kappa(M/P)^\sigma]^{1/\sigma}\} - L\,. \tag{4a}$$

As indicated earlier, the Home household owns all Home firms and it accumulates Home physical capital. The law of motion of capital is:

$$K_{t+1} + \phi(K_{t+1}, K_t) = K_t(1-\delta) + I_t, \tag{5}$$

where I_t is gross investment, $0<\delta<1$ is the depreciation rate of capital, and ϕ is an adjustment cost function: $\phi(K_{t+1},K_t)=\frac{1}{2}\Phi\{K_{t+1}-K_t\}^2/K_t$, $\Phi>0$.

The household can also hold nominal one-period Home and Foreign currency bonds. The period t budget constraint of the Home household is:

$$\mathscr{M}_t+A_t+e_tB_t+P_t(C_t+I_t)=\mathscr{M}_{t-1}+T_t+A_{t-1}(1+r_{t-1})+e_tB_{t-1}(1+r^*_{t-1})+R_tK_t+\int_0^1\pi_t(s)ds+W_tL_t\,. \tag{6}$$

A_{t-1} and B_{t-1} are the household's (net) stock of Home and Foreign currency bonds that mature in period *t*. r_t and r_t^* are the nominal interest rate on these bonds. T_t is a government cash transfer. The last two terms on the right-hand side of (5) are the household's dividend and labor income.

The household chooses a strategy $\{\mathscr{M}_t,A_t,B_t,K_{t+1},C_t\}_{t=0}^{\infty}$ to maximize its expected lifetime utility (4), subject to constraints (5), (6). Ruling out Ponzi schemes, the following equations are first-order conditions of this decision problem:

$$1=(1+r_t)E_t\{\rho_{t,t+1}(P_t/P_{t+1})\}\,, \tag{7}$$

$$1=(1+r_t^*)E_t\{\rho_{t,t+1}(P_t/P_{t+1})(e_{t+1}/e_t)\}\,, \tag{8}$$

$$1=E_t\{\rho_{t,t+1}(R_{t+1}/P_{t+1}+1-d-\phi_{2,t+1})/(1+\phi_{1,t})\}\,, \tag{9}$$

$$U_{m,t}=(r_t/(1+r_t))U_{C,t}\,, \tag{10}$$

$$W_t/P_t=1/U_{C,t}\,. \tag{11}$$

Here, $U_{C,t}\equiv\partial U(C_t,..)/\partial C_t$, $U_{m,t}=\partial U(C_t,..)/\partial(\mathscr{M}_t/P_t)$, $\phi_{1,t}\equiv\partial\phi(K_{t+1},K_t)/\partial K_{t+1}$, $\phi_{2,t}\equiv\partial\phi(K_{t+1},K_t)/\partial K_t$. (7)-(9) are Euler equations; (10) can be viewed as a money demand condition; (11) says that the household equates the marginal rate of substitution between consumption and leisure to the real wage rate.

2.4. Uncovered Interest Parity

Up to a (log-)linear approximation, (7) and (8) imply interest parity (UIP): $E_t\ln(e_{t+1}/e_t)=r_t-r_t^*$. Given the well-documented strong and persistent empirical departure from UIP (see, e.g., Lewis (1995)), variants of the model are explored in which the Euler condition for foreign currency bonds (8) is disturbed by a stationary exogenous stochastic shock, φ_t ("UIP shock", henceforth) whose unconditional mean is unity ($E\varphi_t=1$):

$$1=\varphi_t(1+r_t^*)E_t\{\rho_{t,t+1}(P_t/P_{t+1})(e_{t+1}/e_t)\}\,. \tag{8a}$$

(Log-)linearizing (7) and (8a) yields:

$$E_t\ln(e_{t+1}/e_t)=r_t-r_t^*-\ln(\varphi_t)\,. \tag{12}$$

The UIP shock can be interpreted as reflecting biased exchange rate forecasts or a time-varying "risk premium". [5] [6]

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[5] Assume that household *beliefs* at *t* about e_{t+1} are given by a probability density function, f_t^s, that differs from the true pdf, f_t, by a factor $1/\varphi_t$: $f_t^s(e_{t+1},\Omega)=f_t(e_{t+1}/\varphi_t,\Omega)/\varphi_t$, where Ω is any other random variable. The Home Euler equation for foreign currency bonds is then given by (8a). (Foreign Euler equation for Home bonds: $1=\varphi_t^{-1}(1+r_t)E_t\{\rho^*_{t,t+1}(P_t^*/P^*_{t+1})(e_t/e_{t+1})\}$.)

[6] Several recent studies have assumed UIP shocks (these papers do not study the issues addressed here: a quantitative analysis of differences in macroeconomic behavior across the BW and post-BW periods; the role of price dynamics). See, for example Miller and Williamson (1988), Mark and Wu (1998) and Jeanne and Rose (2002) who interpret the shocks as "fads", and McCallum and Nelson (1999, 2000) and Taylor (1993) who refer to them as a "risk premium".

2.5. Monetary policy

Let M_t be the Home money stock at the end of period *t*. The government pays increases in the money stock out to the household, as a transfer, T_t: $M_t = M_{t-1} + T_t$. Variants of the model with a pegged and a floating exchange rate are considered. In the pegged-rate regime, Home money is exogenous, while Foreign money follows a path that ensures that the nominal exchange rate equals a fixed parity $\overline{e}$: $e_t = \overline{e}$; in the floating-rate regime, by contrast, the money stocks in both countries are exogenous.

2.6. Market clearing conditions

Supply equals demand in intermediate goods markets as producers of intermediate goods meet all demand at posted prices. Market clearing in the Home markets for the final good, labor and rental capital requires: $Z_t = C_t + I_t$, $L_t = \int_0^1 \mathscr{L}_t(s)ds$, and $K_t = \int_0^1 \mathscr{K}_t(s)ds$, where Z_t, L_t and K_t are the supplies of the final good, labor and rental capital; $\int_0^1 \mathscr{L}_t(s)ds$ and $\int_0^1 \mathscr{K}_t(s)ds$ is total demand for labor and capital (by intermediate good producers). Each country's currency is only held by its residents; Home money market equilibrium requires, thus: $M_t = \mathscr{M}_t$, where M_t and $\mathscr{M}_t$ are the money supply and the household's desired money balances. Market clearing in bond markets requires: $A_t + A_t^* = 0$ and $B_t + B_t^* = 0$, where A_t^* [B_t^*] is the Foreign-owned stock of Home [Foreign] currency bonds.

2.7. Solution method

An approximate model solution is obtained by taking a linear approximation of the equations listed above (and of counterparts of these equations for the Foreign country), around a deterministic steady state that is symmetric across countries, and in which each country's trade balance and its net stock of foreign currency bonds are zero. (Log-)linear stochastic processes are specified for the exogenous variables (see below). The resulting linear dynamic system is solved using the Anderson and Moore (1985) method.

2.8. Parameter values

The model is calibrated to quarterly data for the U.S. and an aggregate of the three largest continental European economies (EU3: Germany, France, Italy).

The subjective discount factor is set at β=$(1.01)^{-1}$; the implied steady state real interest rate, *r*, is 1%, as $\beta(1+r)=1$ holds in steady state (business cycle models that are calibrated to quarterly data commonly assume r=0.01, which corresponds roughly to the long run average return on capital).

Equation (10) implies $\mathscr{M}_t/P_t = C_t(r_t(1+r_t)^{-1}\kappa^{-1})^{1/(\sigma-1)}$. Hence, the elasticity of money demand with respect to the interest rate (evaluated at the steady state interest rate) is $emi \equiv \beta/(\sigma-1)$. Based on Fair's (1987) estimates of emi for the U.S. and the EU3 countries (Germany, France, Italy), I set $emi = -0.05$. The preference parameter κ determines the steady state consumption velocity. The key model predictions are not very sensitive to changes in κ. In the simulations, κ is set at a very small (positive) number, which implies that changes in real money balances have no (perceptible) effect on the marginal utility of consumption; this entails that money is (essentially) neutral when prices are flexible.

The price elasticity of a country's aggregate import demand function is given by ϑ (see (2)). For the U.S. and Germany, Hooper and Marquez (1995) report median estimates of ϑ of 1.05 and 0.55, respectively; for France and Italy, Hooper et al. (1998, p.7) report an estimate of 0.4. The simulations set $\vartheta = 0.75$. [7] The ratio of U.S. imports from the EU3 divided by U.S. GDP averaged about 0.4% during the BW period, and about 1% during the post-BW period; the ratio of EU3 imports from the U.S. divided by EU3 GDP was about 1.2% during BW and 1% during post-BW (data source: IMF Direction of Trade Statistics). In the baseline model, α^m (see (1)) is set so that each country's imports/GDP ratio is 1% (for both exchange rate regimes).

The steady state markup of price over marginal cost for intermediate goods is set at $1/(\nu-1) = 0.2$, consistent with the findings of Martins et al. (1996) for the U.S. and the EU3 countries. The technology parameter ψ (see (3)) is set at $\psi = 0.2$, which entails a 2/3 steady state labor income/GDP ratio, consistent with U.S. and EU3 data. Aggregate data indicate a quarterly capital depreciation rate of roughly 2.5%; thus, $\delta = 0.025$ is assumed. The capital adjustment cost parameter Φ is set at $\Phi = 8$, in order to match the fact that the standard deviation of investment is approximately 4 times larger than that of output, in the U.S. and in the EU3.

Micro evidence on the frequency of price changes is sketchy and inconclusive, and it mainly pertains to the U.S.--I am not aware of evidence for the EU3. Retail prices are quite flexible--e.g., the Levy et al. (1998) study of U.S. supermarkets finds that 15% of prices are changed every week. A survey of top management at about 200 major U.S. firms by Blinder et al. (1998) reports a median frequency of 1.4 price changes per year; however, the median price-adjustment lag following a demand or cost change is quite short: 1 quarter. It appears that in many sectors non-price attributes (delivery lags, warranties, after-sale services etc.) are quite responsive to changes in market conditions--changes in these attributes might thus act as a substitute for short term flexibility (Carlton (1986)).

The simulations consider a variant of the model with an average price-change-interval of 4 quarters, $\delta = 0.75$ (a value widely used in New Keynesian macro models; e.g., Erceg et al. (2000)), and a variant with flexible prices, $\delta = 0$ (as assumed in RBC models).

Productivity and the UIP shock follow these processes:

$$z_t^\theta = R^\theta z_{t-1}^\theta + \varepsilon_t^\theta, \quad \text{for } z_t^\theta \equiv (\ln(\theta_t), \ln(\theta_t^*))', \tag{13}$$

$$\ln(\varphi_t) = \rho^\varphi \ln(\varphi_{t-1}) + \varepsilon_t^\varphi. \tag{14}$$

In the pegged-rate regime, Home money evolves according to:

$$\ln(M_t/M_{t-1}) = \rho^m \ln(M_{t-1}/M_{t-2}) + \varepsilon_t^m. \tag{15}$$

In the floating-rate regime, the law of motion of Home and Foreign money is:

$$z_t^\mu = R^\mu z_{t-1}^\mu + \varepsilon_t^\mu, \quad \text{for} \quad z_t^\mu \equiv (\ln(M_t/M_{t-1}), \ln(M_t^*/M_{t-1}^*))'. \tag{16}$$

Here, ε_t^θ, ε_t^m and ε_t^μ are independent (vector) white noises.

Estimates of these processes for 1959Q1-70Q4 and 73Q1-94Q4 are shown in Table 1. The processes have differed markedly across these two periods. The estimates for the 59-70 [73-94] period are used to simulate the pegged-exchange-rate [floating-rate] variant of the model.

The autocorrelation of U.S. productivity (about 0.85) and the standard deviation of U.S. productivity innovations (0.6%) were roughly similar across both periods. By contrast, the autocorrelation of EU3 productivity was much lower during the BW period (0.17) than during the post-BW era (0.81), while the standard deviation of EU3 productivity innovations was higher during the BW era (0.87% vs. 0.54%); this reflects a series of sharp but brief shocks to EU3 output during the 1960s (reflecting, e.g., the French general strike of 1968). The correlation between U.S.

[7] The assumption in the model that the elasticity of substitution is identical across countries is made for simplicity of exposition only. When Home and Foreign elasticities, denoted ϑ and ϑ^*, differ, then combinations of ϑ and ϑ^* for which the mean $(\vartheta+\vartheta^*)/2$ is identical, are observationally equivalent, for the variables discussed below. Computing a weighted average (using GDP weights) of the estimates of ϑ for Germany, France and Italy reported above and then taking the arithmetic mean of this weighted average and of the estimate for the U.S. yields an elasticity of 0.75.

and EU3 productivity innovations was negative in the BW era (-0.28) and positive in the post-BW era (0.18).

The autocorrelation of the UIP shock and the standard deviation of the innovation to that shock were 0.24 and 0.58% during 59Q1-70Q4, compared to 0.50 and 3.30% during 73Q1-94Q4. [8] The UIP shock has thus been more persistent during the post-BW period and--as might be expected--much more volatile (clearly there is much more scope for irrational exchange rate forecasts when exchange rates float than when they are pegged).

The autocorrelation of U.S. money growth was the same during both periods (0.39), but the standard deviation of U.S. money supply innovations was higher in the post-BW era. The autocorrelation of post-BW EU3 money growth was likewise positive (0.18). Spillovers between the post-BW U.S. and EU3 money supply processes were weak (off-diagonal elements of matrix R^{μ} close to zero), and the correlation between U.S: and EU3 money supply innovations has been close to zero.

Note that the estimated post-BW productivity and money processes are roughly symmetric across the two countries; to simplify the discussion, the floating-rate (post-BW) variant of the model uses 'symmetrized' versions of those processes:

$$R^{\theta}=\begin{bmatrix} .81 & .03 \\ .03 & .81 \end{bmatrix}, E_t\varepsilon_t^{\theta}\varepsilon_t^{\theta\prime}=.0058^2\begin{bmatrix} 1 & .18 \\ .18 & 1 \end{bmatrix},\ R^{\mu}=\begin{bmatrix} .29 & .03 \\ .03 & .29 \end{bmatrix},\ E_t\varepsilon_t^{\mu}\varepsilon_t^{\mu\prime}=.0112^2\begin{bmatrix} 1 & -.02 \\ -.02 & 1 \end{bmatrix}.$$

3. Stylized facts about economic fluctuations (BW and post-BW era)

Table 2 reports statistics on the cyclical behavior of key U.S. and EU3 quarterly time series for the periods 59Q1-70Q4 and 73Q1-94Q4. The EU3 time series are weighted averages of German, French and Italian data (weights: shares in 1980 EU3 GDP). All series have been logged, with the exception of interest rates, and Hodrick-Prescott (HP) filtered. Table 2 shows that:

(1) The standard deviations of nominal and real exchange rates were smaller than 1% under BW and exceeded 8% during the post-BW era. The correlation between nominal and real exchange rates was close to unity (0.99) during the post-BW era--markedly higher than under BW (0.43). During the post-BW era, nominal and real exchange rates have been much more volatile than GDP, the money stock and the price level.

(2) Standard deviations of money stocks, price levels and nominal interest rates were higher during the post-BW era, especially in the U.S. (U.S.: increase by factor of roughly 3). The volatility of EU3 real macro aggregates (GDP etc.) shows no systematic differences across the two periods, but the volatility of U.S. real aggregates was higher during the post-BW era (standard deviation of U.S. GDP in BW era [post-BW era]: 1.22% [1.82%]).

(3) Cross-country correlations of real macro aggregates, of productivity and of the price level were markedly higher in the post-BW era than under BW; for example, the cross-country correlation of GDP increased from -0.18 (BW) to 0.48 (post-BW). In both periods, the cross-country correlation of the nominal interest rate (roughly 0.5) was sizable and highly statistically significant.

(4) In both periods, consumption and total factor productivity were less volatile than GDP, while investment and net exports were more volatile.

(These empirical regularities hold also for other industrialized countries--see, e.g. Mussa (1986), Baxter and Stockman (1989), Flood and Rose (1995), Gerlach (1988), Backus et al. (1995)).

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[8] Note that $\ln(\varphi_t)=E_t\ln(\varphi_t')$, with $\ln(\varphi_t')=\ln(e_{t+1}/e_t)+r_t^*-r_t$. I regressed $\ln(\varphi_t')$ on a constant and on variables known at date t (lags 1-4 of $\ln(\varphi_t')$; U.S. and EU3 interest rates, inflation and linearly detrended log GDP at dates t,...,t-4); (14) was then estimated using the fitted $\ln(\varphi_t')$ series.

4. Model predictions

Simulation results are reported in Tables 3-6. In the Tables, Y_t represents real GDP; $RER_t \equiv e_t P_t^*/P_t$ is the real exchange rate. The predicted moments shown in the Tables pertain to variables that have been logged (with the exception of the interest rate) and HP filtered.

4.1. Baseline model--floating exchange rate (Table 3)

Table 3 shows results for the model variant with a floating exchange rate. Cols. 1-4 pertain to the flex-prices structure, while Cols. 5-8 pertain to the sticky-prices structure. Results are presented for model versions that just assume money supply shocks, just productivity shocks, just UIP shocks (see Columns labeled "M,M^*", "θ,θ^*" and "UIP", respectively), as well as for versions with the three simultaneous types of shock (Columns labeled "$M,M^*,\theta,\theta^*\&\varphi$").

Money supply shocks have no effect on real variables when prices are flexible (see Col. 1). In contrast, money shocks have a noticeable effect on real variables, under sticky prices (Col. 5) -- predicted standard deviations of output and the real exchange rate, and cross-country output correlation: 1.95%, 1.71% and 0.08% respectively. The *predicted* standard deviation of the nominal exchange rate, 2.7%, is roughly the same in the flex-prices and sticky-prices structures. With the exception of the predicted standard deviation of output, these statistics are markedly below the corresponding empirical post-BW statistics (see Cols. 9 and 10, Table 3).

For understanding the effect of shocks on the exchange rate, it is useful to note that log-linearizing (7) and (10) yields a difference equation in the Home nominal interest rate and money that has this solution:

$$r_t - r = (1-\zeta)^{-1} \sum_{k=0}^{\infty} E_t \ln(M_{t+1+k}/M_{t+k}), \quad \text{with} \quad 0<\zeta \equiv emi/(emi-r)<1, \qquad (17)$$

where $emi<0$ is the interest rate elasticity of money demand. Hence, the Home nominal interest rate is an increasing function of expected future Home money growth rates. Interestingly, productivity shocks and UIP shocks have no effect on the nominal interest rate; also, the behavior of the nominal interest rate does not depend on the degree of price stickiness.

Solving (12) forward allows to express the nominal exchange rate as a function of (the expected path of) the Home-Foreign nominal interest rate differential and of the UIP shock:

$$\ln(e_t) = -\sum_{k=0}^{\infty} E_t\{r_{t+k} - r_{t+k}^* - \ln(\varphi_{t+k})\} \ + \ \lim_{k\to\infty} E_t \ln(e_{t+k}). \qquad (18)$$

Panels (a) and (b) of Table 5 show dynamic responses to a positive Home money supply shock. The shock induces a nominal exchange rate depreciation and an increase in the Home price level.[9] Price stickiness dampens the response of the price level. Under sticky prices, a positive money supply shock triggers a *real* depreciation of the Home currency, and a fall in the Home real interest rate (in terms of the Home final good), which induces a rise in Home consumption and investment demand; thus Home output rises, on impact; Foreign output rises likewise (as Home demand for Foreign goods rises), though by markedly less than Home output; this explains why the

[9] The shock raises the Home nominal interest rate (as it raises the expected growth rate of money); on impact, the nominal exchange rate undershoots thus its long run response (see (18)). These responses of the nominal interest rate and the nominal exchange rate hinge on the unit intertemporal elasticity of substitution in consumption (*iec*) and the unit elasticity of money demand with respect to consumption (*emc*) implied by the log-CES preference specification (4a) (which was adopted to simplify the presentation). Kollmann (2001a, 2001b) considers a more general specification that allows to set $iec \neq 1$, $emc \neq 1$. When $iec < 1$, $emc < 1$ and prices are sticky, the nominal interest rate may fall--and hence, there may be Dornbusch (1976) style exchange rate overshooting (in response to a money supply shock). However, unless price adjustment lags are implausibly long (in the range of four years), predicted exchange rate volatility remains below that seen in the post-BW data (Kollmann (2001a,b)). The nominal interest rate is affected by productivity shocks and UIP shocks, when $iec \neq 1$, $emc \neq 1$; however, that effect is weak, and the key predictions regarding the effect of money and UIP shocks discussed below continue to hold when $iec \neq 1$, $emc \neq 1$.

cross-country output correlation of output (induced by money supply shocks) is close to zero (see above).

Productivity shocks have a non-negligible effect on output, but only a very weak effect on the nominal exchange rate. Under flexible prices, the predicted standard deviations of output, of the nominal exchange rate and of the real exchange rate (induced by productivity shocks) are 0.96%, 0.06% and 0.83%, respectively (Col. 2, Table 3). Price stickiness dampens the effect of productivity shocks on output and the real exchange rate (Col. 6). When there are just productivity shocks, the floating-exchange-rate version of the model predicts that macroeconomic aggregates are positively correlated across countries, which is mainly due to the fact that (in that variant) the cross-country correlation of productivity is positive (0.21).

The preceding results show that money and productivity shocks cannot explain the standard deviations of (nominal and real) exchange rates (about 8%) seen during the post-BW era--irrespective of whether flexible or sticky prices are assumed.

UIP shocks have a much stronger effect on nominal and real exchange rates: when just UIP shocks are assumed, the predicted standard deviation of nominal and real exchange rates is about 6.5%. This is so irrespective of whether prices are flexible or sticky (see Cols. 3 and 7 in Table 3). By contrast, UIP shocks have only a minor effect on the standard deviations of the other variables considered in Table 3, with the exception of net exports.

As discussed above, UIP shocks have no effect on the nominal interest rate. As these shocks are transitory, they have little long-run effect on the (Home and Foreign) price level, and hence little long-run effect on the nominal exchange rate. Thus, with just UIP shocks (see (18)):

$$\ln(e_t) \cong \sum_{k=0}^{\infty} E_t \ln(\varphi_{t+k}) \;=\; (1-\rho^{\varphi})^{-1} \ln(\varphi_t)\,. \tag{19}$$

Table 5 (Panels (a),(b)) shows that, in accordance with (19), a 1% UIP shock induces a depreciation of the Home currency by about 2%, on impact (in the floating-exchange rate model variant); after the shock, the nominal exchange rate appreciates and moves back towards its pre-shock value. The Home currency depreciation lowers the Home import price index P^m, which lowers the Home price level P. However, the response of P is very weak (less than 0.03%, on impact), as the weight of import prices in the domestic price index (which equals the imports/GDP ratio: 1%) is low. (Foreign responses are a mirror image of Home responses.) The weak responses of P and P^* imply that the behavior of the real exchange rate (eP^*/P) mimics very closely that of the nominal rate, when just UIP shocks are assumed--and that irrespectively of whether prices are flexible or sticky (in both cases, the predicted correlation between nominal and real exchange rates is 0.99).

The weak effect of UIP shocks on (expected) inflation rates (and their zero effect on nominal interest rates) implies also that their effect on expected real interest rates (in terms of Home and Foreign final goods) is weak. This explains why these shocks have little effect on consumption, and GDP. In terms of % standard deviations, (net) exports (*NX*) are the only quantity variable that is significantly affected by UIP shocks, especially when prices are flexible--predicted standard deviation of *NX*: 10.33% with flexible prices, and 1.78% with sticky prices. [10]

When the three types of shock are used simultaneously (Table 3, Cols. 4 and 8), the flex-prices and sticky-prices variants of the floating-rate model generate predicted standard deviations

[10] In Table 3, *NX* is defined as $NX \equiv Q^{m*}/Q^m$, where Q^{m*} [Q^m] is a quantity index of Home exports [imports] (see (1)). Due to the small foreign trade/GDP ratio, the high volatility of HP filtered logged NX is consistent with the low volatility of HP filtered logged output, consumption and investment. The lower variability of NX in the sticky-prices structure is due to the weaker response of import prices (in buyer currency) to the nominal exchange rate, under price stickiness.

of nominal and real exchange rates of about 7%--these variants capture, thus, about 80% of the standard deviation of post-BW U.S.-EU3 nominal and real exchange rates. Note that UIP shocks account for more than 85% of the variances of the nominal exchange rate and of the real exchange rate (that are generated under simultaneous money supply, productivity and UIP shocks), in both the flex- and sticky-prices model variants. Both variants yield high predicted correlations between nominal and real exchange rates (correlation in sticky-prices [flex-prices] variant: 0.97 [0.92]). In terms of the standard deviations of the quantity variables, both variants seem broadly consistent with the post-BW data. Both variants underpredict the post-BW correlation between U.S. and EU3 GDP (0.48). (The predicted cross-country GDP correlation is higher under flexible prices (0.23) than under sticky prices (0.09).)

The substantial variability of real exchange rates since the end of the BW system, and the almost perfect correlation between post-BW nominal and real exchange rates, are widely viewed as reflecting price stickiness--and used to justify (Keynesian) sticky-prices macro models with (e.g., Mussa (1986, 1990), Dornbusch and Giovannini (1990), Caves et al. (1993), and Obstfeld and Rogoff (1996)). The results presented here cast doubt on this view--as sticky-prices and flexible-prices variants of the model both capture these facts. This view seems to be based on the assumption that monetary shocks are the main source of exchange rate fluctuations (as money shocks have no effect on the real exchange rate under price flexibility, but induce high nominal-real exchange rate correlations when prices are sufficiently sticky). However, the simulations discussed above suggest that money shocks only explain a small part of post-BW (nominal and real) exchange rate fluctuations. UIP shocks have a much stronger effect on nominal and real exchange rates, and that under sticky prices *and* under flexible prices. Hence, the high correlation between nominal and real exchange rates in floating exchange rate regimes does not permit to draw conclusions regarding price stickiness.

4.2. Baseline model--pegged exchange rate (Table 4)

Table 4 presents results for the model variant with a pegged exchange rate (these results are based on the time series processes for exogenous variables estimated from BW era data).

In the fixed-exchange rate variant, Home money shocks induce a response of Foreign money that mimics perfectly the path of Home money (see Panels (c) and (d) in Table 5). Under sticky prices, output (as well as consumption and investment) is thus perfectly correlated across countries, when just Home money shocks are assumed (Cols. 1 and 2 in Panel (b), Table 4). With just productivity shocks, the predicted cross-country output correlation is *negative* (-0.08), when prices are flexible (because the cross-country correlation of productivity is assumed to be negative in the pegged rate version of the model); by contrast, the cross-country correlation (induced by productivity shocks) is positive (0.25) in the sticky-prices version (a positive shock to Home productivity triggers a rise in the Foreign money stock, to prevent a depreciation of the Home currency; with sticky prices, Home and Foreign output increase thus, in response to that shock--see Table 5). In the fixed-exchange rate regime, UIP shocks induce significant responses of the Foreign interest rate and money supply, to stabilize the nominal exchange rate; with sticky prices, these responses have a noticeable effect on Foreign real activity (standard deviation of Foreign output when there are just UIP shocks: 1.05%); by contrast, UIP shocks have virtually no effect on Home and Foreign GDP when prices are flexible. The predicted standard deviation of the real exchange rate induced by UIP shocks (0.70% [0.09%] when prices are flexible [sticky]) is much smaller in the pegged-exchange rate variant of the model than in the floating-rate variant--recall that UIP shocks are assumed to be much weaker in the pegged-rate variant. (If under the peg, there were UIP shocks comparable to those under the float, then the predicted standard of the real exchange rate would be 6.63% [1.20%] with flexible [sticky] prices.)

When the pegged-exchange rate structure is simultaneously subjected to the three types of shock, that structure generates predicted standard deviations that are broadly consistent with the BW data (predicted standard deviations of Home GDP, Foreign GDP and of the real exchange rate: 1.13%, 1.18% 1.42% [1.46%, 1.71%, 0.51%] under flexible [sticky] prices). Note, especially, that the model captures the fact that the variability of nominal and real exchange rates was markedly smaller in the BW era, while the variability of real economic activity differed comparatively little (from variability in the post-BW era). This is so irrespective of whether flexible or sticky prices are assumed. However, the sticky-prices version of the fixed-exchange rate model generates a high positive cross-country output correlation (0.73)--while the actual cross-country correlation was negative during the BW era (-0.18). The flex-prices version of the pegged-rate model, by contrast, generates a negative cross-country correlation (-0.06).

4.3. High trade share (Table 6)

In the industrialized world, the rise in exchange rate volatility after the end of the BW system has been strongest among the major currency blocs--which motivates the focus of the present paper on the U.S.-EU3 exchange rate. Trade flows among these blocs are weak, relative to GDP. Can the results be transposed to situations with stronger trade links (such as those observed among EU countries)? A detailed empirical/calibration analysis of such situations is beyond the scope of this paper. Table 6 merely considers a version of the floating-rate model in which the steady state imports/GDP ratio, denoted by α, is set at a markedly higher value than in the baseline case: $\alpha = 0.2$ (baseline: $\alpha = 0.01$). (All other parameters are kept unchanged.)

When there are just money and productivity shocks, the predicted standard deviations of macroeconomic variables are not very sensitive to α. Table 6 and the discussion below focus thus on the effect of UIP shocks.

The nominal-real exchange rate correlation induced by UIP shocks is close to unity (0.99), irrespective of the trade share--and of whether prices are flexible or sticky. Predicted nominal exchange rate variability (induced by UIP shocks) does not depend on the trade share. Real exchange rate variability is inversely related to openness, while price level and output variability is positively linked to openness, especially when prices are flexible.[11] This is due to the fact that the sizable nominal exchange rate movements induced by UIP shocks have a stronger immediate effect on the domestic price level (and thus on real interest rates and output), the greater α, and the greater the degree of price flexibility. But note that the standard deviation of the real exchange rate is sizable in the floating-rate structure with α=0.2. In that structure, the predicted standard deviations (induced by UIP shocks) of the real exchange rate, the price level and GDP are 3.95%, 1.37%, and 0.26%, respectively under flexible prices and 6.35%, 0.23%, 0.06% under sticky prices. (Corresponding statistics in the baseline case with α=0.01: 6.47%, 0.13%, 0.02% [flex-prices]; 6.67%, 0.02%, 0.01% [sticky prices].)

The prediction that the destabilizing effect of UIP shocks on the price level and GDP is stronger in more open economies suggests that more open economies have a stronger incentive to adopt an exchange rate peg, under the plausible assumption that a peg markedly reduces UIP shocks.[12] This prediction is consistent with the data: empirically, the likelihood of adopting a peg is positively linked to openness (see, e.g. Edwards (1996)).

5. Conclusion

This paper has compared business cycle stylized facts across the Bretton Woods (BW) pegged exchange rate period and the post-BW era, for the U.S. and an aggregate of European economies (EU3). Nominal and real exchange rate volatility was much higher under floating; the volatility of aggregate output was hardly affected by floating, but the U.S.-EU3 output correlation was markedly higher during the post-BW period.

[11] Hau (2002) shows that an inverse relationship between post-BW real exchange rate volatility and openness exists, across OECD countries.

[12] See Kollmann (2004) for further discussions of this point; that paper presents a welfare analysis that suggests that the welfare gain from adopting a peg is positively linked to openness.

Based on a two-country dynamic general equilibrium (DGE) model, the paper argues that a flexible-prices structure (in which money is neutral) can capture all the facts described above; a sticky-prices structure can capture the rise in nominal-real exchange rate volatility after the end of BW but fails to explain the rise in the cross-country output correlation.

The model assumes shocks to money supplies and to productivity, as well as shocks to the uncovered interest parity (UIP) condition. Standard DGE models (with just money and productivity shocks) fail to capture the high volatility of the U.S. dollar exchange rate during the post-BW era. The model here (with UIP shocks) generates much more volatile exchange rates than standard models--it captures about 80% of the standard deviations of post-BW U.S.-EU3 nominal and real exchange rates. In contrast to conventional wisdom (e.g., Mussa (1986, 1990), Dornbusch and Giovannini (1990), Caves et al. (1993), and Obstfeld and Rogoff (1996)), the model here suggests that price stickiness is not the key to explaining why the substantial rise in nominal exchange rate volatility between the major currency blocs after the end of the BW system was accompanied by a commensurate rise in real exchange rate volatility. The flex-prices variant of the model captures better the fact that the correlation between U.S. and European output has been higher in the floating-rate era.

DATA APPENDIX

The **data** are quarterly and (unless otherwise indicated) are from International Financial Statistics [IFS] published by the IMF. GDP: real GDP. **Consumption**: real total private consumption. **Investment**: gross fixed capital formation plus change in stock of inventories (nominal series deflated using CPI). **Net exports**: exp/imp, where exp (imp) is volume index of exports (imports) of goods and services. **Money stock**: M1 (from OECD Main Economic Indicators [MEI]; 59-70 series for EU3 M1 are taken from Darby et al. (1983)). **Price level**: CPI. **Nominal interest rate**: short term rates from Citibase, expressed on a quarterly basis (series FYUSCD, FYGECM, FYFRCM, FYITBY; for Italy: bond yield, credit institutions). **Nominal exchange rate**: domestic currency prices of U.S. dollar. **Real exchange rate**: based on relative CPIs.

Productivity (θ): total factor productivity defined as $\ln(\theta) = \ln(Y) - .208\ln(K) - (1-.208)\ln(L)$, where *Y*, *K* and *L* are real GDP, capital and labor (EU3 series for 59-70: $\ln(\theta)=\ln(Y)-(1-.208)\ln(L)$, due to lack of data on K); the weight on log capital (0.208) corresponds to the value in the theoretical model. *Labor*: For the U.S., total employee hours (Citibase series LPMHU) are used; the EU3 series for 1959-70 is total employment (from OECD Main Economic Indicators) while the series for 1973-95 is total hours, from Bulletin of Labor Statistics (International Labor Office). *Capital*: The U.S. capital stock is taken from Survey of Current Business (U.S. Department of Commerce); for EU3 countries, capital stock series do not seem to be readily available, for 1959-70; for 73-94, EU3 capital stock series are taken from the OECD publication 'Flows and Stocks of Fixed Capital'; these capital stock series are annual; quarterly series are constructed by linear interpolation of the annual series.

Aggregate EU3 series are geometric weighted averages of German, French and Italian series (for interest rate: arithmetic average); weights: 0.41, 0.35, 0.24 (shares in 1980 EU3 GDP). Germany series are for West Germany.

Starting dates for GE Consumption (C) & Investment (I): 60Q1; FR C & I: 65Q1; IT C: 70Q1; IT I: 60Q1. The aggregate EU3 C series starts in 60Q1; it equals GE C for 60Q1-64Q4 and a weighted average of GE and FR C, for 65Q1-69Q4 (series for sub-periods spliced together multiplicatively). Aggregate EU3 I series constructed analogously.

REFERENCES

Anderson, G. and G. Moore, 1985, A Linear Algebraic Procedure for Solving Linear Perfect Foresight Models, Economics Letters 17, 247-252.

Bacchetta, P. and E. van Wincoop, 2000, Does Exchange Rate Stability Increase Trade and Welfare? American Economic Review 90: 1093-1109.

Backus, D., Kehoe, P. and F. Kydland, 1995, International Business Cycles: Theory and Evidence, in: T. Cooley, ed., Frontiers of Business Cycle Research (Princeton University Press, Princeton), 331-356.

Baxter, M. and A. Stockman, 1989, Business Cycles and the Exchange Rate Regime, Journal of Monetary Economics 23, 377-400.

Benigno, G., 2004, Real Exchange Rate Persistence and Monetary Policy Rules, Journal of Monetary Economics 51, 473-502.

Bergin, P., 2003. Putting the "New International Macroeconomics" to a Test, Journal of International Economics 60, 3-34.

Betts, C. and M. Devereux, 2000, Exchange Rate Dynamics in a Model of Pricing-To-Market, Journal of International Economics 50, 215-244.

Blinder, A., E. Canetti, D. Lebow and J. Rudd, 1998, Asking About Prices (Russell Sage Foundation, New York).

Calvo, G., 1983, Staggered prices in a utility maximizing framework, Journal of Monetary Economics 12, 383-398.

Carlton, D., 1986, The Rigidity of Prices, American Economic Review 76, 637-658.

Caves, R., J. Frankel, R. Jones, 1993, World Trade and Payments, 6th edition (Harper Collins, New York).

Caves, R., J. Frankel and R. Jones, 1993, World Trade and Payments, 6th edition (Harper Collins, New York).

Chari, V., P. Kehoe and E. McGrattan, 2002, Can sticky price models generate volatile and persistent real exchange rates? Review of Economic Studies 69, 533-563.

Collard, F. and H. Dellas, 2002, Exchange Rate Systems and Macroeconomic Stability 49, 571-599.

Darby, M., J. Lothian, A. Gandolfi, A. Schwartz and A. Stockman, 1983, The International Transmission of Inflation (The University of Chicago Press, Chicago).

Dedola, L. and S. Leduc, 2001, Why is the Business Cycle Behavior of Fundamentals Alike Across Exchange Rate Regimes?, International Journal of Finance and Economics 6, 401-419.

Devereux, M. and C. Engel, 2003, Monetary Policy in the Open Economy Revisited: Price Setting and Exchange Rate Flexibility, Review of Economic Studies 70, 765-783.

Dornbusch, R., 1976, Expectations and Exchange Rate Dynamics, Journal of Political Economy 84, 1161-1176.

Dornbusch, R., 1980, Open Economy Macroeconomics (Basic Books, New York).

Dornbusch, R. and A. Giovannini, 1990, Monetary Policy in the Open Economy, in: B. Friedman and F. Hahn, eds., Handbook of Monetary Economics, Vol. II (Elsevier, Amsterdam), 1231-1303.

Duarte, M., 2003, Why Don't Macroeconomic Quantities Respond to Exchange Rate Variability? Journal of Monetary Economics 50, 889-913.

Edwards, S., 1996, The Determinants of the Choice Between Fixed and Flexible Exchange Rate Regimes, Working Paper 5756, NBER.

Erceg, C., D. Henderson and A. Levin, 2000, Optimal Monetary Policy With Staggered Wage and Price Contracts, Journal of Monetary Economics 46, 281-313.

Faia, E., 2001. Stabilization Policy in a Two Country Model and the Role of Financial Frictions, Working Paper No. 56, European Central Bank.

Fair, R., 1987, International Evidence on the Demand for Money, Review of Economics and Statistics 69, 473-480.

Flood, R. and A. Rose, 1995, Fixing Exchange Rates: A Virtual Quest For Fundamentals, Journal of Monetary Economics 36, 3-37.
Frankel, J. and K. Froot, 1989, Forward Discount Bias: Is it an Exchange Risk Premium?, Quarterly Journal of Economics 104, 139-161.
Gerlach, S., 1988, World Business Cycles under Fixed and Flexible Exchange Rates, Journal of Money Credit and Banking 20, 621-632.
Ghironi, F., Rebucci, A., 2001. Monetary Rules for Emerging Market Economies, Working Paper, Boston College
Hau, H., 2002, Real Exchange Rate Volatility and Economic Openness: Theory and Evidence, Journal of Money, Credit and Banking 34, 611-630.
Hooper, P. and J. Marquez, 1995, Exchange Rates, Prices, and External Adjustment in the United States and Japan, in: P. Kenen, ed., Understanding Interdependence (Princeton University Press, Princeton), 107-168.
Hooper, P., K. Johnson and J. Marquez, 1998, Trade Elasticities for G-7 Countries, International Finance Discussion Paper 609, Board of Governors of the Federal Reserve System.
Jeanne, O. and A. Rose, 2002, Noise Trading and Exchange Rate Regimes, Quarterly Journal of Economics
Kollmann, R., 1996, The Exchange Rate in a Dynamic-Optimizing Current Account Model with Nominal Rigidities, Working Paper, Department of Economics, University College London.
Kollmann, R., 2001a, Explaining International Comovements of Output and Asset Returns: The Role of Money and Nominal Rigidities, Journal of Economic Dynamics and Control 55, 243-262.
Kollmann, R., 2001b, The Exchange Rate in a Dynamic-Optimizing Business Cycle Model with Nominal Rigidities. a Quantitative Examination, Journal of International Economics 55, 242-262.
Kollmann, R., 2002, Monetary Policy Rules in the Open Economy: Effects on Welfare and Business Cycles, Journal of Monetary Economics 49, 989-1015.
Kollmann, R., 2004, Welfare Effects of a Monetary Union: the Role of Trade Openness, Journal of the European Economic Association, forthcoming.
Lane, P., 2001. The New Open Economy Macroeconomics: a Survey, Journal of International Economics 54, 235-266.
Laxton, D., Pesenti, P., 2002. Monetary Policy Rules for Small, Open, Emerging Economies. Paper presented at Carnegie-Rochester Conference (Nov. 2002).
Levy, D., M. Bergen, S. Dutta and R. Venable, 1997, The Magnitude of Menu Costs: Direct Evidence From Large U.S. Supermarket Chains, Quarterly Journal of Economics 112, 791-825.
Lewis, K., 1995, Puzzles in International Financial Markets, in: G. Grossman and K. Rogoff, eds., Handbook of International Economics, Vol. III (Elsevier, Amsterdam), 1913-1971.
Lubik, T., 2000. International Comovement Revisited: The Role of Non-Traded Goods and Price Stickiness. Working Paper, Johns Hopkins University.
Mark, N. and Y. Wu, 1998, Rethinking Deviations From Uncovered Interest Parity: The Role of Covariance Risk and Noise, Economic Journal 108, 1686-1706.
Martins, J., S. Scarpetta and D. Pilat, 1996, Mark-Up Pricing, Market Structure and the Business Cycle, OECD Economic Studies 27, 71-105.
McCallum, B. and E. Nelson, 1999, Nominal Income Targeting in an Open-Economy Optimizing Model, Journal of Monetary Economics 43, 554-578.
McCallum, B. and E. Nelson, 2000, Monetary Policy for an Open Economy: An Alternative Framework with Optimizing Agents and Sticky Prices, Oxford Review of Economic Policy, forthcoming.

Meese, R., and K. Rogoff, 1983, Empirical Exchange Rate Models of the Seventies: Do they Fit Out of Sample? Journal of International Economics 14, 3-24.
Miller, M. and J. Williamson, 1988, The International Monetary System: An Analysis of Alternative Regimes, European Economic Review 32, 1031-1054.
Monacelli, T., 2004, Into the Mussa Puzzle: Monetary Policy Regimes and the Real Exchange Rate in a Small Open Economy, Journal of International Economics 62, 191-217.
Mundell, R., 1968, International Economics (MacMillan, New York).
Mussa, M., 1986, Nominal Exchange Rate Regimes and the Behavior of Real Exchange Rates: Evidence and Implications, Carnegie-Rochester Conference Series on Public Policy 25, 117-214.
Mussa, M., 1990, Exchange Rates in Theory and in Reality, Essay in International Finance No. 179, International Finance Section, Princeton University.
Obstfeld, M. and K. Rogoff, 1996, Foundations of International Macroeconomics (MIT Press, Cambridge, MA).
Obstfeld, M. and K. Rogoff, 2000, New Directions for Stochastic Open Economy Models, Journal of International Economics 50, 117-153.
Parrado, E., Velasco, A., 2001. Optimal Interest Rate Policy in a Small Open Economy: The Case for a Clean Float, Working Paper, NYU.
Rogoff, K., 2000, Monetary Models of Dollar/Yen/Euro Nominal Exchange Rates: Dead or UnDead?, manuscript, Dept. of Economics, Harvard University.
Sarno, L., 2001, Toward a New Paradigm in Open Economy Modeling: Where Do We Stand, Federal Reserve Bank of St. Louis Review 83, 21-36.
Smets, F., Wouters, R., 2002. Openness, Imperfect Exchange Rate Pass-Through and Monetary Policy, Journal of Monetary Economics 49, 947-981.
Sopraseuth, T., 2003, Exchange Rate Regimes and International Business Cycles, Review of Economic Dynamics 6, 339-361.
Sutherland, A., 2001, Incomplete Pass-Through and the Welfare Effects of Exchange Rate Variability, Working Paper, University of St.Andrews.
Taylor, J., 1993, Macroeconomic Policy in a World Economy (Norton, New York).
Tille, C., 2003, How Valuable is Exchange Rate Flexibility? Optimal Monetary Policy under Sectoral Shocks, Working Paper, Federal Reserve Bank of New York.

Table 1. Fitted laws of motion of money, productivity and UIP shock

(a) 1959:Q1-1970:Q4

$$\Delta \ln(M_t^{US}) = \underset{(0.14)}{0.39}\, \Delta \ln(M_{t-1}^{US}) + \varepsilon_t^{US}, \quad \sigma(\varepsilon_t^{m,US}) = 0.0067$$

$$\ln(\theta_t^{US}) = \underset{(0.06)}{0.93}\ \ln(\theta_{t-1}^{US}) \ \underset{(0.11)}{-\ 0.04}\ \ln(\theta_{t-1}^{EU3}) + \varepsilon_t^{\theta,US}$$

$$\ln(\theta_t^{EU3}) = \underset{(0.09)}{0.03}\ \ln(\theta_{t-1}^{US}) \ \underset{(0.15)}{+\ 0.17}\ \ln(\theta_{t-1}^{EU3}) + \varepsilon_t^{\theta,EU3}$$

$$\sigma(\varepsilon_t^{\theta,US}) = 0.0065, \quad \sigma(\varepsilon_t^{\theta,EU3}) = 0.0087, \quad \rho(\varepsilon_t^{\theta,US}, \varepsilon_t^{\theta,EU3}) = \underset{(0.09)}{-0.28}$$

$$\ln(\varphi_t) = \underset{(0.15)}{0.24} \ln(\varphi_{t-1}) + \varepsilon_t^{\varphi}, \quad \sigma(\varepsilon_t^{\varphi}) = 0.0058$$

(b) 1973:Q1-1994:Q4

$$\Delta \ln(M_t^{US}) = \underset{(0.10)}{0.39}\ \Delta \ln(M_{t-1}^{US}) \ \underset{(0.09)}{-\ 0.00}\ \Delta \ln(M_{t-1}^{EU3}) + \varepsilon_t^{m,US}$$

$$\Delta \ln(M_t^{EU3}) = \underset{(0.11)}{0.07}\ \Delta \ln(\mathrm{M}_{t-1}^{US}) \ \underset{(0.10)}{+\ 0.18}\ \Delta \ln(M_{t-1}^{EU3}) + \varepsilon_t^{m,EU3}$$

$$\sigma(\varepsilon_t^{m,US}) = 0.0106, \quad \sigma(\varepsilon_t^{m,EU3}) = 0.0119, \quad \rho(\varepsilon_t^{m,US}, \varepsilon_t^{m,EU3}) = \underset{(0.08)}{-0.02}$$

$$\ln(\theta_t^{US}) = \underset{(0.06)}{0.81}\ \ln(\theta_{t-1}^{US}) \ \underset{(0.06)}{-\ 0.03}\ \ln(\theta_{t-1}^{EU3}) + \varepsilon_t^{\theta,US}$$

$$\ln(\theta_t^{EU3}) = \underset{(0.05)}{0.09}\ \ln(\theta_{t-1}^{US}) \ \underset{(0.05)}{+\ 0.81}\ \ln(\theta_{t-1}^{EU3}) + \varepsilon_t^{\theta,EU3}$$

$$\sigma(\varepsilon_t^{\theta,US}) = 0.0063, \quad \sigma(\varepsilon_t^{\theta,EU3}) = 0.0054, \quad \rho(\varepsilon_t^{\theta,US}, \varepsilon_t^{\theta,EU3}) = \underset{(0.08)}{0.18}$$

$$\ln(\varphi_t) = \underset{(0.09)}{0.50} \ln(\varphi_{t-1}) + \varepsilon_t^{\varphi}, \quad \sigma(\varepsilon_t^{\varphi}) = 0.0330$$

Notes: An intercept was included in all regressions (a linear time trend was also included in regression equation for productivity). Figures in parentheses are standard errors. σ $[\rho]$: standard deviations of [correlations between] innovations. See Appendix for description of data.

Table 2. Historical statistics

	1959Q1-1970Q4		1973Q1-1994Q4	
	U.S.	EU3	U.S.	EU3
	(1)	*(2)*	*(3)*	*(4)*
Standard deviations (in %)				
GDP	1.22 (.10)	1.05 (.11)	1.82 (.22)	1.16 (.14)
Consumption	1.04 (.08)	1.18 (.13)	1.46 (.16)	0.88 (.08)
Investment	3.97 (.57)	4.83 (.51)	7.20 (.90)	5.05 (.63)
Net exports	6.10 (.78)	4.09 (.58)	7.93 (.80)	3.07 (.30)
Productivity	0.71 (.05)	0.87 (.11)	0.87 (.11)	0.63 (.05)
Money	0.87 (.10)	1.31 (.11)	2.36 (.39)	1.49 (.17)
Price level	0.62 (.10)	0.74 (.04)	1.67 (.26)	1.21 (.15)
Nominal interest rate	0.13 (.03)	0.16 (.03)	0.48 (.07)	0.35 (.04)
Nominal $ exchange rate	0.46 (.10)		8.75 (1.1)	
Real $ exchange rate	0.98 (.09)		8.11 (1.0)	
Cross-country correlations				
GDP	-0.18 (.15)		0.48 (.14)	
Consumption	-0.34 (.18)		0.30 (.18)	
Investment	-0.25 (.13)		0.27 (.19)	
Productivity	0.00 (.13)		0.28 (.1ý)	
Money	0.12 (.18)		0.04 (.18)	
Price level	0.16 (.22)		0.56 (.08)	
Nominal interest rate	0.54 (.10)		0.45 (.13)	
Correlation between nom. & real $ exchange rate				
	0.43 (.22)		0.99 (.00)	

Notes: The figures in parentheses are standard errors (obtained using GMM, assuming tenth-order serial correlation in residuals). All series were logged (with exception of interest rates) and HP filtered.

In Cols. 1,2 , doubly underlined statistics (══): difference compared to Bretton Woods statistics (Cols. 3, 4) significant at 1% level (two-sided test); once underlined statistics (──): difference significant at 10% level.

Table 3. Predictions of baseline floating exchange rate model

	Flexible prices				Sticky prices				Data, 73-94	
	Shocks to:				Shocks to:					
	M, M^*	θ, θ^*	φ	M, M^*, θ, θ^* & φ	M, M^*	θ, θ^*	φ	M, M^*, θ, θ^* & φ	*U.S.*	*EU3*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Standard deviations (in %)										
Y	0.00	0.96	0.02	0.96	1.95	0.39	0.01	1.99	1.82	1.16
C	0.00	0.63	0.13	0.64	1.21	0.27	0.02	1.24	1.46	0.88
I	0.00	3.32	0.78	3.41	7.57	1.28	0.13	7.68	7.20	5.05
NX	0.00	0.15	10.33	10.33	2.96	0.07	1.78	3.46	7.93	3.07
M	1.85	0.00	0.00	1.85	1.85	0.00	0.00	1.85	2.36	1.49
P	1.99	0.63	0.13	2.09	1.27	0.27	0.02	1.30	1.67	1.21
r	0.07	0.00	0.00	0.07	0.07	0.00	0.00	0.07	0.48	0.35
e	2.73	0.06	6.73	7.26	2.78	0.04	6.70	7.26	8.75	
RER	0.00	0.83	6.47	6.52	1.71	0.33	6.67	6.90	8.11	
Cross-country correlations										
Y	u	0.23	-1.00	0.23	0.08	0.36	-1.00	0.09	0.48	
C	u	0.25	-1.00	0.20	0.04	0.38	-1.00	0.05	0.30	
I	u	0.20	-1.00	0.14	0.04	0.35	-1.00	0.05	0.27	
M	0.04	u	u	0.04	0.04	u	u	0.04	0.04	
P	0.06	0.19	-1.00	0.07	0.06	0.38	-1.00	0.08	0.56	
r	0.25	u	u	0.25	0.25	u	u	0.25	0.45	
Correlation between e & RER										
	u	0.88	1.00	0.92	0.80	0.93	1.00	0.97	0.99	

Notes: **Y**: GDP (real); **C**: Consumption; **I**: investment; **M**: money supply; **P**: price level; **r**: nominal interest rate; **e/RER**: nominal/real exchange rate; **NX**: net exports (defined as Q_t^{m*}/Q_t^m, where Q_t^{m*} [Q_t^m] is an index of Foreign [Home] imports).

Cols. labeled "M, M^*", "θ, θ^*", "φ" pertain to cases in which shock just to Home and Foreign money, just to Home and Foreign productivity, and just to the UIP equation are assumed. Cols. labeled "$M, M^*, \theta, \theta^* \& \varphi$": all shocks used simultaneously. All series were logged (with exception of interest rates) and HP filtered.

Table 4. Predictions of pegged exchange rate model

	Shocks to: *M*		θ,θ^*		*UIP*		All Shocks		Data, 59-70	
	H	F	H	F	H	F	H	F	U.S.	EU3
	(1)	(2)	(3)	(4)	(5)	(6)	(9)	(10)	(11)	(12)
(a) Flexible prices										
Standard deviations (in %)										
Y	0.00	0.00	1.13	1.19	0.01	0.01	1.13	1.18	1.22	1.05
C	0.00	0.00	0.78	0.72	0.01	0.01	0.78	0.72	1.04	1.18
I	0.00	0.00	3.45	4.48	0.08	0.08	3.45	4.48	3.97	4.83
NX	0.00		0.36		1.12		1.18		6.10	4.09
M	1.24	1.24	0.00	0.16	0.00	3.57	1.24	3.78	0.87	1.31
P	1.36	1.36	0.78	0.77	0.01	0.72	1.57	1.72	0.62	0.74
r	0.06	0.06	0.00	0.00	0.00	0.56	0.06	0.57	0.20	0.16
e	0.00		0.00		0.00		0.00		0.46	
RER	0.00		1.23		0.70		1.42		0.98	
Cross-country correlations										
Y	u		-0.06		-1.00		-0.06		-0.18	
C	u		-0.07		-1.00		-0.07		-0.34	
I	u		-0.05		-1.00		-0.05		-0.25	
M	1.00		u		u		0.32		0.12	
P	1.00		-0.27		0.99		0.63		0.16	
r	1.00		u		u		0.11		0.54	
Correlation between nominal & real exchange rate										
	u		u		u		u		0.43	
(b) Sticky prices										
Standard deviations (in %)										
Y	1.33	1.33	0.61	0.15	0.02	1.05	1.46	1.71	1.22	1.05
C	0.81	0.81	0.44	0.09	0.00	0.65	0.92	1.04	1.04	1.18
I	5.09	5.09	1.86	0.56	0.01	4.08	5.42	6.55	3.97	4.83
NX	0.00		0.29		1.18		1.22		6.10	4.09
M	1.24	1.24	0.00	0.12	0.00	3.56	1.24	3.77	0.87	1.31
P	0.88	0.88	0.44	0.11	0.01	0.10	0.98	0.89	0.62	0.74
r	0.06	0.06	0.00	0.00	0.00	0.56	0.06	0.57	0.20	0.16
e	0.00		0.00		0.00		0.00		0.46	
RER	0.00		0.50		0.09		0.51		0.98	
Cross-country correlations										
Y	1.00		0.28		0.99		0.73		-0.18	
C	1.00		0.40		-0.73		0.69		-0.34	
I	1.00		0.13		-0.66		0.73		-0.25	
M	1.00		u		u		0.32		0.12	
P	1.00		-0.39		0.99		0.85		0.16	
r	1.00		u		u		0.11		0.54	
Correlation between nominal & real exchange rate										
	u		u		u		u		0.43	

Notes: **Columns labeled H [F]: statistics for Home [Foreign] economy.** Cols. labeled "Shocks to M", "Shocks to θ,θ^*", "Shocks to UIP" pertain, respectively, to cases in which just shocks to the Home money supply, just shocks to Home and Foreign productivity θ,θ^*, and just UIP shocks are assumed. Cols. labeled "All Shocks": all shocks used simultaneously. All series were logged (with exception of interest rates) and HP filtered. See Table 3 for definitions of variables.

Table 5. Baseline model: dynamic responses to 1% innovations

	Y	C	M	P	r	Y^*	C^*	M^*	P^*	r^*	e	RER	Exogenous variables
(a) Float, flexible prices													
(a1) Home money supply shock													M
τ=0	0.00	0.00	1.00	1.32	0.06	0.00	0.00	0.00	0.04	0.01	1.27	0.00	1.00
τ=5	0.00	0.00	1.40	1.41	0.00	0.00	0.00	0.05	0.05	0.00	1.35	0.00	1.40
(a2) Home productivity shock													θ
τ=0	1.36	0.89	0.00	-0.89	0.00	0.00	0.01	0.00	-0.01	0.00	0.07	0.95	1.00
τ=5	0.62	0.46	0.00	-0.46	0.00	0.09	0.06	0.00	-0.06	0.00	0.07	0.47	0.43
(a3) UIP shock													φ
τ=0	-0.00	-0.02	0.00	0.02	0.00	0.00	0.02	0.00	-0.02	0.00	1.95	1.92	1.00
τ=5	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	0.08	0.08	0.06
(b) Float, sticky prices													
(b1) Home money supply shock													M
τ=0	1.52	0.93	1.00	0.38	0.06	0.06	0.03	0.00	0.02	0.01	1.30	0.92	1.00
τ=5	0.41	0.31	1.40	1.09	0.00	0.01	0.02	0.05	0.05	0.00	1.37	0.32	1.40
(b2) Home productivity shock													θ
τ=0	0.20	0.18	0.00	-0.18	0.00	0.00	0.01	0.00	-0.01	0.00	0.04	0.21	1.00
τ=5	0.46	0.32	0.00	-0.32	0.00	0.06	0.05	0.00	-0.04	0.00	0.04	0.32	0.43
(b3) UIP shock													φ
τ=0	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	1.94	1.93	1.00
τ=5	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	0.06	0.06	0.06
(c) Peg, flexible prices													
(c1) Home money supply shock													M
τ=0	0.00	0.00	1.00	1.48	0.09	0.00	0.00	1.00	1.48	0.09	0.00	0.00	1.00
τ=5	0.00	0.00	1.62	1.63	0.00	0.00	0.00	1.62	1.63	0.00	0.00	0.00	1.62
(c2) Home productivity shock													θ
τ=0	1.30	0.91	0.00	-0.91	0.00	0.00	0.01	0.18	0.17	0.00	0.00	1.08	1.00
τ=5	0.99	0.75	0.00	-0.75	0.00	0.04	0.03	0.18	0.14	0.00	0.00	0.89	0.74
(c3) Foreign productivity shock													θ^*
τ=0	0.02	0.00	0.00	-0.00	0.00	1.42	0.87	-0.03	-0.91	0.00	0.00	-0.90	1.00
τ=5	-0.07	-0.05	0.00	0.05	0.00	0.01	0.03	-0.03	-0.06	0.00	0.00	-0.12	0.00
(c4) UIP shock													φ
τ=0	0.00	-0.01	0.00	0.01	0.00	0.00	0.01	6.45	1.39	-1.01	0.00	1.38	1.00
τ=5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	-0.01	0.00	0.01	0.01
(d) Peg, sticky prices													
(d1) Home money supply shock													M
τ=0	1.70	1.03	1.00	0.44	0.09	1.70	1.03	1.00	0.44	0.09	0.00	0.00	1.00
τ=5	0.48	0.36	1.62	1.26	0.00	0.48	0.36	1.62	1.26	0.00	0.00	0.00	1.62
(d2) Home productivity shock													θ
τ=0	0.18	0.23	0.00	-0.23	0.00	0.16	0.10	0.13	0.03	0.00	0.00	0.26	1.00
τ=5	0.74	0.55	0.00	-0.55	0.00	0.07	0.06	0.13	0.08	0.00	0.00	0.63	0.74
(d3) Foreign productivity shock													θ^*
τ=0	-0.00	-0.01	0.00	0.01	0.00	0.11	0.07	-0.01	-0.09	0.00	0.00	-0.10	1.00
τ=5	-0.05	-0.04	0.00	0.04	0.00	0.04	0.03	-0.01	-0.04	0.00	0.00	-0.08	-0.00
(d4) UIP shock													φ
τ=0	0.02	0.00	0.00	0.00	0.00	1.89	1.17	6.34	0.11	-1.01	0.00	0.11	1.00
τ=5	0.00	0.00	0.00	0.00	0.00	-0.09	-0.03	-0.01	0.00	0.00	0.00	0.00	0.00

Notes: Panels (a)-(d) pertain to these model variants: float under sticky prices; float, sticky prices; peg, flex-prices; peg, sticky prices. Effects of 1% innovations to Home money supply, M (see (*a1*), (*b1*), (*c1*),(*d1*)); to Home productivity, θ ((*a2*), (*b2*), (*c2*), (*d2*)); to UIP shock, φ ((*a3*), (*b3*), (*c4*), (*d4*)); and to Foreign productivity, θ^* ((*c3*), (*d3*)) are shown.

τ : periods after shock. Columns labeled Y, C etc. show responses of corresponding variables (see Table 3 for definitions of variables). The Table reports differences/relative deviations (that have been multiplied by 100, i.e. expressed in percentage terms) from "unshocked" path. Response of interest rates (r, r^*): differences from "unshocked" path; other responses: relative deviations from "unshocked" path.

Table 6. Predictions of floating rate model with 20% steady state imports/GDP ratio

	Flex. prices	Sticky prices
	(1)	(2)
Standard deviations (in %)		
Y	0.26	0.06
C	1.37	0.23
I	8.16	1.27
NX	12.32	2.07
P	1.37	0.23
r	0.00	0.00
e	6.69	6.65
RER	3.95	6.35
Correlation between e & RER		
	0.99	0.99

Notes: This Table assumes that there are just UIP shocks. See Table 3 for definitions of variables.