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SCIENCE DIRECT
Journal of International Money and Finance
24 (2005) 275–292
Journal of International Money and Finance
www.elsevier.com/locate/econbase

Macroeconomic effects of nominal exchange rate regimes: new insights into the role of price dynamics

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Abstract

This paper analyzes 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 rate parity condition. It captures the fact that the sharp increase in nominal exchange rate volatility after the end 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 GDP. This holds irrespective of whether flexible or sticky prices are assumed—which casts doubt on the widespread view that the roughly equal (post-BW) rise in nominal and real exchange rate volatility reflects price stickiness. A flex-prices variant of the model captures better the fact that the correlation between US and European GDP has been higher in the post-BW era than under BW.

JEL classification: E4; F3; F4

Keywords: Exchange rate regimes; Exchange rate volatility; Interest parity; Price dynamics

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doi:10.1016/j.jimonfin.2004.12.007

1. Introduction

Much research has been devoted to explaining the macroeconomic effects of exchange rate regimes. After the end of the Bretton Woods (BW) pegged-exchange rate system, the volatility of nominal and real exchange rates between the major currency blocs (US, Europe, Japan) rose sharply. 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 US 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 US and EU3 GDP was between 1% and 2%, in both eras; the US–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 the relevance of these facts for a central and controversial issue: the role of price stickiness in (international) macroeconomic models. The simultaneous rise in nominal and real exchange rate volatility after the end of the BW system, is widely viewed as reflecting price stickiness—and used to justify (Keynesian) sticky-prices 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 money supply, productivity and to the uncovered interest rate parity (UIP) condition–can capture the stylized facts described in the first paragraph. A sticky-prices variant accounts for the post-BW rise in nominal and real exchange rate volatility, but fails to explain the rise in the cross-country GDP correlation. Thus, the simultaneous rise in nominal and real exchange rate volatility after the BW era cannot be interpreted as evidence for price stickiness (flex- and sticky-prices variants both capture this phenomenon).

The widespread view described above seems to be based on the assumption that money shocks are the main source of real 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 failed (Rogoff (2000)). Also, structural models driven only by these fundamentals generate insufficient exchange rate volatility. This applies both to flex- and to sticky-prices models.[1]

[1] E.g., the Backus et al. (1995) flex-prices (RBC) model captures only 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).

In order to generate more realistic exchange rate volatility, this paper allows for UIP shocks; these shocks can be interpreted as reflecting transitory biases in households' exchange rate forecasts. Variants of the model with a pegged and with a floating exchange rate are calibrated to the US and the EU3. I document 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 and a sticky-prices version are compared. The latter assumes Calvo (1983) staggered price setting; the mean lag 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. Predicted real exchange rate volatility is markedly higher under the float than under the peg. The floating-rate variant (with post-BW UIP shocks) captures about 80% of the standard deviations of post-BW nominal and real US–EU3 exchange rates. In the model, nominal exchange rate movements induced by UIP shocks have only a limited effect on national price levels, due to the small volume of US–EU3 trade (about 1% of GDP); 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 GDP. The model thus captures the fact that the sharp rise in exchange rate volatility after the end of BW did not greatly affect the volatility of US and EU3 GDP. These results hold irrespective of whether sticky or flexible prices are assumed.

By contrast, flex- and sticky-prices model versions yield sharply differing predictions regarding the effect of the exchange rate regime on the cross-country GDP correlation. Monetary policy affects output under sticky prices, but is neutral under flexible prices. As a peg requires international synchronization of monetary policy, the sticky-prices version predicts that the cross-country GDP correlation is higher under a peg than under a float. That prediction is inconsistent with the finding that the US–EU3 GDP correlation was lower under BW. Flex-prices variants of the model, by contrast, capture that finding, provided the calibration takes into account the fact that US and EU3 productivity innovations were negatively correlated under BW, but positively correlated after BW.

The work here is related to the Keynesian literature of the 1960s to 1980s that analyzed exchange rate pegs and floats (e.g., Mundell, 1968); this literature predicted that the exchange rate regime affects real variables, but provided only limited quantitative results. It also lacked the micro-foundations that characterize modern DGE macro models. The recent open economy DGE literature typically assumes a floating exchange rate. Exceptions include Bacchetta and van Wincoop (2000), Obstfeld and Rogoff (2000) and Devereux and Engel (2003) who compare the welfare effects of pegs and floats, using highly stylized sticky-prices models (with closed form solutions) that generate insufficient exchange rate volatility. In contrast, the paper here presents a positive analysis of the BW/post-BW regimes, based on a quantitative business cycle model with realistic exchange rate volatility.[2]

2. The model

There are two countries, "Home" and "Foreign". In each country there are: a household; a central bank that issues a national currency; monopolistic competitors that produce a continuum of tradable intermediate goods indexed by $s \in [0,1]$, using *domestic* capital and labor (immobile internationally); competitive firms that bundle domestic and imported intermediates into a non-tradable final consumption/investment good. Each household owns the domestic producers and domestic capital (which it rents to firms), and it supplies labor. Markets for rental capital and labor are competitive. Preferences and technologies are symmetric across countries. An asterisk denotes Foreign variables. The following description focuses on the Home country.

2.1. Final good production

The Home final good is produced using the aggregate technology

$$Q_t = \left\{ (\alpha^{\mathrm{d}})^{1/\vartheta} (Q_t^{\mathrm{d}})^{(\vartheta-1)/\vartheta} + (\alpha^{\mathrm{m}})^{1/\vartheta} (Q_t^{\mathrm{m}})^{(\vartheta-1)/\vartheta} \right\}^{\vartheta/(\vartheta-1)}, \quad \text{with } \alpha^{\mathrm{d}}, \alpha^{\mathrm{m}} > 0,\ \alpha^{\mathrm{d}} + \alpha^{\mathrm{m}} = 1,\ \vartheta > 0.$$

Q_t is date t final good output. Q_t^{d} $[Q_t^{\mathrm{m}}]$ is a quantity index of domestic [imported] intermediate goods: $Q_t^i = \{\int_0^1 q_t^i(s)^{(\nu-1)/\nu}\, \mathrm{d}s\}^{\nu/(\nu-1)}$, with $\nu > 1$, for $i = \mathrm{d}, \mathrm{m}$ where $q_t^{\mathrm{d}}(s)$ and $q_t^{\mathrm{m}}(s)$ are quantities of the domestic and imported type s intermediates. Let $p_t^{\mathrm{d}}(s)$, $p_t^{\mathrm{m}}(s)$ be the Home currency prices of these goods. Cost minimization in final good production gives: $q_t^i(s) = (p_t^i(s)/P_t^i)^{-\nu} Q_t^i$, $Q_t^i = \alpha^i (P_t^i/P_t)^{-\vartheta} Q_t$, for $i = \mathrm{d}, \mathrm{m}$, with $P_t^i = \{\int_0^1 p_t^i(s)^{1-\nu}\, \mathrm{d}s\}^{1/(1-\nu)}$; $P_t = \{\alpha^{\mathrm{d}} (P_t^{\mathrm{d}})^{1-\vartheta} + \alpha^{\mathrm{m}} (P_t^{\mathrm{m}})^{1-\vartheta}\}^{1/(1-\vartheta)}$. P_t^{d} $[P_t^{\mathrm{m}}]$ is the price index for domestic [foreign] intermediates sold in the Home market. The price of the Home final good is P_t (its marginal cost).

[2] Several recent papers discuss calibrated open economy sticky-prices DGE models, but those studies focus on the post-BW era (see Collard and Dellas (2002) for references). With the exception of McCallum and Nelson (1999) and Kollmann (2002, 2004a)–who assume UIP shocks–these models markedly underpredict post-BW exchange rate volatility, which casts doubt on their relevance for analyzing the effects of a float on nominal/real exchange rates and economic fluctuations. The last remark also applies to Dedola and Leduc (2001), Duarte (2003), Monacelli (2004) and Sopraseuth (2003) who (like the paper here) use calibrated DGE models to compare floats and pegs (I received those papers after the framework here had been developed); these authors consider a smaller set of business cycle statistics than the paper here, do not allow for UIP shocks, and claim that price stickiness is necessary for explaining BW vs. post-BW exchange rate facts.

2.2. Intermediate goods producers

The technology of the firm that produces intermediate good s, in the Home country, is:

$$y_t(s) = \theta_t(\mathcal{K}_t(s))^{\psi}(\mathcal{L}_t(s))^{1-\psi}, \quad 0<\psi<1.$$

$y_t(s)$ is the firm's output at date t. θ_t is an exogenous productivity parameter (common to all Home intermediates' producers). $\mathcal{K}_t(s)$ $[\mathcal{L}_t(s)]$ is the capital [labor] used by the firm. Its marginal cost is: $\mathrm{MC}_t = (1/\theta_t)R_t^{\psi}W_t^{1-\psi}\psi^{-\psi}(1-\psi)^{\psi-1}$, where R_t $[W_t]$ is the rental rate of capital [wage rate]. The firm's good is sold in the domestic market and exported: $y_t(s) = q_t^{\mathrm{d}}(s) + q_t^{\mathrm{m}^*}(s)$, where $q_t^{\mathrm{d}}(s)$ $\left[q_t^{\mathrm{m}^*}(s)\right]$ is domestic [export] demand. Its profit is: $\pi_t(p_t^{\mathrm{d}}(s), p_t^{\mathrm{m}^*}(s)) = (p_t^{\mathrm{d}}(s) - \mathrm{MC}_t)q_t^{\mathrm{d}}(s) + (e_t p_t^{\mathrm{m}^*}(s) - \mathrm{MC}_t)q_t^{\mathrm{m}^*}(s)$, where e_t is the nominal exchange rate (Home currency price of Foreign currency).

Intermediate goods firms price-discriminate between domestic and export markets. Quantitative sticky-prices open economy models typically assume price setting in buyer currency (''pricing-to-market'', PTM); see, e.g., Kollmann (2001a,b). The sticky-prices version of the model here too postulates PTM; it assumes that the prices of intermediates are set in a staggered fashion, à la Calvo (1983): intermediate goods 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 $1-\mathfrak{d}$, a constant. Firms are assumed to meet all demand at posted price. They maximize the value of their profit stream, subject to the restriction on price adjustment that was just described. Derivations of the firms' price setting equations can be found in the working paper version of this paper (Kollmann, 2004b).

2.3. The representative household

The preferences of the Home household are described by:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, \mathcal{M}_t/P_t, L_t), \quad \text{with } 0<\beta<1. \tag{1}$$

C_t $[L_t]$ is consumption [labor effort]. $\mathcal{M}_t$ are the household's nominal balances at the end of period t. U is a utility function given by: $U(C,M/P,L) = \ln\{[C^{\sigma} + \kappa(M/P)^{\sigma}]^{1/\sigma}\} - L$ with $\sigma<1$, $\kappa>0$. The Home household accumulates Home physical capital, subject to the law of motion

$$K_{t+1} + \phi(K_{t+1}, K_t) = K_t(1-\delta) + I_t, \tag{2}$$

where I_t is gross investment, $0<\delta<1$ is the depreciation rate of capital, and ϕ is an adjustment cost function: $\phi(K_{t+1}, K_t) = (1/2)\Phi\{K_{t+1} - K_t\}^2/K_t$, $\Phi>0$. The household holds nominal one-period Home and Foreign currency bonds. Its period t budget constraint is:

$$\mathcal{M}_t + A_t + e_t B_t + P_t(C_t + I_t) = \mathcal{M}_{t-1} + T_t + A_{t-1}(1+r_{t-1}) + e_t B_{t-1}\left(1+r_{t-1}^*\right) + R_t K_t + \int_0^1 \pi_t(s)\,\mathrm{d}s + W_t L_t. \tag{3}$$

A_{t-1} and B_{t-1} are stocks of Home and Foreign currency bonds that mature in period t. r_t and r_t^* are the interest rates on these bonds. T_t is a government cash transfer.

The household chooses $\{\mathcal{M}_t, A_t, B_t, K_{t+1}, C_t, L_t\}_{t=0}^{\infty}$ to maximize expression (1), subject to constraints (2) and (3). The following equations are first-order conditions of this problem:

$$1=(1+r_t)E_t\{\rho_{t,t+1}(P_t/P_{t+1})\}, \tag{4}$$

$$1=(1+r_t^*)E_t\{\rho_{t,t+1}(P_t/P_{t+1})(e_{t+1}/e_t)\}, \tag{5}$$

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

$$U_{m,t}=(r_t/(1+r_t))U_{C,t}, \quad W_t/P_t=1/U_{C,t}, \tag{6}$$

where, $U_{C,t}\equiv\partial U(C_t,\ldots)/\partial C_t$, $U_{m,t}=\partial U(C_t,\ldots)/\partial(\mathcal{M}_t/P_t)$, $\phi_{1,t}\equiv\partial\phi(K_{t+1},K_t)/\partial K_{t+1}$, $\phi_{2,t}\equiv\partial\phi(K_{t+1},K_t)/\partial K_t$.

2.4. Uncovered interest parity

Up to a (log-)linear approximation, Eqs. (4) and (5) imply uncovered interest parity, UIP: $E_t \ln(e_{t+1}/e_t)=r_t-r_t^*$. Given the well-documented strong departures from UIP (Lewis, 1995), I assume that the Home Euler condition for Foreign currency bonds (5) is disturbed by a stationary exogenous shock, φ_t (UIP shock):

$$1=\varphi_t(1+r_t^*)E_t\rho_{t,t+1}(P_t/P_{t+1})(e_{t+1}/e_t). \tag{5a}$$

(Log-) linearizing Eqs. (4) and (5a) yields:

$$E_t \ln(e_{t+1}/e_t)=r_t-r_t^*-\ln(\varphi_t). \tag{7}$$

φ_t can be interpreted as reflecting a bias in the household's date t forecast of the $t+1$ exchange rate.[3]

2.5. Monetary policy

Let M_t be the Home money supply 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. Under the peg, Home money is exogenous, while the Foreign money supply is set at

[3] Home and Foreign households make identical forecasts. Let household *beliefs* at t about e_{t+1} be 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 Eq. (5a). Eq. (7) is also implied by a (log-) linear approximation of the Foreign household's counterparts of Eqs. (4) and (5a).

values that keep the nominal exchange rate constant through time; in the floating-rate regime, by contrast, both countries' money stocks are exogenous.

2.6. Market clearing conditions

Markets for intermediates clear as intermediate goods firms meet all demand at posted prices. Market clearing in Home final good, labor, and rental capital markets requires: $Z_t = C_t + I_t$, $L_t = \int_0^1 \mathcal{L}_t(s)\,\mathrm{d}s$, and $K_t = \int_0^1 \mathcal{K}_t(s)\,\mathrm{d}s$. Bond market clearing requires: $A_t + A_t^* = 0, B_t + B_t^* = 0$. A country's currency is only held by its residents; Home money market equilibrium requires, thus: $M_t = \mathcal{M}_t$.

2.7. Exogenous variables

Productivity and the UIP shock follow these processes:

$$z_t^\theta = R^\theta z_{t-1}^\theta + \varepsilon_t^\theta, \quad \text{for } z_t^\theta \equiv \left(\ln(\theta_t), \ln\left(\theta_t^*\right)\right)' \tag{8}$$

$$\ln(\varphi_t) = \rho^\varphi \ln(\varphi_{t-1}) + \varepsilon_t^\varphi. \tag{9}$$

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

$$\ln(M_t/M_{t-1}) = \rho^m \ln(M_{t-1}/M_{t-2}) + \varepsilon_t^m. \tag{10}$$

Under the float, the law of motion of Home and Foreign money is:

$$z_t^\mu = R^\mu z_{t-1}^\mu + \varepsilon_t^\mu, \quad \text{for } z_t^\mu \equiv \left(\ln(M_t/M_{t-1}), \ln\left(M_t^*/M_{t-1}^*\right)\right)'. \tag{11}$$

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

2.8. Parameters, solution method

I calibrate the model to quarterly data for the US and an aggregate of Germany, France and Italy (EU3). The ratio of US imports from the EU3 divided by US GDP averaged 0.4% [1%] in the BW [post-BW] period; the average ratio of EU3 imports from the US divided by EU3 GDP was 1.2% [1%] during BW [post-BW]. I thus set α^{m} so that each country's imports/GDP ratio is 1%.

I set $\beta = 0.99$, $1/(\nu - 1) = 0.2$, $\vartheta = 0.75$, $\psi = 0.2$, $\Phi = 6$, $\delta = 0.025$, $\sigma = -18.8$.[4] I consider a variant of the model with a mean price-change interval $(1/(1-\mathfrak{d}))$ of four

[4] These parameters are standard in business cycle models; the key results are robust to changes in these parameters. Here, I just discuss money demand parameters. Eq. (6) gives $\mathcal{M}_t/P_t = C_t\left(r_t(1+r_t)^{-1}\kappa^{-1}\right)^{1/(\sigma-1)}$. $\sigma = -18.8$ implies that the interest rate elasticity of money demand (at steady state) is -0.05 (a standard value). $\kappa > 0$ determines the velocity of money—results not sensitive to κ. I set κ at a very small number, which implies that changes in real balances have no (perceptible) effect on the marginal utility of consumption, and that money is (essentially) neutral under flexible prices. See Kollmann (2004b) for further details.

quarters, $\mathfrak{d}=0.75$ (a value widely used in New Keynesian models; e.g., Erceg et al. (2000)), and a flex-prices variant, $\mathfrak{d}=0$.

Estimates of the forcing processes (8)–(11) for 1959–1970 and 1973–1994 (quarterly data) are shown in Table 1. These estimates are used to calibrate the pegged- and floating exchange rate structure, respectively. The forcing processes have differed markedly across the two periods. Note, especially, that the correlation between US and EU3 productivity innovations was negative in the BW era (−0.28) and positive in the post-BW era (0.18). The autocorrelation of UIP shocks and the standard deviation of innovations to UIP shocks were 0.24 and 0.58%, respectively, during 1959–1970, compared to 0.50 and 3.30% during 1973–1994.[5] As might be expected, UIP shocks have thus been more persistent and much more volatile in the post-BW period (clearly there is much more scope for irrational exchange rate forecasts under a float than under a peg).

The autocorrelation of US money growth was the same during both periods (0.39), but the standard deviation of US money innovations was higher in the post-BW era. Spillovers between post-BW US and EU3 money supply processes were weak, and the correlation between US and EU3 post-BW money innovations was close to zero.

The estimated post-BW productivity and money processes are roughly symmetric across countries; for simplicity, the floating-rate structure uses 'symmetrized' versions of those processes:

$$R^{\theta}=\begin{bmatrix}0.81 & 0.03\\ 0.03 & 0.81\end{bmatrix},\quad E_t\varepsilon_t^{\theta}\varepsilon_t^{\theta'}=0.0058^2\begin{bmatrix}1.00 & 0.18\\ 0.18 & 1.00\end{bmatrix},$$
$$R^{\mu}=\begin{bmatrix}0.29 & 0.03\\ 0.03 & 0.29\end{bmatrix},\quad E_t\varepsilon_t^{\mu}\varepsilon_t^{\mu'}=0.0112^2\begin{bmatrix}1.00 & -0.02\\ -0.02 & 1.00\end{bmatrix}.$$

An approximate model solution is obtained by linearizing the model around a deterministic steady state that is symmetric across countries, and in which each country's net stock of foreign currency bonds is zero.

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

Table 2 reports statistics on key US and EU3 quarterly time series for the periods 1959–1970 and 1973–1994. The EU3 series are weighted averages of German, French and Italian data. All series have been logged, with the exception of interest rates, and 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% in the post-BW era. The nominal–real exchange

[5] 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 variables known at t (lags 1–4 of $\ln(\varphi_t')$; US and EU3 interest rates, inflation, detrended GDP at $t, \ldots, t-4$); Eq. (9) was estimated using the fitted $\ln(\varphi_t')$ series.

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

(a) 1959:Q1–1970:Q4

$$\begin{bmatrix}\ln(\theta_t^{US})\\ \ln(\theta_t^{EU3})\end{bmatrix}=\begin{bmatrix}0.93 & -0.04\\ 0.03 & 0.17\end{bmatrix}\begin{bmatrix}\ln(\theta_{t-1}^{US})\\ \ln(\theta_{t-1}^{EU3})\end{bmatrix}+\begin{bmatrix}\varepsilon_t^{US}\\ \varepsilon_t^{EU3}\end{bmatrix}$$

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

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

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

(b) 1973:Q1–1994:Q4

$$\begin{bmatrix}\ln(\theta_t^{US})\\ \ln(\theta_t^{EU3})\end{bmatrix}=\begin{bmatrix}0.81 & -0.03\\ 0.09 & 0.81\end{bmatrix}\begin{bmatrix}\ln(\theta_{t-1}^{US})\\ \ln(\theta_{t-1}^{EU3})\end{bmatrix}+\begin{bmatrix}\varepsilon_t^{US}\\ \varepsilon_t^{EU3}\end{bmatrix}$$

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

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

$$\begin{bmatrix}\Delta\ln(M_t^{US})\\ \Delta\ln(M_t^{EU3})\end{bmatrix}=\begin{bmatrix}0.39 & 0.00\\ 0.07 & 0.18\end{bmatrix}\begin{bmatrix}\Delta\ln(M_{t-1}^{US})\\ \Delta\ln(M_{t-1}^{EU3})\end{bmatrix}+\begin{bmatrix}\varepsilon_t^{m,US}\\ \varepsilon_t^{m,EU3}\end{bmatrix}$$

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

Notes: An intercept was included in all regressions (linear time trend also included in regression equation for productivity). σ [ρ]: standard deviations of [correlations between] innovations. The data are quarterly. M_t: money supply (M1). θ_t: productivity; $\ln(\theta_t)=\ln(Y_t)-0.2\ln(K_t)-0.8\ln(L_t)$, where Y_t, K_t and L_t are GDP, capital and labor, respectively (EU3 series for 1959–1970: $\ln(\theta_t)=\ln(Y_t)-0.8\ln(L_t)$, due to lack of data on K_t); the weight on log capital (0.2) equals value in model. US labor series: total employee hours; EU3 labor series for 1959–1970 and 1973–95 represent total employment and total hours worked, respectively. See Table 2 and Kollmann (2004b) for further information on data.

rate correlation was 0.99 in the post-BW era—markedly higher than under BW (0.43). In the post-BW era, nominal and real exchange rates have been much more volatile than GDP, money and the price level.

(2) Standard deviations of money stocks, price levels and interest rates were higher in the post-BW era (than under BW), especially in the US. The volatility of EU3 real activity shows no systematic differences across the two eras, but the standard deviation of US GDP was higher in the post-BW period (1.22% [1.82%] in BW [post-BW] era).

(3) Cross-country correlations of real macro aggregates and 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).

(Similar stylized facts hold also for other OECD countries—see, e.g., Mussa (1986), Baxter and Stockman (1989), Backus et al. (1995).)

Table 2
Historical statistics

	1959Q1–1970Q4		1973Q1–1994Q4	
	US	EU3	US	EU3
	(1)	(2)	(3)	(4)
Standard deviations (in %)				
GDP	1.22 (0.10)	1.05 (0.11)	1.82* (0.22)	1.16 (0.14)
Consumption	1.04 (0.08)	1.18 (0.13)	1.46* (0.16)	0.88* (0.08)
Investment	3.97 (0.57)	4.83 (0.51)	7.20** (0.90)	5.05 (0.63)
Net exports	6.10 (0.78)	4.09 (0.58)	7.93 (0.80)	3.07 (0.30)
Money	0.87 (0.10)	1.31 (0.11)	2.36** (0.39)	1.49 (0.17)
Price level	0.62 (0.10)	0.74 (0.04)	1.67** (0.26)	1.21** (0.15)
Nominal interest rate	0.13 (0.03)	0.16 (0.03)	0.48** (0.07)	0.35** (0.04)
Nominal $ exchange rate	0.46 (0.10)		8.75** (1.1)	
Real $ exchange rate	0.98 (0.09)		8.11** (1.0)	
Cross-country correlations				
GDP	−0.18 (0.15)		0.48** (0.14)	
Consumption	−0.34 (0.18)		0.30* (0.18)	
Investment	−0.25 (0.13)		0.27 (0.19)	
Money	0.12 (0.18)		0.04 (0.18)	
Price level	0.16 (0.22)		0.56* (0.08)	
Nominal interest rate	0.54 (0.10)		0.45 (0.13)	
Correlation between nominal and real $ exchange rate	0.43 (0.22)		0.99** (0.00)	

Notes: The figures in parentheses are standard errors (GMM-based, assuming tenth-order serial correlation in residuals). All series were logged (with exception of interest rates) and HP filtered. In Cols. 3, 4, **statistics marked with two stars** (**): difference compared to Bretton Woods statistics (Cols. 1, 2) significant at 1% level (two-sided test); **statistics marked with one star** (*): difference significant at 10% level.
The data are quarterly (see Kollmann (2004b) for data sources). **Consumption**: total private consumption. **Investment**: gross fixed capital formation plus change in inventories. **Net exports**: ex/im, where ex (im) is volume of exports (imports) of goods and services. **Money**: M1. **Price level**: CPI. **Nominal interest rate**: short term rate (quarterly basis). **Nominal exchange rate**: bilateral US dollar rate. **Real exchange rate**: CPI based. 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). German series are for West Germany.

4. Model predictions

Model predictions are shown in Tables 3–5. Predicted statistics pertain to variables that have been logged (with the exception of interest rates) and HP filtered.

4.1. Floating exchange rate

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

Money supply shocks have no effect on real variables when prices are flexible (Col. 1). In contrast, their effect on real variables is noticeable, under sticky prices (Col. 5)—predicted standard deviations of (real) GDP (Y_t) and the real exchange rate $\left(\text{RER}_t \equiv e_t P_t^* / P_t\right)$, and cross-country GDP correlation: 1.95%, 1.71% and 0.08%, respectively. The *predicted* standard deviation of the nominal exchange rate (induced by money shocks), 2.7%, is roughly the same under flex- and sticky prices. With the exception of the predicted standard deviation of GDP, these statistics are markedly below the corresponding empirical post-BW statistics.

Panels (a) and (b) of Table 5 show dynamic responses to a positive Home money supply shock (under float). The shock induces a nominal exchange rate depreciation

Table 3
Predictions of floating exchange rate model

	Flexible prices				Sticky prices				Data, 73-94	
	Shocks to:				Shocks to:					
	M,M^*	θ,θ^*	φ	M,M^*, $\theta,\theta^*\&\varphi$	M,M^*	θ,θ^*	φ	M,M^*, $\theta,\theta^*\&\varphi$	*US*	*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 nominal & real exchange rate										
	u	0.88	0.99	0.92	0.80	0.93	0.99	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). u: correlation not defined (series with zero variance).

Cols. labeled "M,M^*", "θ,θ^*", "φ" pertain to cases in which shocks 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	US	EU3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(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 "M,M^*", "θ,θ^*", "φ" pertain to cases in which shocks 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. u: correlation not defined (series with zero variance). All series were logged (with exception of interest rates) and HP filtered. See Table 3 for definitions of variables.

and an increase in the Home price level (measured by the final good price, P_t). Price stickiness dampens the price level response. Under sticky prices, a positive Home money shock triggers a *real* depreciation of the Home currency, and a fall in the Home real interest rate, which induces a rise in Home consumption, investment and GDP; Foreign GDP increases likewise (as Home demand for Foreign goods rises), though by markedly less than Home GDP; this explains why the cross-country GDP correlation (induced by money shocks) is close to zero (see above).

Productivity shocks have a non-negligible effect on GDP, but only a very weak effect on the nominal exchange rate. Under flexible prices, the predicted standard deviations of GDP, the nominal exchange rate and 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 GDP and the real exchange rate (Col. 6). With just productivity shocks, the floating exchange rate variant 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 in 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: with just UIP shocks, the predicted standard deviations of nominal and real exchange rates are about 6.5%—and that under both flexible and sticky prices. By contrast, UIP shocks have only a minor effect on the other variables considered in Table 3, with the exception of net exports.

Table 5 shows that a 1% UIP shock induces a depreciation of the Home currency by about 2%, on impact (under float). That depreciation raises the Home import price index P_t^{m}, which increases the Home price level P_t; however, the response of P_t is weak (less than 0.03%), as the weight of import prices in the domestic price index, which equals the steady state imports/GDP ratio (1%), is low. (Foreign responses to UIP shocks are mirror images of Home responses.) This implies that the real exchange rate tracks very closely the nominal rate, when there are just UIP shocks—both under flexible and sticky prices (in both cases, predicted nominal–real exchange rate correlation: 0.99). The low trade share also explains why the sizable exchange rate movements induced by UIP shocks have little effect on GDP and consumption.

When the *three types of shock* are used simultaneously (Table 3; Cols. 4, 8), the flex- and sticky-prices variants of the floating-rate model generate predicted standard deviations of nominal and real exchange rates of about 7%—both variants capture, thus, about 80% of the standard deviations of post-BW US–EU3 nominal and real exchange rates. Both variants yield high nominal–real exchange rate correlations (0.97 [0.92] under sticky prices [flex-prices]). Regarding the predicted standard deviations of real activity, both variants seem broadly consistent with the post-BW data, but underpredict the correlation between US and EU3 GDP, 0.48 (the

Table 5
Predicted 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
$\tau=0$	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
$\tau=5$	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
$\tau=0$	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
$\tau=5$	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
$\tau=0$	−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
$\tau=5$	−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
$\tau=0$	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
$\tau=5$	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
$\tau=0$	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
$\tau=5$	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
$\tau=0$	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
$\tau=5$	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
$\tau=0$	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
$\tau=5$	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
$\tau=0$	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
$\tau=5$	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^*
$\tau=0$	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
$\tau=5$	−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
$\tau=0$	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
$\tau=5$	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
$\tau=0$	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
$\tau=5$	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
$\tau=0$	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
$\tau=5$	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^*
$\tau=0$	−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
$\tau=5$	−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
$\tau=0$	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
$\tau=5$	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 flex-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.

predicted cross-country GDP correlation is higher under flexible prices, 0.23, than under sticky prices, 0.09).[6]

The substantial variability of real exchange rates since the end of the BW system, and the high correlation between post-BW nominal and real exchange rates, are widely viewed as reflecting price stickiness—and used to justify sticky-prices models (e.g., Mussa, 1986, 1990; Dornbusch and Giovannini, 1990; Caves et al., 1993; Obstfeld and Rogoff, 1996). The results here cast doubt on this view—as sticky- and flex-prices variants of the present model both capture these facts. This view seems to be based on the assumption that money shocks are the main source of exchange rate fluctuations (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 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 both sticky and flexible prices. Hence, the high post-BW nominal–real exchange rate volatility does not permit to draw conclusions regarding price stickiness.

4.2. Pegged-exchange rate

Table 4 shows results for the model variant with a pegged-exchange rate. Under the peg, *Home money shocks* induce a response of Foreign money that mimics perfectly the path of Home money (see Panels (c), (d) in Table 5). Under sticky prices, GDP, consumption and investment are thus perfectly correlated across countries, when there are just Home money shocks (Panel (b), Table 4). With just *productivity shocks*, the predicted cross-country GDP correlation is *negative* (−0.06), when prices are flexible (because the cross-country correlation of productivity innovations is assumed to be negative in the pegged-rate structure); by contrast, the cross-country correlation is positive (0.28) 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 GDP increase thus, in response to that shock—see Table 5). In the pegged-exchange rate regime, *UIP shocks* induce significant responses of the Foreign money supply, to stabilize the nominal exchange rate; with sticky prices, these responses have a noticeable effect on Foreign real activity; 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 model than in the floating-rate model—recall that UIP shocks are much weaker in the pegged-rate variant. (If under the peg, there were UIP shocks comparable to those under the

[6] Across the US and EU3, the average post-BW standard deviations of GDP, consumption and investment are 1.4%, 1.1% and 6.1%, respectively. The flex- and sticky-prices variants capture equally closely the (average) volatility of Y. The sticky-prices variant captures somewhat better the volatility of C and I.

float, then the predicted standard deviation 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 post-BW variability). This is so irrespective of whether flexible or sticky prices are assumed. However, the sticky-prices version of the pegged-exchange rate model generates a high positive cross-country GDP correlation (0.73)—while the actual cross-country correlation was negative in the BW era (−0.18). The flex-prices version of the pegged-rate model, by contrast, generates a negative cross-country GDP correlation (−0.06).

Acknowledgement

I thank two referees for suggestions. Thanks for useful discussions are due to workshop participants at the ECB, Bank of Portugal, Bank of Spain, University of Crete, AEA and SED meetings, North American meetings of the Econometric Society, as well as to G. Benigno, M. Chinn, R. Cumby, H. Dellas, M. Devereux, C. Engel, C. Erceg, O. Jeanne, G. Kouretas, and P. Teles.

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