

The dynamics of the real exchange rate: a Bayesian DSGE approach

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Plan of the presentation

- Motivation and objective
- The dynamics of the real exchange rate
- Brief description of the model
- Estimation results and moments matching
- Decomposition of the real exchange rate dynamics
- Conclusions

Motivation (1)

- Real exchange rate is a key relative price in international macroeconomics
- Stylized facts have proved quite difficult to explain (for example Meese and Rogoff, 1983, Backus and Smith, 1993 and Chari, Kehoe and McGrattan, 2002)
- Large and persistent fluctuations are evidence of failure of the purchasing power parity condition; They do not translate into import and consumer prices (incomplete pass-through)
- Negative correlation between the real exchange rate and relative consumption is evidence of market incompleteness: Difficult to replicate with DSGE models

Motivation (2)

- The ability of a model to match selected second moments depend on parameter values: e.g. risk aversion, price rigidity and the elasticity between home and foreign traded goods (CKM, 2002, CDL, 2006, BT, 2005)
- **Our objective:** Estimate a model to evaluate its ability to match stylized facts regarding the RER and understand which features of the model and which shocks are important
- Lubik and Schorfheide (2005), Rabanal and Tuesta (2005), de Walque, Smets and Wouters (2006) all estimate 2C NOEM models. None of them consider nontraded goods

The dynamics of the real exchange rate (1)

- Chari *et al.* (2002): The fraction of the variance of the real exchange rate between US and Europe due to the relative prices of nontraded to traded goods is very small. Similar results in Engle (1999)
- The traded goods based real exchange rate explains the dynamics of the CPI based real exchange rate
- Burstein *et al.* (2005): Changes in the price of nontraded relative to traded goods account for 50 percent of the movements in real exchange rates for some of the OECD countries

The dynamics of the real exchange rate (3)

- The real exchange rate of one country (for example the home country) can be defined as:

$$RS_t \equiv \frac{S_t P_t^*}{P_t}$$

- The consumption price index is defined as:

$$P_t^* = \left[a_T P_{T,t}^{*1-\phi} + (1 - a_T) P_{N,t}^{*1-\phi} \right]^{\frac{1}{1-\phi}} \quad \phi > 0$$

- The price index of traded goods is defined as:

$$P_{T,t}^* = \left[(1 - a_H) P_{H,t}^{*1-\rho} + a_H P_{F,t}^{*1-\rho} \right]^{\frac{1}{1-\rho}} \quad \rho > 0$$

The dynamics of the real exchange rate (4)

- Decomposition of the changes in the real exchange rate into its components (Benigno and Thoenissen, 2003)

$$\begin{aligned}\Delta RS_t = & (1 - a_T)(\pi_{N,t}^* - \pi_{T,t}^*) - (1 - a_T)(\pi_{N,t} - \pi_{T,t}) + \\ & a_H (\Delta S_t + \pi_{F,t}^* - \pi_{F,t}) + (1 - a_H) (\Delta S_t + \pi_{H,t}^* - \pi_{H,t}) + \\ & (2a_H - 1)(\pi_{F,t} - \pi_{H,t})\end{aligned}$$

- First two terms represent, respectively, the home and foreign internal real exchange rate
- Third and fourth capture international price discrimination
- Last term represents the home bias component of the real exchange rate

The model

- The model is based on Corsetti, Dedola and Leduc (2006)
- Main features are:
 - international price discrimination
 - distributions costs for traded goods (intensive in local non-traded goods)
 - sticky prices and nominal wages
 - home bias in consumption preferences
 - incomplete financial markets at the international level
 - systematic monetary policy

The model: the nontraded goods sector

- We assume monopolistic competition and costly price adjustment (Rotemberg, 1996)

$$AC_{N,t}^p(n) = \frac{\kappa_N^p}{2} \left(\frac{p_t(n)}{p_{t-1}(n)} \right)^2 D_{N,t}$$

Note that demand for nontraded goods come also from the traded goods sector

The model: price discrimination and distribution costs

- In our model the law of one price does not hold because of two assumptions: the presence of distribution costs and different degree of nominal rigidities (LCP)
- Bringing one unit of traded goods to consumers in the each country requires local nontraded goods (Corsetti and Dedola, 2004):

$$P_t^H = \bar{P}_t^H + \eta P_t^N$$

- International price discrimination can be the result of either different degree of price rigidity or different price for nontraded goods in the two countries

The model: incomplete markets

- Incomplete financial markets, preference shocks and UIP shocks help in generating the Backus-Smith correlation
- A modified uncovered interest parity condition holds:

$$E_t \hat{S}_{t+1} - \hat{S}_t = \hat{R}_t - \hat{R}_t^* + \kappa_0 \hat{b}_t - \hat{z}_{u,t}$$

- The condition can be expressed in the following form:

$$E_t [\widehat{RS}_{t+1} - \widehat{RS}_t] = E_t [\sigma_C(\hat{C}_{t+1} - \hat{C}_t) - (\hat{z}_{p,t+1} - \hat{z}_{p,t})] - \\ E_t [\sigma_C(\hat{C}_{t+1}^* - \hat{C}_t^*) - (\hat{z}_{p,t+1}^* - \hat{z}_{p,t}^*)] + \kappa_0 \hat{b}_t - \hat{z}_{u,t}$$

$z_{u,t}$ is the autocorrelated risk premium shock while $z_{p,t}$ and $z_{p,t}^*$ are preference shocks

The model: Structural shocks

- There are eleven shocks in the model:
 - home and foreign monetary policy shocks (i.i.d)
 - home and foreign technology shocks, in both the traded and nontraded goods sectors (AR)
 - home and foreign preference shocks (AR)
 - shock to the uncovered interest parity condition (AR)
 - mark-up shocks in the labor market (i.i.d)

The data

- **Nine observables:** real private consumption, nontraded goods inflation, CPI inflation and the short-term interest rate for the euro-area and the US plus the real exchange rate
- **Sample period:** 1983:1 - 2005:2
- **All inflation rate** are computed as q-on-q changes in the corresponding price indices and are de-meanned, the short-term interest rates are de-meanned, consumption is linearly detrended and the real exchange rate is de-meanned

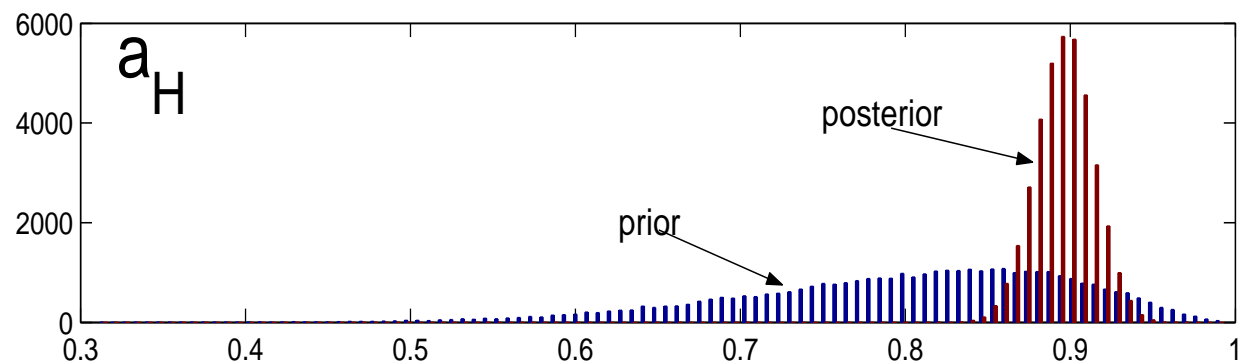
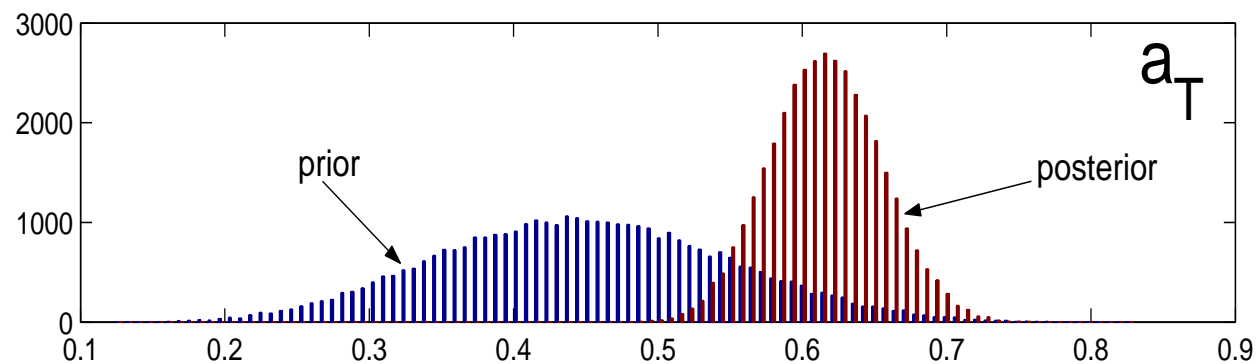
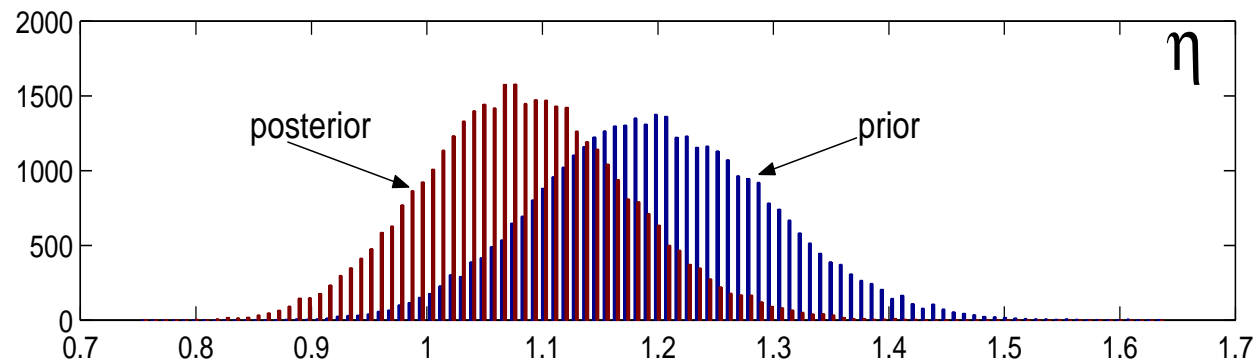
Statistics for the posterior distribution: Benchmark model

parameter	2.5	50	97.5	mean	st. dev.
κ_0	0.00	0.01	0.02	0.01	0.00
ϕ	1.05	1.22	1.41	1.23	0.09
ρ	0.69	0.91	1.17	0.92	0.12
σ_C	1.99	2.35	2.75	2.35	0.19
κ_H	3.39	10.13	27.16	11.49	6.19
κ_F	1.61	3.27	6.98	3.53	1.41
κ_N	22.52	53.63	113.58	57.35	23.63
κ_H^*	7.99	22.65	60.44	25.72	13.64
κ_F^*	1.91	2.83	4.47	2.93	0.69
κ_N^*	8.44	26.79	73.63	30.63	17.28
κ_W	162.11	283.88	491.34	295.89	84.55
κ_W^*	197.62	348.96	550.35	355.65	90.60
η	0.92	1.08	1.27	1.08	0.09
a_H	0.86	0.90	0.93	0.90	0.02
a_T	0.54	0.61	0.69	0.62	0.04

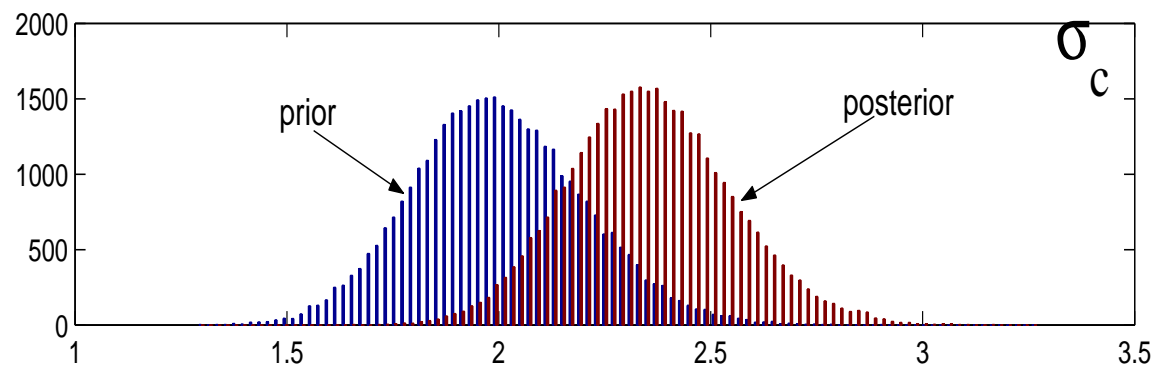
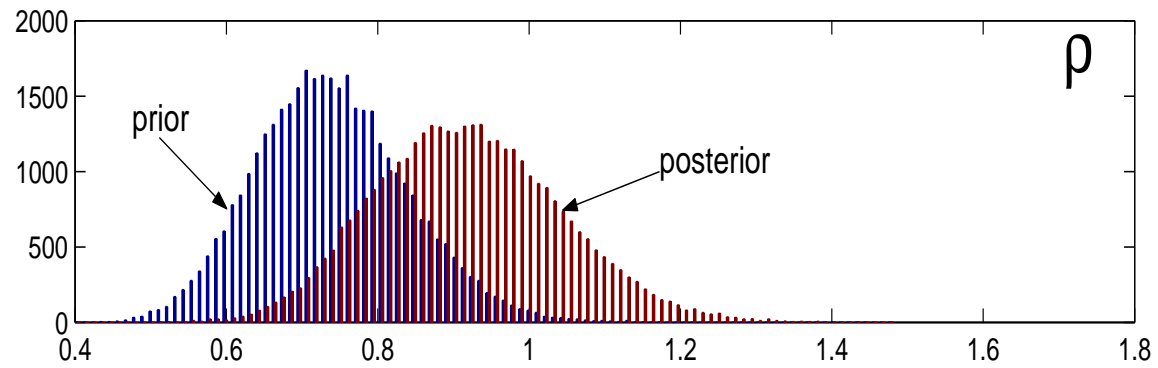
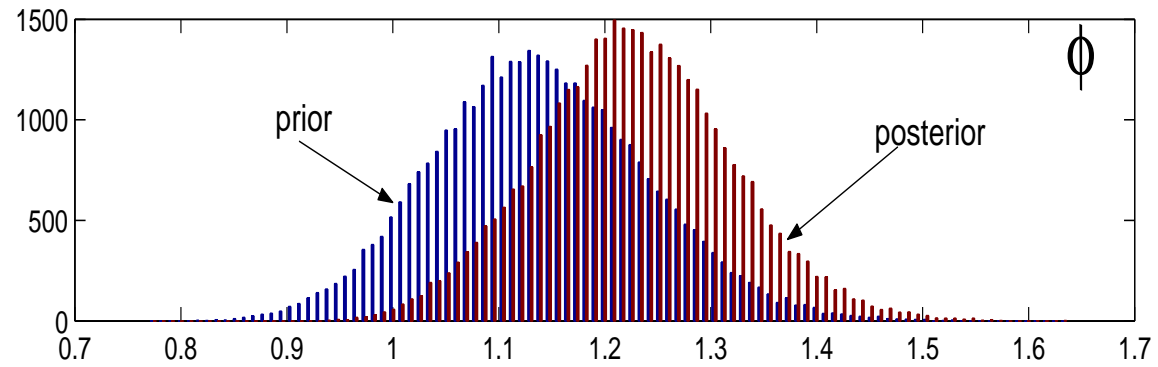
Statistics for the posterior distribution: Benchmark model

parameter	2.5	50	97.5	mean	st. dev.
ρ_R	0.83	0.87	0.90	0.87	0.02
ρ_π	1.47	1.67	1.88	1.67	0.11
ρ_Y	0.10	0.20	0.29	0.20	0.05
ρ_S	-0.05	-0.02	0.02	-0.02	0.02
ρ_R^*	0.86	0.90	0.93	0.90	0.02
ρ_π^*	1.33	1.52	1.72	1.52	0.10
ρ_Y^*	-0.10	0.10	0.30	0.10	0.10
ρ_S^*	-0.06	-0.02	0.03	-0.02	0.02

Prior and posterior marginal densities (1)



Prior and posterior marginal densities (2)



Matching the moments (1)

Selected second moments of the real exchange rate

Moment	Data	Benchmark			LCP			PCP		
percentiles		2.5	50	97.5	2.5	50	97.5	2.5	50	97.5
$\sigma(RS_t)$	20.74	7.41	14.32	33.01	8.57	14.10	23.09	7.94	14.46	26.73
$\rho(RS_t)$	0.97	0.92	0.92	0.94	0.91	0.93	0.94	0.91	0.93	0.94
$\rho\left(RS_t, \frac{C_t}{C_t^*}\right)$	-0.48	-0.32	-0.39	-0.37	-0.29	-0.28	-0.29	-0.39	-0.51	-0.63

Matching the moments (2)

Selected second moments of the observable variables: Benchmark model

	σ					ρ				
	All	$\sigma_u = 0$	$\sigma_p = 0$	$\sigma_R \neq 0$	$\sigma_Z \neq 0$	All	$\sigma_u = 0$	$\sigma_p = 0$	$\sigma_R \neq 0$	$\sigma_Z \neq 0$
<i>RS</i>	14.32	6.12	13.37	1.30	2.56	0.92	0.96	0.92	0.78	0.96
π_c	0.50	0.49	0.46	0.05	0.44	0.64	0.65	0.59	0.68	0.60
π_c^*	0.45	0.44	0.42	0.06	0.41	0.48	0.47	0.42	0.80	0.40
π_n	0.42	0.42	0.37	0.04	0.36	0.79	0.78	0.75	0.86	0.75
π_n^*	0.35	0.34	0.31	0.06	0.30	0.74	0.74	0.71	0.86	0.70
<i>R</i>	0.48	0.48	0.32	0.14	0.28	0.95	0.95	0.91	0.75	0.95
<i>R</i> *	0.35	0.35	0.24	0.16	0.17	0.93	0.92	0.87	0.78	0.93
<i>C</i>	1.35	1.32	0.79	0.33	0.67	0.84	0.84	0.91	0.75	0.94
<i>C</i> *	1.15	1.13	0.66	0.44	0.42	0.84	0.83	0.87	0.78	0.94

Matching the moments (2)

Selected second moments of the observable variables: Benchmark model

	σ					ρ				
	All	$\sigma_u = 0$	$\sigma_p = 0$	$\sigma_R \neq 0$	$\sigma_Z \neq 0$	All	$\sigma_u = 0$	$\sigma_p = 0$	$\sigma_R \neq 0$	$\sigma_Z \neq 0$
<i>RS</i>	14.32	6.12	13.37	1.30	2.56	0.92	0.96	0.92	0.78	0.96
π_c	0.50	0.49	0.46	0.05	0.44	0.64	0.65	0.59	0.68	0.60
π_c^*	0.45	0.44	0.42	0.06	0.41	0.48	0.47	0.42	0.80	0.40
π_n	0.42	0.42	0.37	0.04	0.36	0.79	0.78	0.75	0.86	0.75
π_n^*	0.35	0.34	0.31	0.06	0.30	0.74	0.74	0.71	0.86	0.70
<i>R</i>	0.48	0.48	0.32	0.14	0.28	0.95	0.95	0.91	0.75	0.95
<i>R</i> *	0.35	0.35	0.24	0.16	0.17	0.93	0.92	0.87	0.78	0.93
<i>C</i>	1.35	1.32	0.79	0.33	0.67	0.84	0.84	0.91	0.75	0.94
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π_c^*	0.45	0.44	0.42	0.06	0.41	0.48	0.47	0.42	0.80	0.40
π_n	0.42	0.42	0.37	0.04	0.36	0.79	0.78	0.75	0.86	0.75
π_n^*	0.35	0.34	0.31	0.06	0.30	0.74	0.74	0.71	0.86	0.70
<i>R</i>	0.48	0.48	0.32	0.14	0.28	0.95	0.95	0.91	0.75	0.95
<i>R</i> *	0.35	0.35	0.24	0.16	0.17	0.93	0.92	0.87	0.78	0.93
<i>C</i>	1.35	1.32	0.79	0.33	0.67	0.84	0.84	0.91	0.75	0.94
<i>C</i> *	1.15	1.13	0.66	0.44	0.42	0.84	0.83	0.87	0.78	0.94

Matching the moments (2)

Selected second moments of the observable variables:
Benchmark model

	All	$\sigma_u = 0$	$\sigma_p = 0$	$\sigma_R \neq 0$	$\sigma_Z \neq 0$
$\rho\left(RS_t, \frac{C_t}{C_t^*}\right)$	-0.39	-0.29	-0.35	1.00	0.85

Matching the moments (2)

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The dynamics of the real exchange rate (2)

- The real exchange rate is given by:

$$\begin{aligned}\Delta RS_t = & (1 - a_T)(\pi_{N,t}^* - \pi_{T,t}^*) - (1 - a_T)(\pi_{N,t} - \pi_{T,t}) + \\ & a_H (\Delta S_t + \pi_{F,t}^* - \pi_{F,t}) + (1 - a_H) (\Delta S_t + \pi_{H,t}^* - \pi_{H,t}) + \\ & (2a_H - 1)(\pi_{F,t} - \pi_{H,t})\end{aligned}$$

- Variance decomposition suggests that:
 - international price discrimination accounts for 55 percent of total variance
 - 34 percent is explained by covariance terms involving the prices of traded goods
 - the home bias contributes to around 7 percent
 - the contribution of the internal real exchange rates is small

The dynamics of the real exchange rate (1)

Real exchange rate fluctuations decomposition

(Percentage of variance of the real exchange rate)

	Benchmark			LCP			PCP		
component	2.5	50	97.5	2.5	50	97.5	2.5	50	97.5
$\sigma(\text{Internal Rer})$	0.86	0.24	0.06	1.87	0.67	0.22	0.85	0.24	0.13
$\sigma(\text{Home bias})$	12.17	7.55	4.87	36.24	35.68	32.03	93.91	96.60	98.08
$\sigma(\text{IPD})$	45.71	55.71	65.35	18.19	25.06	32.63	0.00	0.00	0.00
$\sigma(\text{Int. Rer, home bias})$	-1.07	-0.08	-0.00	7.31	1.78	-0.29	5.28	3.16	1.82
$\sigma(\text{Int. Rer, IPD})$	4.39	2.34	0.96	4.85	1.91	0.62	0.00	0.00	0.00
$\sigma(\text{Home bias, IPD})$	37.94	34.22	28.74	31.47	34.83	34.73	0.00	0.00	0.00

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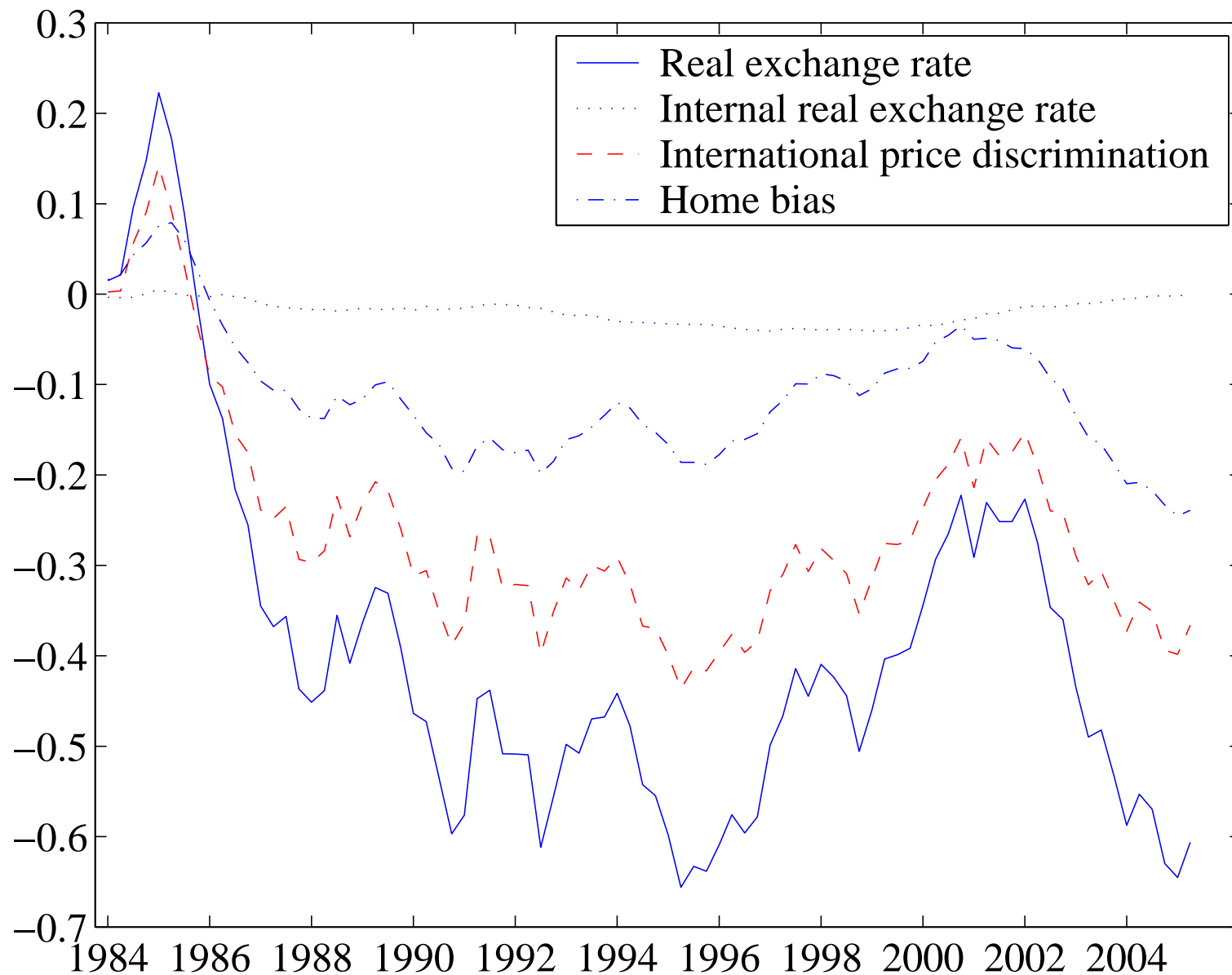
The dynamics of the real exchange rate (1)

Real exchange rate fluctuations decomposition

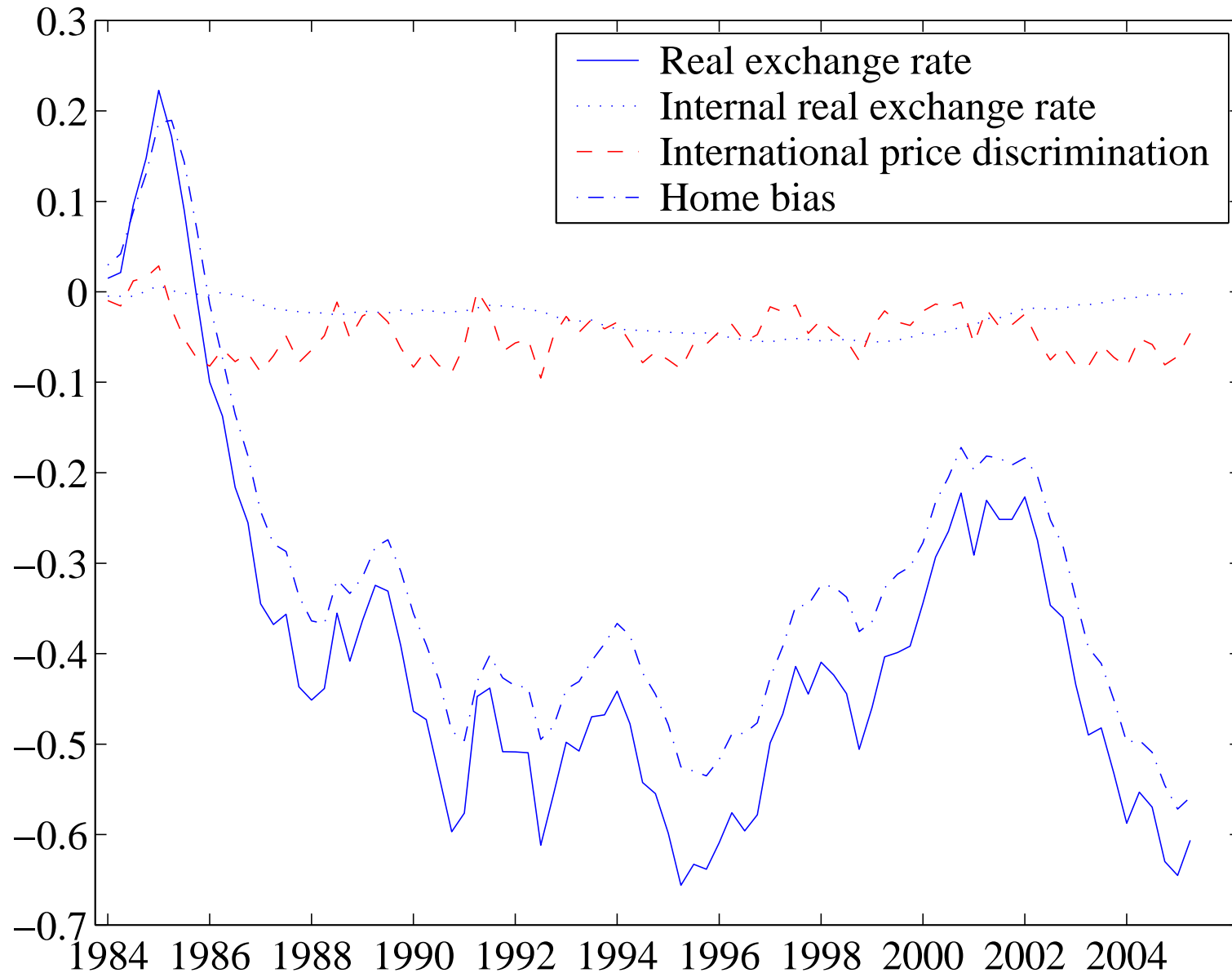
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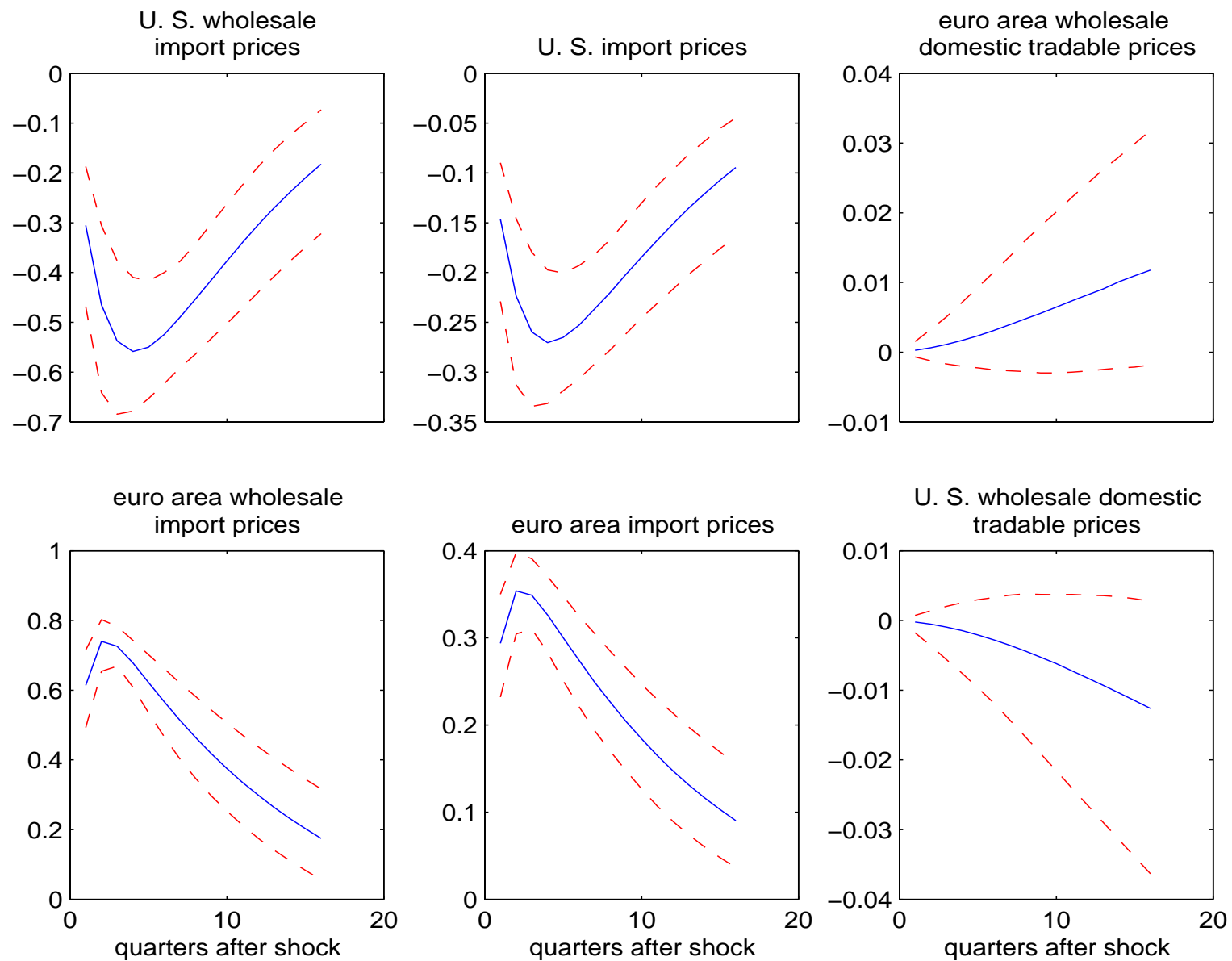
Real exchange rate decomposition: Benchmark model



Real exchange rate decomposition: LCP model



The dynamics of the real exchange rate (3): Incomplete pass-through



The importance of the different shocks

Variable	z_H	z_F^*	z_N	z_N^*	z_R	z_R^*	z_U	z_U^*	z_U	z_W	z_W^*	Total
euro-area												
C	10.2	0.3	13.3	0.0	5.4	0.0	63.9	0.7	5.9	0.3	0.0	100
π_c	47.8	0.4	29.3	0.0	0.7	0.1	15.5	0.2	4.8	1.1	0.0	100
π_n	14.8	0.0	59.7	0.0	0.8	0.0	21.6	0.2	1.7	1.2	0.0	100
R	16.7	0.1	16.2	0.0	8.4	0.0	56.2	0.2	1.8	0.4	0.0	100
re	1.5	0.6	0.5	0.3	0.2	0.3	11.1	8.0	77.5	0.0	0.0	100
US												
C	0.8	3.8	0.0	8.3	0.0	13.1	1.4	64.2	8.2	0.0	0.2	100
π_c	0.4	53.0	0.0	28.0	0.0	1.7	0.7	10.4	4.4	0.0	1.4	100
π_n	0.1	8.2	0.0	64.2	0.0	2.4	1.1	17.2	5.2	0.0	1.7	100
R	0.1	7.6	0.0	14.2	0.0	18.2	1.1	53.1	5.4	0.0	0.3	100

The importance of the different shocks

Variable	z_H	z_F^*	z_N	z_N^*	z_R	z_R^*	z_U	z_U^*	z_U	z_W	z_W^*	Total
euro-area												
C	10.2	0.3	13.3	0.0	5.4	0.0	63.9	0.7	5.9	0.3	0.0	100
π_c	47.8	0.4	29.3	0.0	0.7	0.1	15.5	0.2	4.8	1.1	0.0	100
π_n	14.8	0.0	59.7	0.0	0.8	0.0	21.6	0.2	1.7	1.2	0.0	100
R	16.7	0.1	16.2	0.0	8.4	0.0	56.2	0.2	1.8	0.4	0.0	100
re	1.5	0.6	0.5	0.3	0.2	0.3	11.1	8.0	77.5	0.0	0.0	100
US												
C	0.8	3.8	0.0	8.3	0.0	13.1	1.4	64.2	8.2	0.0	0.2	100
π_c	0.4	53.0	0.0	28.0	0.0	1.7	0.7	10.4	4.4	0.0	1.4	100
π_n	0.1	8.2	0.0	64.2	0.0	2.4	1.1	17.2	5.2	0.0	1.7	100
R	0.1	7.6	0.0	14.2	0.0	18.2	1.1	53.1	5.4	0.0	0.3	100

The importance of the different shocks

Variable	z_H	z_F^*	z_N	z_N^*	z_R	z_R^*	z_U	z_U^*	z_U	z_W	z_W^*	Total
euro-area												
C	10.2	0.3	13.3	0.0	5.4	0.0	63.9	0.7	5.9	0.3	0.0	100
π_c	47.8	0.4	29.3	0.0	0.7	0.1	15.5	0.2	4.8	1.1	0.0	100
π_n	14.8	0.0	59.7	0.0	0.8	0.0	21.6	0.2	1.7	1.2	0.0	100
R	16.7	0.1	16.2	0.0	8.4	0.0	56.2	0.2	1.8	0.4	0.0	100
re	1.5	0.6	0.5	0.3	0.2	0.3	11.1	8.0	77.5	0.0	0.0	100
US												
C	0.8	3.8	0.0	8.3	0.0	13.1	1.4	64.2	8.2	0.0	0.2	100
π_c	0.4	53.0	0.0	28.0	0.0	1.7	0.7	10.4	4.4	0.0	1.4	100
π_n	0.1	8.2	0.0	64.2	0.0	2.4	1.1	17.2	5.2	0.0	1.7	100
R	0.1	7.6	0.0	14.2	0.0	18.2	1.1	53.1	5.4	0.0	0.3	100

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π_n	14.8	0.0	59.7	0.0	0.8	0.0	21.6	0.2	1.7	1.2	0.0	100
R	16.7	0.1	16.2	0.0	8.4	0.0	56.2	0.2	1.8	0.4	0.0	100
re	1.5	0.6	0.5	0.3	0.2	0.3	11.1	8.0	77.5	0.0	0.0	100
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C	0.8	3.8	0.0	8.3	0.0	13.1	1.4	64.2	8.2	0.0	0.2	100
π_c	0.4	53.0	0.0	28.0	0.0	1.7	0.7	10.4	4.4	0.0	1.4	100
π_n	0.1	8.2	0.0	64.2	0.0	2.4	1.1	17.2	5.2	0.0	1.7	100
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π_n	14.8	0.0	59.7	0.0	0.8	0.0	21.6	0.2	1.7	1.2	0.0	100
R	16.7	0.1	16.2	0.0	8.4	0.0	56.2	0.2	1.8	0.4	0.0	100
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C	0.8	3.8	0.0	8.3	0.0	13.1	1.4	64.2	8.2	0.0	0.2	100
π_c	0.4	53.0	0.0	28.0	0.0	1.7	0.7	10.4	4.4	0.0	1.4	100
π_n	0.1	8.2	0.0	64.2	0.0	2.4	1.1	17.2	5.2	0.0	1.7	100
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The importance of the different shocks

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π_n	0.1	8.2	0.0	64.2	0.0	2.4	1.1	17.2	5.2	0.0	1.7	100
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R	16.7	0.1	16.2	0.0	8.4	0.0	56.2	0.2	1.8	0.4	0.0	100
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π_c	0.4	53.0	0.0	28.0	0.0	1.7	0.7	10.4	4.4	0.0	1.4	100
π_n	0.1	8.2	0.0	64.2	0.0	2.4	1.1	17.2	5.2	0.0	1.7	100
R	0.1	7.6	0.0	14.2	0.0	18.2	1.1	53.1	5.4	0.0	0.3	100

The importance of the different shocks

- Around three quarters of the real exchange variance is explained by the **UIP shock**. (Rabanal and Tuesta, 2005). The remaining part is explained by **home and foreign preference shocks**
- Consumption and the short-term interest rates are mainly explained by domestic preference shocks
- Wage shocks are not important at all, while monetary policy shocks are, to some extent, only relevant for interest rates and consumptions
- Inflation rates are driven by technology shocks

Conclusions

- The model with distribution costs is able to replicate the main stylized facts of the real exchange rate and outperforms in terms of fit (marginal density) the LCP and PCP models
- International price discrimination, due to a combination of LCP and distribution costs plays an important role in accounting for the dynamics of the real exchange rate
- The pass-through of nominal exchange rate changes into import prices is rather low at the border, and even lower at consumer level, given the presence of distribution costs